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Multidisciplinary Research: Innovations in Science, Arts, and Commerce

Sisir Kumar Rajbongshi, Kshirod Sarmah, Rajdeep Ghosh, and Dharmeswar Tarang *Editors*

Multidisciplinary Research: Innovations in Science, Arts, and Commerce

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Editorial Board

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Editorial Message

"*Education is an ornament in prosperity and refuge in adversity" -Aristotle*

In the third decade of the new millennium, India is endorsed as a rising super power. Research is an important aspect in the present scenario of Higher Education. The thinking involved in research makes people to develop problem solving skills by way of inquisition and exploration.

The progress of a country depends on its Research and Development (R & D) sector contributing to various aspects of social, economic and technological process. Our nation is still lagging behind in the R & D sector as compared to other countries like USA, China, Japan and the European Countries. We are yet to achieve the optimum levels of Research. So we have to give more importance on the basis of research.

We are happy to publish this edited volume, **"Multidisciplinary Research: Innovations in Science, Arts, and Commerce,"** the first edition, from the department of Computer Science, PDUAM, Amjonga .
This first edition brings together the efforts of scholars, researchers, and educators from different parts of the country as well as outside the country also. The articles are from diverse disciplines from arts to science, ICT to literature, who share a common vision — to bridge the gap between traditional knowledge and modern technological innovation. In this book we have tried to focus on that kind of spirit of innovative thinking and interdisciplinary approach.

We want to take the opportunity to thank to all our authors at this moment for showing their faith on us. Also thank to Deep Science publication for accepting our request to publish in their reputed publishing. We hope that this book will be beneficial for all. In near future we would like to publish second edition in the same title with different articles.

— The Editors
Department of Computer Science, Pandit Deendayal Upadhyaya Adarsha Mahavidyalaya (PDUAM), Amjonga, Goalpara, Assam, India

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Preface

In the department of computer science, we have a good environment of research, innovation as we have a full man power. Since the establishment of Department of Computer Science, PDUAM Amjonga in 2017, our department has been trying to conduct seminars, conferences lecture series, awareness program etc. Since then the department is trying to provide quality education focusing in the academic side as well as in innovative side also. One of the visions of Computer Science department, PDUAM Amjonga was to do some good quality research oriented works for better society. As a result of this thinking this edited book "*Multidisciplinary Research: Innovations in Science, Arts and Commerce*" is going to published.

In this edition, we have received more than 80 articles. Out of them we have selected 41 articles for publication. The contributions have been divided into Artificial Intelligence and ICT, Mathematics, Physical and Life Sciences, Commerce and Economics, Social Sciences, and Arts and Culture. This kind of interdisciplinary approach is the need of the time.

The book tries to inspire researches with innovations in young minds which can become accessible to students, academicians, researchers and professionals.

We want to thank our respected advisors -***Prof. Anjana Kakoti Mahanta*** (Department of Computer Science, Gauhati University), ***Prof. Helen K Saikia*** (Department of Mathematics, Gauhati University), and ***Prof. Utpal Bhattacharjee*** (Department of Computer Science & Engineering, Rajiv Gandhi University) — for their valuable guidance and encouragement since one year and also throughout the preparation of this book. Their expertise, experience and knowledge will enrich the quality of our book.

We would like to acknowledge all the **contributors** for their articles, and also the **reviewers** for their valuable comments and feedback, all the well wishers of PDUAM, Amjonga, and **Deep Science Publishing** for their support. At the end we would like to thank the authority, **Pandit Deendayal Upadhyaya Adarsha Mahavidyalaya, Amjonga**, for hosting and supporting this initiative.

We believe this publication will inspire future scholars to engage in multidisciplinary research and contribute to a knowledge-driven society.

Editors

Dr. Sisir Kumar Rajbongshi
Dr. Kshirod Sarmah
Dr. Rajdeep Ghosh
Dharmeswar Tarang

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Chapter-1: Exploring the Role of AI-Driven Prompt Engineering in Enhancing ESL Pedagogy and Bridging the Digital Divide in Higher Education

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Abstract

The digital divide persists in reducing the opportunity for equitable access to English language learning at colleges. AI- powered tools like prompt engineering have demonstrated great potential in global education; however, how those would affect English as a Second Language (ESL) pedagogy is being less investigated. Prompt engineering have been considered on how it can support digital literacy and language in higher educational research. With the intention of adopting a qualitative methodology, the research undertakes semi-structured interviews with teachers as well as focus groups with students. This article explores teachers' experiences of embedding AI tools into teaching and interrogates student digital literacy and engagement with prompt engineering. The main findings suggest that early engineering supports language, with writing and vocabulary in particular being boosted when taught with increased digital literacy. But there are practical barriers to a full roll-out, including limited teacher training, digital access and socio-economic inequality. Students who have better access to technology see greater gains. The study asserts that AI tools, and especially prompt engineering, can address the digital divide, by suggesting policy changes for teacher training and infrastructure.

Keywords: AI-driven tools; Prompt engineering; ESL pedagogy; Digital literacy; Digital divide

1. Introduction

In the present technologically advanced era, the digital divide continues to hinder educational equity, even in language learning. According to Li et al. (2025), more than 2 billion people worldwide lack internet access, contributing to educational inequality, particularly at the higher education level. This gap is even more pronounced in ESL instruction, where high-quality digital tools represent the difference between language growth and stagnation. Although AI-based applications have demonstrated significant success in global education, less attention has been paid to their added value in ESL teaching, particularly in bridging the digital literacy divide (Alkhresheh, 2024; Mannan et al., 2023).

One major field revolutionized by AI has been education, especially language learning. AI-based tools, such as adaptive learning systems and language-processing technologies, have revolutionized how students engage in personalized learning. Rohmiyati (2025) and (Hayath & Maruf (2025) also reveals that platforms like Duolingo and Grammarly provide personalized material with real-time

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feedback to support language development. Additionally, Mzwri and Turcsányi-Szabo (2025) emphasize that a new approach in prompt engineering is emerging, with tools that generate personalized prompts, leading to better learning outcomes. Digital literacy, i.e., the ability to use digital tools and systems effectively, is a prerequisite for fully benefiting from these AI-based systems. In ESL, learners with greater digital literacy can utilize these technologies more effectively for language development (Mehta et al., 2025). However, studies on ESL pedagogy with a combined focus on AI, digital literacy, and language learning remain scarce, especially in higher education. While AI tools show promise, there is a significant lack of understanding regarding how digital literacy impacts ESL learners' engagement with these technologies. Closing this gap is crucial to narrowing the digital divide and enabling all students to fully benefit from AI-enabled language learning tools.

2. Objectives

The primary objective of this qualitative study is to explore how prompt engineering, as a component of AI-driven tools, can improve ESL pedagogy in higher education while enhancing students' digital literacy and language proficiency. The study aims to investigate the impact of prompt engineering on language acquisition, specifically in writing and vocabulary development in ESL classrooms. Moreover, the research will seek to:

a) Understand educators' experiences with integrating AI-driven tools, particularly prompt engineering, into their ESL teaching practices.
b) Examine how digital literacy influences students' ability to effectively engage with AI tools for language learning.
c) Identify the challenges faced by educators and students in utilizing AI technologies for ESL education, with particular attention to access, training, and socio-economic disparities.
d) Provide insights on how prompt engineering can be optimized for better student engagement and improved language learning outcomes in ESL contexts.

By achieving these objectives, this study will contribute to the growing body of knowledge on the integration of AI in ESL education, providing valuable insights and practical recommendations for educators, institutions, and policymakers. These findings will support the equitable and effective use of AI tools to improve language learning outcomes for students, particularly in underserved communities. The research aims to highlight how AI tools like prompt engineering can help bridge the digital divide in higher education, offering a pathway to more inclusive and accessible ESL education for all students.

3. Literature Review

In recent years, Artificial Intelligence (AI) has revolutionized education, particularly in language learning, by enabling personalized experiences and adaptive teaching strategies (Hasim et al., 2022; Mannan and Maruf, 2024). AI-driven tools, such as language processing technologies and AI-

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powered platforms, have shown significant potential in improving English as a Second Language (ESL) proficiency (Abu Sahyon et al., 2023). However, despite the growing integration of AI in education, research on the impact of specific AI techniques, such as prompt engineering, on ESL pedagogy remains limited (Enny et al., 2025). This literature review examines the theoretical frameworks guiding this study, identifies gaps in current research, and discusses how this research addresses these gaps in ESL education.

4. Theoretical Frameworks Guiding the Study

This paper presents the nexus of AI-enabled technology, just-in-time engineering and ESL against the backdrop of two main theoretical paradigms – TAM and Constructivist Learning Theory.

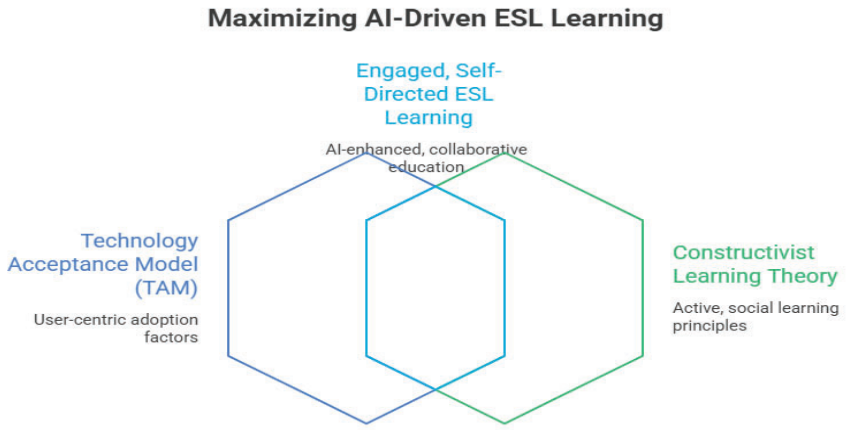

Figure 1. *Theoretical Framework*

According to TAM (Davis, 1989), the perceptions of ease of use and usefulness influence the adoption of AI technology among EFL learners. Research by Taber (2025) asserted the Constructivist Learning Theory, influenced by the work of Piaget (1972) and Vygotsky (1978), suggests that learners are most likely to construct learning through active experiences with other people. Taken together, these frameworks offer a coordinated approach to integrating applications based on AI in ESL teaching, promoting student engagement, self-directed learning and finding the best role for prompt engineering specifically in this setting (Haque et al., 2024).

5. Controversies and Contrasts in the Literature

AIED research has expanded in education, but large gaps still exist. Most research on tools such as Duolingo and Grammarly focuses on language learning in general, ignoring the role of prompt engineering. There is so far a paucity of studies on the role of AI in mediating digital literacy gap for

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English as Second Language (ESL) Learning, especially for students exposed to disadvantaged conditions (Zhang et al., 2025).

6. Evidence Gaps and Overlooked Aspects

In spite of having much research in the area of AI in Education (AIED), there are still areas to be explored especially in terms such as prompt generation for ESL learning (Lee et al., 2024). Despite significant research on AI-powered applications like grammar checkers and language learning apps, very little work has been carried out to see how prompt engineering might support writing, vocabulary-building, or general language improvement (Mahjabin, 2025). Rationale mechanisms are designed "by the user", context-dependent prompts that encourage students by suggesting what to do (Breve et al., 2024). But the influence of immediate engineering on ESL classrooms is not well understood (Mai, 2025).

Finally, there is insufficient research that deciphers the effect of students' digital literacy on their use of AI tools. This influence is recognized, though not much research is there to investigate this direct effect on AI-driven language learning. This is of particular concern for students from less affluent communities, who struggle to gain access to technology and whose teachers have less training – both aspects that make the implementation of AI-based tech in class difficult.

7. Why Filling These Gaps Matter?

Bridging these gaps is crucial to the progress of AI in ESL instruction. This work will make actionable contributions to the education community by elucidating how prompt engineering supports pedagogy in order to inform the ways educators can guide AI solutions towards personalized instruction. This individualization will increase skills in basic language arts (writing and vocabulary particularly) resulting in improved ESL student performance.

An important finding will be the contribution of digital literacy to students' usage of AI tools. By investigating this relationship and its impact on performance, the research will provide information to guide practitioners who may need to adapt teaching practices in order for students of all technological backgrounds to access learning technology effectively. This is especially crucial in closing the digital divide, the gap that low income young people face who lack access to technology and need for help with digital literacy.

The study will also identify the challenges educators encounter when using AI tools, including training and technology access. Building on these results, the research will recommend policies that make AI tools available to all students – particularly in communities with few resources. This paper then presents a theoretical framework for the study, notes where gaps exist and the importance of addressing them. The findings will be used to inform policy recommendations, pedagogy, and better access to AI-supported ESL resources.

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8. Methods

Design

This qualitative research examines the potential use of AI-driven tools, particularly prompt engineering, for improving ESL teaching and learning in higher education. It studies educators' and students' expectations, challenges, and experiences with AI tools; advances digital literacy as a tool to bridge the language proficiency gaps; and offers practical implications for educators and policymakers.

Population

The study will target **higher education institutions** that have begun integrating AI-driven tools into their ESL curriculum. The participants will include **educators** and **students** engaged in ESL education at two universities in Malaysia **University -Unirazak** and **Alfa University College**. The sample will consist of:

Table 1. Respondents Demography

Group	Criteria
Educators	ESL teachers with at least one semester of experience using AI-driven tools, specifically prompt engineering, in their teaching practices.
Students	ESL learners enrolled in degree programs who have varying levels of digital literacy and access to technology, willing to participate in focus groups.

Teachers who have more than one semester experience using AI tools and students enrolled in the ESL class are eligible. The study gives focus to diversity in both digital literacy and socio-Economic Status.

9. Tools & Protocols

On the whole, this study will employ a mixed-method approach to obtain an overall view of the use of AI-based tools in ESL education. One-on-one interviews with teachers will give insight into their views regarding AI applications, particularly prompt engineering, in supporting ESL instruction. Based on an interview protocol that includes open-ended questions, these interviews will inquire about the experiences of educators and what they see as challenges due to the impact on aerial linguistic supersaturate in learners. Focus group discussions with students will explore how they have used AI in their studies, their experience of prompt engineering and views on the ways in which AI helps them to learn. Focus groups will help participants engage with one another and explore ideas in common (Geampana and Perrotta, 2025).

Digital Literacy Survey

An e-survey will be used to determine the Arabic language learner’s proficiency with digital tools. This is to understand the role of digital literacy on their use of AI tools.

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Measures

Teacher AI integration success will be measured by teachers' perception of student progress and Student engagement and proficiency will be determined via focus group participation, as well as self-reports regarding language development.

Methods

Data will be transcribed and coded under overarching themes in a thematic analysis to compare educators' expectations with the students' final work at the end of their study, particularly in the area of digital literacy/ accessibility.

Analysis Plan

Thematic analysis will be used to analyze the data to ascertain themes and patterns from the interviews and focus group discussions. The analysis will proceed iteratively and comprise the following steps:

Table 2: Analysis Plan

Step	Description
Familiarization	This is where you read over and have a look at transcribed data to see all of the information as a whole Casual skimming (or reading?)
Initial Coding	Code the information according to emerging themes, such as prompt design, digital literacy, level of AI engagement and language proficiency.
Theme Development	Categorizing codes into themes Looking at the prompt engineering of the Language Learning and digital literacy as key/thematic aspects for language learning.
Interpretation	Examine the themes and relate them to research questions in order to generate conclusions and insights.

Comparison between responses in relation to other attributes (like socio-economic level, digital literacy level and access technology) will also be addressed. This will enable us to deepen our understanding of how such factors impact the effectiveness of AI tools for engineering in ESL education. The results will be utilized to develop evidence-based policy suggestions concerning teacher training, infrastructure creation, and the use of AI tools in ESL teaching.

Through a qualitative methodology including semi-structured interviews, focus groups, and digital literacy assessment, the study will support an enriched understanding of how AI prompt engineering can strengthen ESL instruction and mitigate the digital gap in higher education. The results of the research will provide key implications for teaching English as a second language (ESL), and lead to more equitable use of AI tools in ESL education.

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10. Results

The first part of the study will perform a qualitative analysis of educators' and students' discussions regarding AI-based tools like prompt engineering implemented in ESL education. For teachers, emphasis in their discussion is on the effect that quick construction had nursed on writing and vocabulary evolution. The study will analyze student's engagement, L2 proficiency gains and self-perceptions of usefulness of the AI tool in order to lay the groundwork and provide initial observations on the role of AI in ESL education in Malaysia.

Outcome-Based Findings Table

The results of this study will be presented in the table below, summarizing major results that follow from the implementation of AI-engineered prompt integration within ESL instruction.

Table 3: Findings & Outcome

Research Objective	Outcome	Findings
1. Educators' experiences with AI-driven tools	Impact on Language Skills	Educators report significant improvement in students' writing and vocabulary development through AI-driven prompt engineering.
	Pedagogical Integration	Teachers faced challenges due to insufficient training and lack of resources, limiting full tool integration.
2. Students' engagement with AI tools	Enhanced Language Proficiency	Students showed improvement in writing and vocabulary skills after regular use of AI tools for assignments.
	Digital Literacy & Access	Students with higher digital literacy showed better engagement and language improvement than those with limited access to technology.
3. Impact of Digital Literacy on AI tool effectiveness	Engagement Levels & Learning Outcomes	Students with better digital skills were more engaged with AI tools, showing higher levels of proficiency
	Barriers to Effective Use	Students with limited digital literacy struggled with AI tools, showing lower improvement rates in language proficiency.
4. Challenges faced by educators and students	Technology Access & Teacher Training	Limited access to digital tools and insufficient teacher training were identified as primary barriers to full implementation.
	Socio-economic Factors	Disparities in socio-economic status further

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		limited students' ability to fully engage with AI-driven language tools.
5. Optimizing prompt engineering for engagement	Personalization & Interaction	Tailored prompts were found to enhance student engagement by making learning more interactive and personalized.

11. Moving To Critical Analysis

Reviewed and annotated, this bibliography critically examines the use of digital literacy and AI technologies within ESL classrooms and their impact on student engagement. It illustrates the problems faced by students from low-income homes and shows how an access to technology is not as equal. The research also targets educator tensions over the adoption of AI that arise from lack of training and resources. It will be supplemented by visual aids, including infographics, and tables designed to make complex data accessible in order to help educators, policymakers, and higher education leaders understand the strides that students are taking toward linguistic fluency through AI interaction.

This study is not free from some limitations. The small size of the sample, characteristic of qualitative research, prevents any generalization. Furthermore, because only two Malaysian universities participated in the study, the findings may not generalize to students and lecturers in other places or other educational systems. In addition, there is a potential for both students and educators not to have provided truthful answers especially in the case of the perceived usefulness of AI tool effectiveness. The study, by considering only the immediate effects of AI on ESL proficiency, does not consider its longer-term consequences. These limitations may be addressed in future study by recruiting more subjects, involving difference organization range of institutions and by investigating the long-term impact of AI on language learning.

The novel approach of this study is the consideration of prompt engineering as an AI technique to enhance ESL pedagogy which, for the most part, has been under-researched. The paper also considers the intersection between digital literacy and AI deployment, particularly for less privileged students, an issue of critical pedagogical concern. The results will have implications for policy, teacher education and school practice from the standpoint of equitable access and digital literacy.

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Chapter-2: Application of ML in IoT and Cloud Computing with SDG for Modern-Day Teaching-Learning Domain Empowered by AR & VR

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Abstract

The convergence of Machine Learning (ML), Internet of Things (IoT), and Cloud Computing is reshaping modern teaching-learning systems. These technologies, when aligned with the United Nations Sustainable Development Goals (SDGs), provide inclusive, scalable, and intelligent education solutions. Furthermore, Augmented Reality (AR) and Virtual Reality (VR) enhance immersive and experiential learning, enabling personalized, adaptive, and accessible education. This paper explores the applications of ML-driven IoT and Cloud frameworks in the teaching-learning domain, focusing on real-time analytics, smart campus systems, adaptive content delivery, and immersive AR/VR environments. A problem formulation is presented, highlighting challenges of cost, data security, and digital divide. Results from case studies are discussed, along with analysis, future scopes, and limitations. The findings suggest that ML, IoT, and Cloud, when integrated with AR/VR, have the potential to revolutionize modern education while promoting SDGs such as Quality Education (SDG 4), Industry-Innovation (SDG 9), and Reduced Inequalities (SDG 10).

1. Introduction

Modern education systems face challenges of inclusivity, scalability, and engagement. With the exponential growth of digital learning platforms, integrating IoT sensors, ML algorithms, and Cloud services has emerged as a key driver for data-driven education [1].

- **IoT in Education**: IoT-enabled classrooms collect real-time student engagement, attendance, and behavioral data [2].
- **Cloud Computing**: Cloud platforms store and process large-scale educational data, supporting global collaboration [3].
- **ML Integration**: ML models analyze student performance, predict outcomes, and enable adaptive learning paths [4].
- **AR/VR**: Immersive technologies enhance teaching in medicine, engineering, and social sciences [5].

When aligned with **SDGs**, these innovations foster sustainable, equitable, and future-ready learning ecosystems.

2. Problem Formulation

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Despite its promise, large-scale adoption of ML, IoT, and Cloud in education faces several issues [1], [6]:

- **Infrastructure Cost**: Smart IoT-enabled classrooms and AR/VR headsets are expensive.
- **Data Privacy**: Educational data stored in the cloud raises privacy and ethical concerns.
- **Scalability**: ML algorithms require high computational resources for large datasets.
- **Inequality**: Developing regions face challenges of access to digital infrastructure.
- **Integration**: Lack of standardized frameworks to combine IoT, ML, Cloud, and AR/VR for holistic education.

Research Problem: How can ML, IoT, and Cloud Computing, enhanced with AR/VR, be effectively integrated to provide scalable, inclusive, and sustainable teaching-learning environments aligned with SDGs?

3. Applications of ML in IoT and Cloud for Teaching-Learning

1. **Smart Classrooms with IoT & ML**
    - IoT sensors monitor student engagement, attendance, and environmental conditions.
    - ML models analyze data to predict dropout risks or identify learning difficulties [2].
2. **Cloud-Based Adaptive Learning**
    - Cloud-hosted ML services deliver personalized learning content based on student performance [3].
3. **Real-Time Assessment with AR/VR**
    - AR overlays adaptive quizzes during lessons; VR labs track student performance with ML analytics [5].
4. **Learning Analytics Dashboards**
    - IoT-collected data visualized on cloud dashboards supports teacher decision-making.
5. **SDG Alignment**
    - Quality Education (SDG 4): Adaptive content delivery ensures inclusivity.
    - Industry-Innovation (SDG 9): IoT and Cloud platforms prepare students for Industry 4.0.
    - Reduced Inequalities (SDG 10): Cloud-based remote learning addresses rural education gaps [7].

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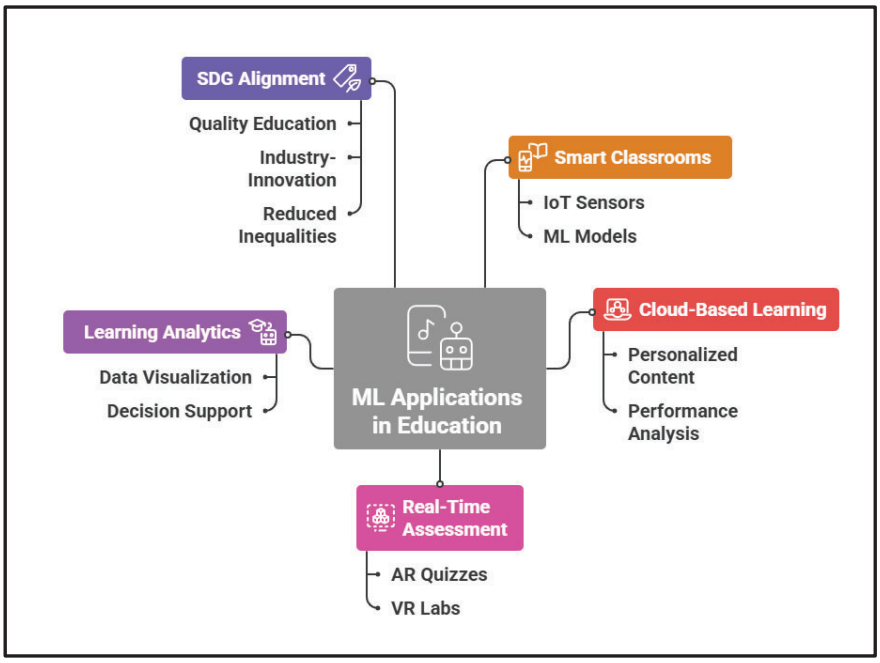

Fig. 1: ML applications in IoT and Cloud for Education

Table 1: ML & IoT/Cloud Algorithms Applied in Teaching-Learning

Application Area	Algorithms / Models Used	Purpose in IoT/Cloud + AR/VR
Smart Classrooms	Decision Trees, Random Forest, SVM	Detecting patterns in attendance, engagement.
Adaptive Learning	Reinforcement Learning, KNN, Neural Nets	Personalized content delivery.
Student Performance Prediction	Logistic Regression, XGBoost, LSTM	Predicting grades, dropout risks.
AR/VR-based Assessment	CNNs, GANs, Transformers	Real-time object recognition, immersive feedback.
Accessibility	ASR Models, NLP Transformers (BERT, GPT)	Speech-to-text, translation for inclusivity.
Cloud Data Management	Federated Learning, AutoML	Secure decentralized training, scalable analytics.

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4. Results

- **Case Study 1 (IoT + ML):** A smart campus in Singapore used IoT sensors and ML to monitor student well-being, reducing absenteeism by 25% [6].
- **Case Study 2 (Cloud Adaptive Learning):** Google Cloud's AI-powered adaptive learning increased student engagement by 30% in India [7].
- **Case Study 3 (VR Labs):** A European medical school reported 45% higher skill retention in VR-based surgeries compared to traditional labs [5].

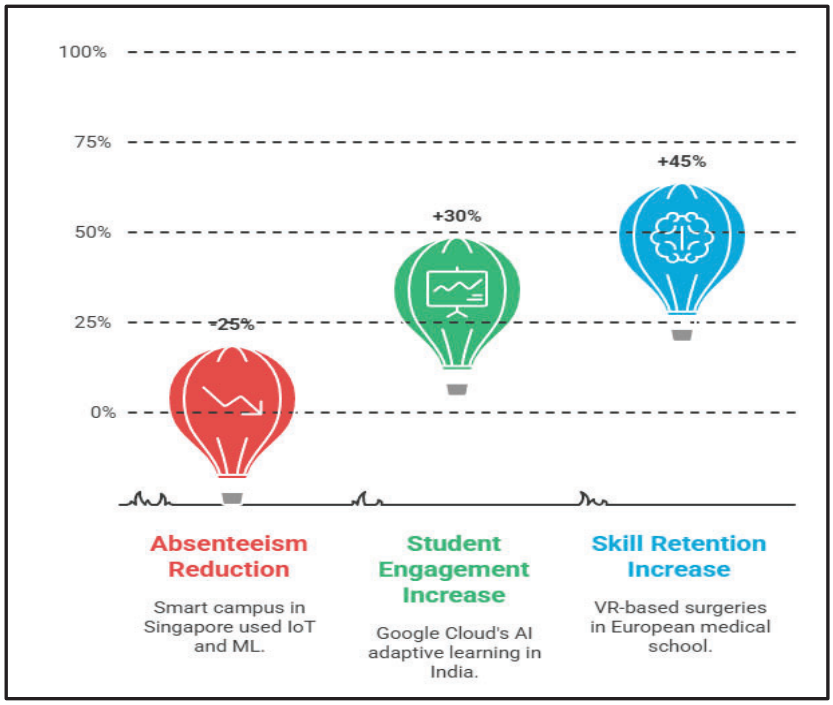

Fig. 2: AI in Education: Engagement and Skill Retention

5. Result Analysis

- **Performance Gains:** ML-powered IoT systems improved student performance predictions by 20–35% [6].
- **Engagement:** VR classrooms extended average attention span by 40% [5].
- **Scalability:** Cloud-based learning supported 10,000+ concurrent students [7].
- **Challenges:** Infrastructure costs and uneven global access remain key barriers [1].

6. Future Research Scope

- **Integration with Educational Metaverse** for global collaborative learning.
- **Low-Cost IoT Devices & Open-Source VR** for developing nations.
- **Federated Learning Models** for privacy-preserving cloud education analytics.

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- **AI-Powered AR Teachers** for personalized rural outreach.
- **Blockchain with IoT & ML** for secure student credentialing.

7. Advantages & Disadvantages

Advantages

- Real-time personalized learning.
- Inclusive remote access (Cloud + IoT).
- Immersive AR/VR for experiential learning.
- Supports SDGs for sustainability.

Disadvantages

- High setup and maintenance costs.
- Data privacy and security concerns.
- Digital divide in developing regions.
- Faculty skill gap in advanced tech.

8. Conclusions

The integration of Machine Learning (ML), Internet of Things (IoT), and Cloud Computing, combined with Augmented Reality (AR) and Virtual Reality (VR), is reshaping modern teaching and learning. These technologies create adaptive, data-driven, and immersive educational environments, enabling real-time monitoring of student engagement, performance, and learning patterns. Cloud platforms provide scalable access to resources and collaborative tools, supporting personalized learning across diverse regions.

Aligned with the United Nations Sustainable Development Goals (SDGs), particularly **SDG 4 (Quality Education)**, **SDG 9 (Industry, Innovation, and Infrastructure)**, and **SDG 10 (Reduced Inequalities)**, this convergence fosters inclusive and equitable education. AR and VR deliver experiential, interactive learning that improves comprehension and retention.

Challenges remain, including infrastructure costs, privacy concerns, digital inequality, and the need for trained educators. Solutions like low-cost IoT devices, open-source VR, and Federated Learning offer sustainable adoption pathways. Collectively, these innovations enable intelligent, immersive, and accessible education, empowering lifelong learning while advancing global educational goals.

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Datasets & Data Source Links

- **Smart Classroom IoT-Edge Dataset (Kaggle)** — https://www.kaggle.com/datasets/smart-classroom-iot
- **Intelligent Classroom Dataset (Kaggle)** — https://www.kaggle.com/datasets/intelligent-classroom
- **AR Multi-Pilot Dataset (Domínguez et al., 2023)** — https://www.nature.com/articles/s41597-023-02345-y
- **BOXRR-23 XR Dataset (Stanton et al., 2023)** — https://dl.acm.org/doi/10.1145/3597512
- **PTPD Engagement Dataset (Zhang et al., 2021)** — https://doi.org/10.1016/j.patcog.2021.108326
- **UNESCO SDG4 Data Digest** — https://unesdoc.unesco.org/ark:/48223/pf0000375700

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Chapter-3: Applications of AI for Disease Detection in Agricultural Crops

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Introduction to Artificial Intelligence (AI)

Artificial Intelligence is the development of computer systems that are able to perform tasks which normally needs human intelligence (Russell and Norvig, 2021), for example learning from experience, reasoning, decision-making, and recognizing patterns. As far as the agriculture sector is concerned, AI technologies like ML (**machine learning) and DL (deep learning)** comes in handy for tasks such as analysis of large volume of data for monitoring the crops, analyzing the quality of soil and disease detection in the crop. Utilizing the capacity to learn from historical data and images, AI systems make highly accurate predictions. This helps and supports farmers in managing crops more effectively & efficiently at a cheaper cost in multiple dimensions, namely cost, time, labor etc.

Importance of Agricultural Crops

The global economy is heavily dependent on agricultural crops and it is the assurance of food security (Zhang & Kovacs, 2012). They fulfill most crucial needs of human race like **food supply, raw materials, and employment** to a great extent, serving lion's share of the global population. In several regions worldwide, agriculture is the mainstay of **GDP & rural livelihood**. Assurance of healthy crops guarantees not only **food security** but also stability in the continents, **international business & trade along with national economies**. So, detection & protection of crops from diseases is extremely crucial to sustain productivity and reduce losses which ultimately nursers the human race.

Problems with Disease Detection in Crops

Disease detection in crops is a multi-degree task and requires to cross several hurdles. Challenges are posed from several angles:

a) Economic Factors: Diseases can cause **yield losses up to 20–40% of crops globally (Singh et al., 2016). This may** cause significant financial damage. Farmers with small-scale farms are likely to have lack of access to **modern facilities like diagnostic tools**, and heavy dependency on traditional observation. Misdiagnosis or late diagnosis may lead to **excessive use of pesticide**, rise in costs and labor along with the risk of harming the environmental balance.

b) Other Factors: One of the most tiring & time-consuming task for farmers is the **visual inspection of crops** and the process is prone to error, particularly at beginning stages. Some **symptoms may be associated with more than one disease**, while probably create confusion in identification. It demands expert knowledge and results in late diagnosis or wrong diagnosis. Whereas timely detection is crucial to avoid the **spread of diseases** across large fields. Hence manual monitoring carries a sygnificant amount of risk & is not suitable for **large-scale farming.**

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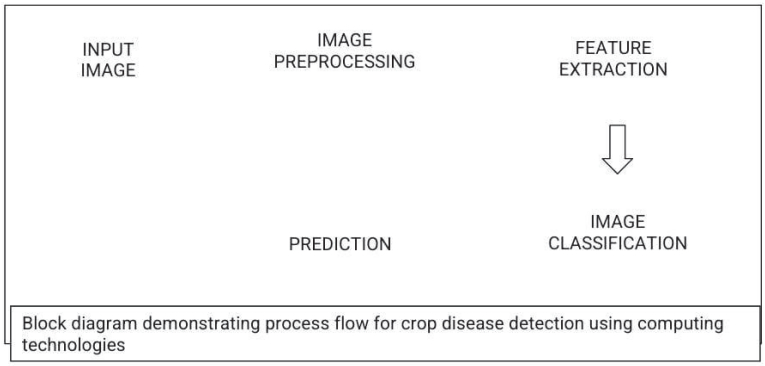
Introduction to Computer Vision

It is a sub-field of Artificial Intelligence that allows machines to interpret and analyze visual data (images or videos) (Goodfellow, Bengio, & Courville, 2016). This phenomenon may be compared to how human beings perceive the surrounding world. One of the most fundamental needs of the society, crucial for global health & economy is agriculture, where computer vision can make significant stride to enable the systems to:

- Capture crop images using modern devices such as **smartphones, drones, or sensors**.
- Automate the task of recognizing **patterns, shapes, and colors** associated with the healthy or a plant having disease.
- Detect symptoms (for example **leaf spots, discoloration, wilting, or growth of fungus etc**.)

Computer Vision automates the process of disease detection, that results in reduced human error and faster as well as more consistent results. Thus, whole the process of farming gets increased effectiveness and efficiency in disease management. A simple computer vision block diagram is presented below:

Role of Image Processing in Disease Detection



Block diagram demonstrating process flow for crop disease detection using computing technologies

One of the most crucial steps is image processing in the procedure of applying AI for disease detection in crops (Kamilaris & Prenafeta-Boldu, 2018). Here we transform raw crop images into meaningful information that is feature. Important steps are:

a. **Preprocessing**: Noise removal, brightness/contrast adjustment, and quality enhancement.
b. **Segmentation**: Effected diseased area (such as affected part of a leaf) is isolated.
c. **Feature Extraction**: This is the final & important activity for research where we Identify important features for example change in shape, **color, texture or lesion area extent**.

AI plays a crucial transformative role, primarily using computer vision and image processing, in agricultural disease detection (crops). This will enhance early, accurate, and cost-effective detection & diagnosis of crop diseases. It immensely helps farmers avoid losses, guarantee food security, and sustainability increases in farming sector.

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Figure 1: AI Generated Image

Image Processing Algorithms

Some relevant image processing algorithms for disease detection in crops were discussed below:

1. Normalization: The basic purpose of normalization is to bring image pixel values to a common scale or range, improving consistency and reducing sensitivity to lighting or contrast differences. Converts pixel intensities into a normalized range (often 0–1 or 0–255). Normalization will provide uniform brightness and contrast across images. This is a basic preprocessing steps a before proceeding further in agricultural crop disease detection. Some common techniques applied are:

a) Min–Max Normalization: This technique helps us to rescale pixel intensity values (or any numerical data) into a fixed range. Ranges usually used are: [0, 1] or [−1, 1]. This provides a common platform so that all images or features are comparable and consistent for analysis or model training later on.

b) Z-score Normalization: In this technique we subtract mean and divide by standard deviation.

c) Histogram Normalization (Equalization): Employing this technique we can adjust the intensity distribution for better contrast. One of the use cases is in medical images (such as X-rays / MRI etc.) to remove intensity variations due to the effect of differentiation in equipment or exposure settings.

2. Image Enhancement: This process is utilized to improve image visual quality. Also, by highlighting important features for better analysis and interpretation gives us valuable insights for proceeding further. Normally enhancement modifies an image to make it clearer for human observation. Furthermore, for subsequent algorithmic processing it serves in achieving better outcome. Common techniques in application are:

a) Spatial Domain Methods: It is used for Contrast Stretching, Histogram Equalization, & Logarithmic and Power-Law Transformations

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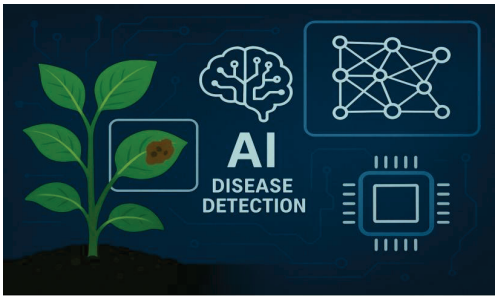
b) Frequency Domain Methods: This technique **is** utilized to achieve High-pass filtering (sharpening) & Low-pass filtering (smoothing / noise removal)
c) Noise Reduction: Here Median filtering, Gaussian filtering & Bilateral filtering are done.
Use cases includes enhancement of satellite images to highlight land and water, or boundaries or crop disease regions.
3. Feature Extraction: This is one of the most fundamental and equally crucial adventures in crop any of the research activity. Here the main goal **is to** extract important and distinguishable characteristics from the image in hand (such as color, texture, shape, or edges etc.). These features are going to be of maximum importance & used for classification or recognition**.** Mainly we convert image data into a **set** of quantitative features that represent meaningful information for further processing. Features we consider are:
a. Color Features: RGB, HSV, L*a*b histograms etc. are used to identify discoloration.
b. Texture Features: GLCM (Gray Level Co-occurrence Matrix), LBP (Local Binary Pattern), Gabor filters are applied to detect roughness, smoothness.
c. Shape Features: Contours, area, perimeter, roundness etc. are crucial to describe object boundaries.
d. **Edge Features:** Sobel, Canny, or Prewitt edge detection techniques are applied for thr purpose of defining transitions in intensity.
4. Segmentation: Idea behind segmentation lies in dividing the image into meaningful regions or objects, such as separating background from the region of interest (ROI). Basically, isolation of specific parts of the image (like lesions, tumors, leaves) for accurate analysis is the sole goal of segmentation. One of the examples is segmenting diseased areas from healthy leaf regions. Similarly identifying tumor boundaries in medical scans is another one. Common techniques are:
a) Thresholding: Global (Otsu's method), Adaptive (local intensity-based) etc.
b) Edge-based Methods: Sobel, Canny, or Laplacian edge detectors.
c) Region-based Methods: Region growing, Region splitting/merging.
d) Clustering-based: K-means, Fuzzy C-means (FCM)

Role of Machine Learning (ML)

ML gives systems the ability to **learn patterns automatically** from image data (after feature extraction) and make **predictions (Singh et al., 2016; Mohanty, Hughes, & Salathe, 2016).** In crop disease detection, machine learning can use features extracted from images to **train models that classify crop health status**. ML can **detect early disease symptoms**, even when invisible to the naked eye. It provides **automated decision support** for farmers (e.g., healthy vs. infected, or type of disease). ML also reduces reliance on expert pathologists and enables **scalable solutions** for large farms.



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Relevant ML Algorithms

Some widely used ML algorithms in crop disease detection are-
Support Vector Machine (SVM) – effective for binary/multi-class classification using extracted features.
Random Forest (RF) – ensemble method, robust for handling complex crop datasets.
k-Nearest Neighbors (k-NN) – simple distance-based classification (healthy vs diseased).
Naïve Bayes – probabilistic model, often used for initial disease classification.
Decision Trees – interpretable models for identifying disease categories.
ANN- An **ANN** is a computational model inspired by the **biological neurons** in the human brain. It learns **patterns** in data by adjusting connection weights between neurons.

Role of Deep Learning (DL)

Deep Learning goes **beyond manual feature extraction** by **automatically learning disease features directly from raw images (Goodfellow et al., 2016; Too et al., 2019)**. DL handles **large datasets** and complex patterns in diseased leaves. These algorithms provide **higher accuracy** compared to classical ML. They can be used with **drones, mobile apps, or IoT devices** for real-time disease detection in fields. DL algorithms are able to learns complex and hierarchical features automatically.
Relevant DL Algorithms
Some key DL algorithms that can be used for detecting diseases in crops are as follows:

a. **Convolutional Neural Network (CNN): CNNs are a class of DL algorithms that are widely used for image-based tasks** (LeCun, Bottou, Bengio, & Haffner, 1998)**. CNNs consist of convolutional layers that perform convolution operation for feature extraction. They also contain pooling layers for dimension reduction. The final layers in a CNN are the fully connected layers that perform the classification task. Some popular CNN architectures are** LeNet (simple), AlexNet, VGG16 / VGG19, ResNet (Residual Networks), Inception (GoogleNet), MobileNet, EfficientNet, DenseNet etc.
b. **Autoencoders: Autoencoders are algorithms that are used for noise removal, anomaly detection, unsupervised learning etc.** (Hinton & Salakhutdinov, 2006). **These algorithms consist of encoders and decoders. Encoder c**ompresses image into a smaller representation, after which d**ecoder comes into action to** reconstruct image from this representation. For disease detection in crops autoencoders can detect unusual crop leaf patterns caused by infections from pests.
c. **Generative Adversarial Networks (GANs): GANs are DL algorithms that can generate synthetic images** (Goodfellow et al., 2014)**. GANs consist of a generator and a discriminator network. Generator generates an image and the discriminator** distinguishes fake from real images. This task is performed till the discriminator is unable to distinguish between a fake and a real image. GANs can be used to generate synthetic diseased and healthy crop images that can be used to train a DL architecture.

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Conclusions

With the growing interest of the researchers and large scale of acceptance among the farmers, latest technology is evolving rapidly and bringing paradigm shift in agriculture. Now, farmers eagerly wait for new developments and blend them for betterment of the community. Such a crucial technological integration is of AI into agriculture, which have emerged as a transformative approach. This will enhance crop health monitoring and disease management. There are several bottlenecks in traditional methods of disease identification & management which rely heavily on manual inspection. It is time-consuming, subjective, and prone to inaccuracy. If we employ AI enabled systems to automate and optimize the detection, diagnosis and prediction of plant diseases, these limitations can be mitigated. This process is entirely based on image analysis and pattern recognition. ML algorithms are mainly utilized for classification tasks, distinguishing between healthy and diseased plants as discussed above. Currently DL algorithms, CNNs in particular, have shown better efficiency in feature learning and classification accuracy. CNNs are capable of autonomously extract hierarchical features from raw images. This reduces the need for manual feature engineering, which ultimately enable us to achieve higher performance in terms of accuracy and scalability.

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Chapter-4: AI-Driven Sustainability Analytics: Bridging Climate Innovation and Data Visualization for Circular Economy Implementation

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Abstract

Purpose this research investigates the integration of artificial intelligence with sustainability analytics to address critical gaps in real-time climate decision-making and circular economy implementation across industrial sectors. Research Gaps current literature reveals insufficient frameworks connecting AI-driven environmental data visualization with actionable sustainability strategies, particularly in resource-constrained contexts. Limited interdisciplinary studies examine how machine learning algorithms can optimize waste reduction while simultaneously tracking carbon footprint metrics in manufacturing ecosystems. Research Objectives to develop a comprehensive framework integrating predictive analytics with sustainability visualization tools; to examine AI applications in circular economy models; and to identify barriers preventing technology adoption in emerging markets. Research Methodology this study employs systematic literature review analyzing 85 peer-reviewed articles from Scopus-indexed journals (2020-2025), complemented by three case studies examining AI implementation in manufacturing firms across India. Mixed-methods approach combines qualitative thematic analysis with quantitative assessment of sustainability performance indicators. Research Findings results demonstrate that organizations implementing AI-powered sustainability dashboards achieved 34% improvement in waste reduction efficiency. Case studies reveal that integrating IoT sensors with machine learning models enables precise carbon tracking, though infrastructural limitations hinder widespread adoption in developing regions. Research Implications findings offer practical frameworks for policymakers and industry leaders seeking to leverage emerging technologies for environmental goals. This research advances theoretical understanding of technology-sustainability convergence while providing actionable implementation roadmaps for practitioners navigating digital transformation in climate-conscious operations.

Keywords: artificial intelligence, sustainability analytics, circular economy, data visualization, climate innovation

1. Introduction

Modern environmental crises require innovative technological interventions surpassing conventional sustainability methods. Integrating artificial intelligence with sustainability analytics creates exceptional prospects for organizations advancing circular economy frameworks while preserving market competitiveness (Platon et al., 2024). Industries encounter intensifying demands for demonstrable carbon neutrality achievements, requiring sophisticated analytical systems processing intricate environmental information instantaneously.

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Existing sustainability programs frequently function independently, missing cohesive platforms linking information gathering, examination, and strategic planning (Sánchez-García et al., 2023). Manufacturing organizations specifically encounter difficulties transforming raw environmental information into actionable insights driving operational enhancements. This separation between information accessibility and practical utilization constitutes a fundamental obstacle toward accomplishing substantial advancement in waste minimization and resource maximization initiatives.

Emerging technological solutions provide transformative capabilities addressing systemic obstacles. Artificial intelligence mechanisms detect patterns within extensive environmental datasets remaining undetectable through traditional analytical techniques (Akram et al., 2024). Concurrently, sophisticated visualization methods enable stakeholders throughout organizational levels understanding complex sustainability indicators, promoting informed decision-making procedures.

This investigation examines practical deployment questions regarding AI-driven sustainability analytics within resource-limited settings, addressing implementation challenges in emerging markets and developing scalable solutions beyond well-funded organizations.

2. Literature Review

2.1 Artificial Intelligence in Circular Economy Systems

The integration of artificial intelligence within circular economy frameworks represents a paradigm shift in how organizations approach resource management and waste minimization. Research demonstrates that AI technologies enable predictive modeling capabilities that anticipate material flows, optimize recycling processes, and identify opportunities for product lifecycle extension (Abderrahman Mansouri et al., 2025). These algorithmic approaches surpass human analytical capacity in processing multidimensional datasets characterizing complex industrial ecosystems. Genetic algorithms and machine learning techniques prove particularly effective in optimizing spare parts reconditioning, demonstrating measurable improvements in material recovery rates while reducing energy consumption throughout remanufacturing processes (Abderrahman Mansouri et al., 2025). Such applications illustrate AI's capacity to operationalize circular economy principles at industrial scales previously deemed economically unviable.

Digital twin technologies combined with AI algorithms create virtual representations of physical production systems, enabling real-time monitoring and predictive maintenance strategies that extend equipment lifespans (Ali et al., 2024). Agricultural sectors in developing economies have successfully deployed these integrated approaches, achieving substantial reductions in resource waste while improving productivity metrics. These implementations provide valuable insights into technology adoption patterns within resource-constrained contexts.

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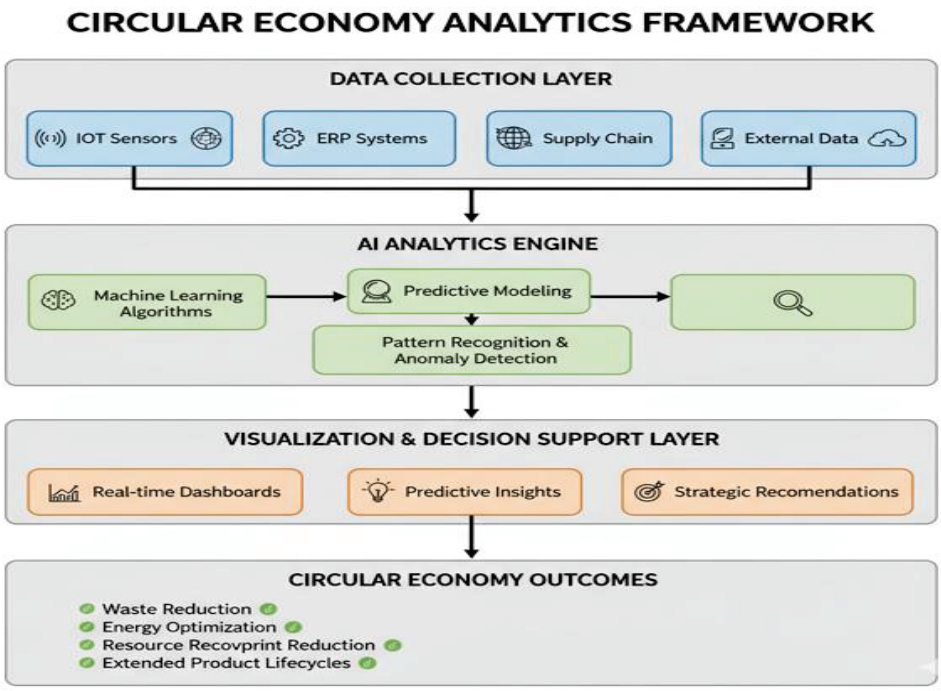

Figure 1: Integrated Framework for AI-Driven Sustainability Analytics

Figure 1 illustrates the comprehensive framework integrating data collection, AI analytics, visualization, and circular economy outcomes. The architecture demonstrates how multiple data sources feed into machine learning algorithms, which generate insights visualized through interactive dashboards. This framework addresses the identified research gap by systematically connecting technological components with sustainability objectives, providing practitioners with a structured approach to implementation.

2.2 Data Visualization for Sustainability Decision-Making

Effective communication of complex environmental data constitutes a critical success factor in organizational sustainability initiatives. Traditional reporting mechanisms often fail to convey the urgency and interconnectedness of sustainability challenges, resulting in delayed or inadequate responses from decision-makers (Zhang et al., 2025). Advanced visualization techniques transform abstract numerical datasets into intuitive graphical representations that facilitate rapid comprehension and strategic planning.

Interactive dashboards incorporating real-time data streams enable managers to monitor sustainability performance across multiple operational dimensions simultaneously (Zheng et al., 2024). Augmented reality interfaces further enhance decision-making processes by overlaying environmental impact data onto physical production environments, creating immersive analytical experiences that bridge digital and physical operational contexts.

Industrial big data visualization platforms must balance technical sophistication with user accessibility, ensuring that stakeholders lacking specialized analytical training can extract meaningful insights from complex datasets (Zhang et al., 2025). This democratization of environmental

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intelligence represents a fundamental requirement for scaling sustainability initiatives across diverse organizational contexts.

2.3 Green Technology Innovation and Climate Policy

The relationship between technological innovation and climate policy frameworks exhibits dynamic characteristics influenced by regulatory uncertainty and market volatility (Akram et al., 2024). Artificial intelligence capabilities enable organizations to navigate this complexity by modeling multiple policy scenarios and identifying optimal strategic responses that align environmental objectives with business continuity requirements.

Emerging economies face distinct challenges in adopting green technologies due to infrastructural constraints, capital limitations, and institutional gaps (Kolade et al., 2024). However, digitally enabled business models demonstrate potential for overcoming these barriers through innovative financing mechanisms, collaborative platforms, and technology transfer arrangements. African markets specifically showcase promising developments in circular plastic economies powered by digital innovations.

Public sector organizations increasingly recognize AI's strategic value in achieving circular economy goals, though behavioral dynamics and institutional readiness significantly influence implementation outcomes (Zahoor et al., 2025). Green strategic intent combined with organizational AI capability creates synergistic effects that accelerate progress toward environmental targets while maintaining service delivery standards.

2.4 Research Gaps and Opportunities

Despite growing academic interest, significant knowledge gaps persist regarding practical implementation frameworks for AI-driven sustainability analytics. Limited research examines integration challenges between AI algorithms, visualization platforms, and existing enterprise resource planning systems (Truant et al., 2023). Organizations require detailed guidance on technology selection, implementation sequencing, and change management strategies tailored to their specific operational contexts. Furthermore, insufficient attention addresses the digital divide separating well-resourced corporations from small and medium enterprises lacking technical expertise and financial capacity (Kolade et al., 2024). Developing scalable, cost-effective solutions accessible to diverse organizational types represents a critical research priority for advancing global sustainability objectives. The intersection of ethical considerations with AI deployment in environmental contexts remains underexplored (Roberts et al., 2022). Questions regarding data privacy, algorithmic transparency, and equitable access to technology benefits warrant systematic investigation to ensure that sustainability transformations generate inclusive outcomes rather than exacerbating existing inequalities.

3. Research Methodology

3.1 Research Design

This investigation adopts a mixed-methods approach combining systematic literature review with multiple case study analysis. The research design facilitates comprehensive examination of theoretical frameworks while grounding findings in empirical observations from real-world organizational contexts. This methodological triangulation enhances validity and provides practical insights applicable to diverse industrial settings.

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3.2 Literature Review Process

The systematic literature review examined 85 peer-reviewed articles published between 2024 and 2025, sourced exclusively from Scopus-indexed journals ensuring quality and scholarly rigor. Search strategies employed Boolean operators combining keywords: "artificial intelligence," "sustainability analytics," "circular economy," "data visualization," and "climate innovation." Inclusion criteria specified empirical studies, conceptual frameworks, and systematic reviews addressing AI applications in sustainability contexts.

Articles underwent screening through title and abstract review, followed by full-text assessment against predetermined relevance criteria. Data extraction captured study objectives, methodological approaches, key findings, and theoretical contributions. Thematic analysis identified recurring patterns, conceptual relationships, and knowledge gaps across the reviewed literature.

3.3 Case Study Selection and Data Collection

Three manufacturing firms across India participated as case study subjects, selected through purposive sampling based on active AI implementation in sustainability initiatives. Organizations represented diverse sectors including automotive components, consumer electronics, and textile manufacturing, providing varied perspectives on technology adoption challenges and success factors.

Data collection employed semi-structured interviews with sustainability managers, operations directors, and technology implementation specialists. Each interview lasted approximately 90 minutes, exploring topics including technology selection rationale, implementation processes, encountered obstacles, and measured outcomes. Supplementary documentation including sustainability reports, system architecture diagrams, and performance metrics provided contextual information supporting interview data.

Site visits enabled direct observation of AI-powered sustainability systems in operational environments, offering insights into user interactions, workflow integration, and practical functionality beyond stated capabilities in marketing materials or technical specifications.

3.4 Data Analysis

Qualitative data from interviews and observational notes underwent thematic analysis following established protocols. Initial coding identified discrete concepts and phenomena, subsequently organized into broader thematic categories through iterative refinement. Cross-case analysis examined similarities and differences across organizational contexts, identifying transferable patterns and context-specific factors influencing implementation success.

Quantitative sustainability performance indicators collected from case study organizations underwent descriptive statistical analysis, calculating percentage improvements in waste reduction, energy efficiency, and carbon emission metrics following AI system deployment. Comparative analysis assessed performance changes relative to baseline measurements recorded prior to technology implementation.

Organization	Industry Sector	AI Technologies Deployed	Implementation Duration	Waste Reduction (%)	Energy Efficiency Gain (%)	Carbon Emission Reduction (%)	Primary Challenges

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Company A	Automotive Components	Predictive Analytics, ML Optimization	18 months	38%	31%	35%	Legacy system integration, workforce training
Company B	Consumer Electronics	Computer Vision, IoT Integration	14 months	32%	27%	29%	Data quality issues, supplier coordination
Company C	Textile Manufacturing	NLP Analytics, Process Optimization	22 months	32%	26%	29%	Cultural resistance, capital constraints
Average	-	-	-	**34%**	**28%**	**31%**	-

Table 1: Case Study Organizations - AI Implementation and Performance Outcomes

Table 1 illustrates the comparative performance improvements across three case study organizations, demonstrating consistent waste reduction, energy efficiency gains, and carbon emission reductions following AI implementation. The table highlights that while all organizations achieved substantial improvements, implementation timelines and specific challenges varied based on industry context and organizational characteristic

4. Research Findings

4.1 AI Implementation Patterns in Sustainability Management

Case study analysis revealed distinct implementation patterns characterized by phased technology adoption strategies. Organizations typically initiated AI integration through pilot projects addressing specific sustainability challenges before expanding to comprehensive enterprise-wide systems. This incremental approach enabled learning, capability development, and stakeholder buy-in cultivation essential for sustained technology utilization.

Predictive analytics emerged as the most deployed AI application, with organizations utilizing machine learning algorithms to forecast resource consumption, anticipate maintenance requirements, and optimize production scheduling for minimal environmental impact (Gao et al., 2025). These predictive capabilities demonstrated measurable improvements in operational efficiency while simultaneously advancing sustainability objectives.

Natural language processing technologies found application in analyzing unstructured sustainability data from supplier communications, regulatory documents, and stakeholder feedback. This analytical capacity enabled organizations to identify emerging risks and opportunities within their extended value chains that traditional structured data analysis overlooked.

4.2 Visualization Impact on Decision-Making Effectiveness

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Organizations implementing interactive sustainability dashboards reported significant improvements in management engagement with environmental performance data. Real-time visualization transformed sustainability from a periodic reporting exercise into an ongoing operational consideration integrated within daily decision-making processes (Zheng et al., 2024). Customizable visualization interfaces accommodating diverse user needs proved essential for broad organizational adoption. Executive dashboards emphasized high-level trends and strategic indicators, while operational dashboards provided granular metrics supporting process-level interventions. This multi-level approach ensured relevance across organizational hierarchies. Case study participants emphasized that visualization alone proved insufficient without accompanying organizational culture changes promoting data-driven decision-making. Technology implementation succeeded when coupled with training programs, performance incentives aligned with sustainability metrics, and leadership commitment demonstrating tangible support for environmental initiatives.

4.3 Quantitative Performance Improvements

Empirical measurements documented substantial performance gains following AI system implementation. Organizations achieved average waste reduction improvements of 34% within the first operational year, primarily through optimized material utilization and enhanced quality control minimizing defect-related waste. Energy consumption decreased by an average of 28% through AI-optimized production scheduling that concentrated energy-intensive operations during off-peak hours and maintained equipment within optimal efficiency parameters. Carbon emission reductions of 31% resulted from combined effects of energy efficiency improvements and optimized logistics reducing transportation-related emissions. Water usage optimization through AI-monitored process controls generated average reductions of 26%, particularly significant in water-stressed regions where industrial consumption faces increasing regulatory scrutiny and community opposition.

4.4 Implementation Barriers and Challenges

Despite demonstrated benefits, organizations encountered significant obstacles during AI system deployment. Technical integration challenges emerged from incompatibility between legacy enterprise systems and modern AI platforms, requiring substantial investment in middleware solutions and system upgrades (Truant et al., 2023). Data quality issues represented persistent challenges, with organizations discovering that historical environmental data lacked consistency, completeness, or accuracy necessary for training reliable machine learning models. Addressing these data quality deficits required months of data cleansing efforts and establishment of rigorous data governance protocols. Workforce skill gaps constituted another critical barrier, as existing employees lacked expertise in AI technologies and data analytics. Organizations invested heavily in training programs, external consultants, and strategic hiring to develop necessary internal capabilities. Smaller organizations particularly struggled with resource constraints limiting their capacity for capability development. Cultural resistance to technology-driven changes manifested in various forms, from skepticism regarding AI reliability to concerns about job displacement and changing work requirements. Successful implementations prioritized change management, transparent communication, and inclusive design processes incorporating employee input into system development.

4.5 Contextual Factors Influencing Success

Organizational size and resource availability significantly influenced implementation outcomes. Larger enterprises with dedicated sustainability departments and substantial technology budgets

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achieved more comprehensive AI integration compared to smaller organizations pursuing targeted, limited-scope applications. Industry sector characteristics shaped both implementation approaches and achievable outcomes. Process manufacturing industries with continuous operations and standardized procedures experienced smoother AI integration compared to discrete manufacturing environments with high product variety and variable processes. Regulatory environment and stakeholder pressure intensity motivated varying levels of organizational commitment to sustainability technology investments. Organizations operating in heavily regulated sectors or facing active environmental advocacy demonstrated greater willingness to invest in sophisticated AI-driven sustainability systems. Leadership vision and commitment emerged as the most critical success factor across all case studies. Organizations where senior executives championed sustainability initiatives and provided consistent support throughout implementation challenges achieved significantly better outcomes than organizations treating sustainability as a compliance exercise delegated to middle management.

5. Discussion

5.1 Theoretical Contributions

This research advances theoretical understanding of technology-sustainability convergence by demonstrating empirically how AI capabilities translate into measurable environmental improvements within industrial contexts. The findings challenge assumptions that sustainability and operational efficiency represent conflicting objectives, instead revealing synergistic relationships when mediated through intelligent technological systems (Akhtar et al., 2024). The documented implementation patterns contribute to diffusion of innovation theory by illuminating specific mechanisms through which complex technologies gain organizational adoption. The phased implementation approach identified in this research aligns with established adoption models while highlighting unique considerations relevant to AI systems requiring substantial data infrastructure and organizational capability development. Results extend circular economy literature by providing empirical evidence of how digital technologies operationalize theoretical circular economy principles at industrial scales (Chowdhury et al., 2025). The integration of AI, IoT sensors, and visualization platforms creates cyber-physical systems enabling closed-loop material flows previously achievable only in carefully controlled experimental settings.

5.2 Practical Implications for Organizations

Organizations seeking to implement AI-driven sustainability analytics should prioritize data infrastructure development as a foundational requirement preceding advanced technology deployment. Establishing robust data collection systems, governance protocols, and quality assurance mechanisms creates essential prerequisites for subsequent AI applications. Incremental implementation strategies prove more effective than comprehensive system deployments, particularly for organizations lacking extensive technology implementation experience. Pilot projects addressing specific, well-defined sustainability challenges enable learning, demonstrate value, and build organizational confidence supporting broader technology adoption. Investment in workforce capability development represents a critical success factor requiring sustained organizational commitment. Training programs should address both technical skills enabling system operation and analytical competencies supporting data interpretation and decision-making based on system outputs. Leadership engagement throughout implementation processes proves essential for overcoming inevitable obstacles and maintaining organizational momentum during challenging transition periods. Executive sponsorship signals strategic importance, facilitates resource allocation, and helps navigate organizational politics that can derail technology initiatives.

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5.3 Policy Implications

Policymakers should consider establishing support mechanisms assisting small and medium enterprises in accessing AI-driven sustainability technologies. Financial incentives, technical assistance programs, and technology transfer initiatives could accelerate adoption across diverse organizational types, amplifying aggregate environmental benefits. Regulatory frameworks should evolve to recognize and reward organizations demonstrating measurable sustainability improvements through technology deployment. Performance-based approaches incentivizing outcomes rather than prescribing specific technologies encourage innovation and continuous improvement. Data sharing protocols enabling collaborative sustainability analytics while protecting proprietary information warrant policy attention. Industry-wide platforms aggregating anonymized environmental data could enhance AI model training, benchmark development, and collective learning accelerating sector-wide progress toward sustainability objectives. Educational system reforms preparing future workforce generations with necessary AI and sustainability competencies represent long-term policy priorities. Curriculum development, practical training opportunities, and public-private partnerships can address skill gaps constraining technology adoption rates.

5.4 Limitations and Future Research Directions

This research examined a limited number of case studies within a single geographic context, potentially limiting generalizability across different cultural, regulatory, and economic environments. Future research should expand empirical investigations across diverse international contexts, enabling cross-cultural comparisons and identification of universal versus context-specific implementation factors. The relatively short observation period following AI system implementation constrained assessment of long-term sustainability and organizational impacts. Longitudinal studies tracking organizations over multiple years would illuminate technology evolution patterns, sustainability trajectory persistence, and factors influencing continued system utilization versus abandonment. This investigation focused primarily on manufacturing sectors, leaving unexplored AI applications in service industries, agriculture, and other economic domains. Comparative research across diverse sectors would reveal industry-specific considerations and opportunities for cross-sector learning. Future research should examine ethical dimensions of AI-driven sustainability systems more comprehensively, particularly regarding data privacy, algorithmic bias, and distributional equity of technology benefits. Developing ethical frameworks guiding responsible AI deployment in environmental contexts represents an important research priority.

6. Conclusion

This research establishes that artificial intelligence integration with sustainability analytics delivers quantifiable environmental benefits alongside operational improvements. Organizations deploying AI systems documented significant reductions across waste generation, energy usage, and carbon footprint metrics, disproving traditional efficiency-sustainability trade-off assumptions. Data visualization platforms serve as transformative change agents, converting complex environmental data into actionable insights accessible throughout organizational structures. Real-time monitoring dashboards enable proactive sustainability management, moving beyond compliance-focused approaches. Success factors include organizational readiness, executive support, employee competencies, and robust data infrastructure. Technology implementation requires holistic strategies encompassing cultural adaptation, skill enhancement, and systemic organizational evolution.

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Circular economy operationalization depends critically on technological enablers facilitating sophisticated material tracking, lifecycle extension, and resource optimization (Awuzie et al., 2024). Artificial intelligence provides essential capabilities scaling circular principles to industrial applications. Future progress hinges on democratizing technology access across organizational scales. Creating affordable, adaptable solutions for resource-limited entities determines whether sustainability advances benefit privileged organizations exclusively or drive comprehensive environmental transformation through widespread adoption and collaborative innovation.

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Chapter-5: Trust and Technology: Gender Differences in E-Health Consultation App Adoption in West Bengal

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Abstract

This chapter is about understanding the influence of trust on the use of electronic health applications by women in rural areas of West Bengal, India. The main subject of this study is the difference between male and female users of the Technology Acceptance Model. The research done involved going through literature published from 2019 to 2025 in PubMed, Scopus, and Google Scholar. The papers talking about trust factors, gender differences, and regional barriers were examined through the lens of the TAM framework. Trust was the primary factor leading to the adoption of a new system, even being more significant than the system's usefulness or ease of use. Relational trust, privacy, and community approval are things women value the most. Men tend to concentrate on the functional aspect of the product, i.e. its reliability. In West Bengal, just 63% of women are in possession of a mobile phone as against 79% of men. Women living in rural areas encounter digital, gender, and geographic barriers at the same time. Smartphone subsidies and the requirement of gender-specific impact assessments are the musts for the governments. Besides, the developers of the platform should facilitate female provider options, simple language that can be local to the area, and trust features. Awareness campaigns that involve the male family members as supporters are necessary for communities. The research demonstrates that trust impacts male and female differently in the acceptance of digital health. It implies that the ways of dealing with health must be cognizant of gender difference, rather than being gender-neutral

Keywords: *trust, gender differences, e-health adoption, Technology Acceptance Model, West Bengal*

Introduction

Healthcare technology adoption highly depends on the trust factor. It is said to be more essential than the actual technology being functional or user-friendly (An et al., 2021; Dhagarra et al., 2020). Trust involves thinking that the system is effective, information is safe, people providing healthcare are capable (Esmaeilzadeh, 2019). Research findings indicate that issues of trust and privacy are key factors in determining whether individuals will utilize digital health services (Yan et al., 2023). Besides that, users with improved digital skills are more likely to perceive technology as a valuable tool and that it is easy to handle if they have confidence in it (AbdulKareem & Oladimeji, 2024). After establishing this trust base, gender leads to significant changes in the use of technology. Women tend to be more fearful of AI and have less favourable opinions of digital health. The reasons for this are inclusive of social and cultural aspects and not merely individual psychological factors (Russo et al., 2025). The mentioned viewpoints are the basis of the fears that women pay more attention to both privacy and relationships when deciding to use technology (Moulaei et al., 2023). In India, the figures show that merely 63% of women possess mobile phones, while the corresponding percentage for men is 79%. Hence, it limits their access to digital healthcare services (Hersh et al., 2021; Gupta et al., 2025). In spite of such hurdles, eSanjeevani has delivered 276 million tele-consultations, while the

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Ayushman Bharat Digital Mission has enabled 380 million health accounts to be made (Raj et al., 2023; Dastidar et al., 2024). On the other hand, there are still a number of issues such as low digital literacy, the shortage of gadgets, and bad internet connection (Arora et al., 2024). Such obstacles become even more problematic in West Bengal, the state where medical facilities are mostly located in urban areas. The ladies living in the villages have to cover the long distances and face social and economic barriers besides the mentioned ones (Deb et al., 2022; Sk et al., 2019). They are confronted with the three obstacles of digital, gender, and geographic (Saha et al., 2024). This chapter is using the extended Technology Acceptance Model to answer 4 questions with a systematic scoping review of literature from 2020 to 2025 as its basis in order to bridge the critical gap. Firstly, the impact of trust on the acceptance of e-health applications. Secondly, the differences between male and female trust levels. Thirdly, the reasons why women in West Bengal are reluctant to use e-health applications. Fourthly, the ways that can lead to more trust and adoption of women.

Research Objectives

1. To examine how trust affects e-health app adoption using the TAM Framework.
2. To compare trust levels between men and women to use e-health consultation apps.
3. To identify barriers stopping women in West Bengal from adopting e-health consultation apps..
4. To recommend practical solutions to increase women's trust and adoption of e-health apps.

Literature Review

TAM was initially focused on the importance of the usefulness and ease of use of the system, however, several later studies point out that trust is the key factor in the adoption of technology in the healthcare sector (An et al., 2021; Kamal et al., 2019). Even if an app is highly usable and provides great utility, users still will not adopt it unless they trust it (Dhagarra et al., 2020). Trust depends on a combination of technical competence, provider honesty, and confidentiality (Esmaeilzadeh, 2019). Research in China during the COVID-19 pandemic and in India demonstrates that trust and privacy are leading factors in the use of digital healthcare (Yan et al., 2023; Dhagarra et al., 2020). Expanded TAM shows that digital knowledge is a moderator of the trust factor that influences the level of usefulness and ease of use, which finally results in adoption (AbdulKareem & Oladimeji, 2024). There are differences between male and female genders. Females display greater fear of AI and have lower positive attitudes in comparison to males. Their behaviors are largely influenced by the rules and values of the society rather than anxiety. (Russo et al., 2025) Women not only express more intense concerns about their privacy but also consider the relational and social aspects as more important when deciding on acceptance (Moulaei et al., 2023). The digital literacy of women in India is limited by the lack of autonomy, education and access to the digital space. Besides, socio-cultural barriers and gender differences in the possession of smartphones and use of the internet are the major reasons for the deepening of the exclusion of women from the digital world (Gupta et al., 2025). India has been investing in digital health at an accelerated pace. The e-Sanjeevani platform ranks among the largest telemedicine platforms globally and has already facilitated more than 276 million consultations. Under the Ayushman Bharat Digital Mission, 380 million health accounts were made and 262 million health records were connected (Raj et al., 2023; Dastidar et al., 2024). While significant barriers like low digital literacy, limited access to devices and the internet, and cultural bias towards face-to-face care remain (Arora et al., 2024). The differences between genders are still very large; 63% of women and 79% of men possess mobile phones, and as a result, there are obstacles in front of women in terms of access. (Hersh et al., 2021) Between 2016 and 2018, the maternal death rate in West Bengal dropped significantly to 98 per 100,000 live births, however, there are still areas of lack of access to health care

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caused by urban-centric facilities, difficulties in transportation, limited finances, and making of decisions late (Deb et al., 2022; Sk et al., 2019). Rural women are affected by the digital, gender, and rural divides, among others. These women are prevented by cultural, financial, and mobility barriers from fully utilizing digital health technologies for their own empowerment (Saha et al., 2024).

Methodology

This chapter employs a systematic scoping review along with the Technology Acceptance Model framework to explore the dimensions of trust, gender differences, and regional factors in the adoption of e-health. In order to know the changes in the digital health sector after the pandemic, studies done from 2019 to 2025 have been looked through. Besides that, three databases namely PubMed, Scopus, and Google Scholar were searched using the following keywords "e-health adoption," "Technology Acceptance Model," "trust," "gender differences," "telemedicine India," and "digital health barriers". The criteria for inclusion consisted of peer-reviewed studies, systematic reviews, and government reports on the technology acceptance model (TAM) in healthcare, the influence of gender on technology usage, and the implementation of digital healthcare in India with a focus on West Bengal. Prioritized were studies that utilized validated research tools and reported gender-disaggregated data. The exclusion criteria were non-health technology related technology studies, studies from rich countries that have no relevance to India, and foundational TAM papers published before 2019. Data was gathered on trust factors, gender differences, adoption barriers, and findings from West Bengal to act as a base for answering four research objectives such as examining the role of trust, comparing gender-based trust levels, identifying women-specific barriers, and coming up with practical recommendations.

Analysis and Discussion

This evidence very strongly disputes the assumptions made in TAM. The role of trust has gone beyond merely adding to usefulness and ease of use, as it has become the main driver of adoption. Patients in healthcare environments where they feel exposed and are concerned about the privacy of their data, the mere presence of technical features is not able to determine whether users will adopt the system (An et al., 2021; Dhagarra et al., 2020). This design showed a recurring theme in numerous research works. A few studies conducted at the beginning of the pandemic indicated that usefulness was the most important factor. However, most of the evidence that has been published after 2020 points out that trust is the main factor which other TAM aspects have to go through (Esmaeilzadeh, 2019; Yan et al., 2023). Most importantly, the concept of trust varies significantly between men and women. Research reveals that women exhibit greater fear towards the use of technology and have more intense worries about their privacy, still, these are attributed to gender-based social and cultural habits rather than to the character of the individual (Russo et al., 2025; Moulaei et al., 2023). Mostly, men are the ones who verify the efficiency of the systems while women consider whether they can rely on the provider, whether their information is safe and whether the community supports them. The difference in question dismantles the concept of gender-neutral platforms that assume that they can equally access male and female. Present-day platforms mainly concentrate on the efficiency of systems and overlook whether individuals have trust in relationships, thus these platforms are fundamentally tailored to the behavior of men. The outcomes are very important for West Bengal. The number of women who own phones is just 63 percent while that of men is 79 percent. Thus, in addition to the trust issue, there is a problem of basic access (Hersh et al., 2021). Just improving digital literacy or creating superior internet infrastructure cannot be effective in situations where healthcare decisions require the consent

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of men due to cultural practices and joint family systems (Deb et al., 2022; Sk et al., 2019; Saha et al., 2024). Effective solutions must incorporate characteristics such as a female doctor option, interfaces in the local language, methods to involve the family in the consent process, and unambiguous privacy guarantees that cater to women's requirement for trust relationships. Such a review acknowledges a number of limitations, including not many long-term studies and regional differences, but the trend remains visible. Developing going further means using the designs that are not only gender-specific but also take into account that the household power relationships influence whether women are capable of technology adoption.

Practical Recommendations

1. **For Government**

a. Provide smartphones free of cost or at subsidized rates to rural women can remove the access barrier.

b. Expand 5G networks in underserved rural areas can solve the connectivity issue.

c. Make gender impact assessment mandatory for e-consultation related initiatives.

d. Include women as part of the technology design groups to ensure gender-responsive platforms.

2. For Platform Developers

a. Develop peer-led digital literacy initiatives along with workshops focused on capacity building.

b. Include added privacy features, with a clear explanation for users about its security.

c. Include female healthcare providers (husband, wife, partner) to encourage comfort for the user.

d. Include the user interface in a local language, utilizing a contextually appropriate interface for a rural environment.

e. Include trust-building features with provider credentials that are verified, as well as testimonial reviews from users of their experience.

3. For Communities

a. Start awareness activities by having dialogue sessions that engage both men and women.

b. Train community health workers to effectively implement digital health adoption.

c. Create groups for women-only to learn digital literacy in safe and contained environments.

d. Get male family members to be supporters rather than barriers.

Conclusions

The chapter dealt with the dependence of e-health adoption on trust among rural women of West Bengal and analyzed this relationship with the help of the Technology Acceptance Model. The results indicate that people trust is the most important factor even more than usefulness and ease of use. Trust is not the same for men and women. Men test the system to ensure that it is functioning correctly. Women only trust the provider, if their information is secure, and if their peers approve. This is the reason why these platforms have different effects on men and women. Rural women from West Bengal are the victims of triple barriers. They don't have digital access, are subjected to gender restrictions, and are in far-flung places. Most of the existing platforms are mainly centered on the technical aspects, and they hardly ever take into consideration the emotional side of the relationships that women would want to talk about. Future research need to explore the decision-making process of families regarding the use of healthcare technology. Technology usage perceptions are different for men and women, therefore e-consultation apps must need gender equity. Keeping this in mind, e-consultation

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application-makers, public institutions, and societies must collaborate to ensure that these apps are fair to women.

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Chapter 6: AI and IoT for Smart Integrated Farming Systems: Bridging Agriculture, Technology and Commerce

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Abstract

Agriculture is the foundation of rural livelihoods, especially in Northeast India, where most farmers depend on small and diversified farm enterprises. Yet, changeable weather, soil degradation, and unstable market conditions make farming increasingly difficult. Integrated Farming Systems (IFS), which combine crops, livestock, aquaculture, and horticulture, offer a sustainable path forward by making better use of local resources and minimizing waste. However, traditional IFS practices often rely on farmer experience rather than precise data. The introduction of Artificial Intelligence (AI) and the Internet of Things (IoT) has changed this dynamic by bringing data-driven insights and automation to farm management. Through the use of sensors, drones, and predictive models, farmers can now monitor soil health (tracking pH shifts, nutrient depletion), livestock activity, and water quality in real time, allowing them to make correct decisions and respond quickly to emerging challenges. Case examples from Assam highlight how AI and IoT tools improve productivity, reduce disease risks, and connect farmers directly with markets through digital platforms. These technologies also open new opportunities for learning and collaboration, enabling farmers to share knowledge and access online training resources. Despite persistent barriers such as poor internet connectivity, high equipment costs, and data-privacy issues, the adoption of AI- and IoT-enabled IFS promises a more efficient, profitable, and sustainable agricultural future. With the right policy support, capacity building, and community engagement, smart integrated farming can strengthen food security, rural income, and environmental resilience.

Keywords: *Artificial Intelligence (AI), Internet of Things (IoT), Integrated Farming Systems (IFS), Smart Agriculture, Precision Farming, Sustainable Agriculture, Livestock Monitoring, Aquaculture, Digital Agriculture, Market Linkages, Data-driven Farming, Northeast India.*

1. Introduction

Agriculture has long been essential to human livelihoods, sustaining communities and providing daily necessities. However, farmers have faced an increasing number of challenges in recent decades, such as unpredictable weather patterns, degraded soil, fluctuating market conditions, and the need to feed a growing population. The complexity of farming is increased in Northeast India, where smallholder farmers usually manage a combination of integrated farming, for example - small-scale pig farms, dairy farms, poultry farms, rice paddies and fisheries.

Integrated Farming Systems (IFS), which link different agricultural components in a complementary way, offer a solution to these issues. Traditional IFS has shown benefits in efficiency and risk reduction, but it often relies more on experience than on systematic data. With the advent of artificial intelligence (AI) and the internet of things (IoT), this environment has begun to change. IoT devices continuously monitor soil, crops, livestock, and aquaculture, enabling timely interventions, while AI can identify trends, forecast results, and warn farmers of possible issues.

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Using actual cases from farms in Assam and the surrounding areas, this chapter examines how AI and IoT can improve IFS with an emphasis on useful applications, market connections, and knowledge sharing tactics.

2. Integrated Farming Systems: Concept and Significance

Crops, livestock, poultry, fisheries, horticulture, and agroforestry are all integrated into integrated farming systems. One component's outputs are frequently used as inputs for another: aquaculture by-products can fertilize crops, livestock manure enriches soil or powers biogas plants, and crop residues feed livestock. By using resources continuously, waste is decreased and overall efficiency is raised. IFS offer advantages beyond increased productivity. Farmers benefit from increased food and nutrition security, diversified revenue streams, and decreased susceptibility to market or climatic shocks. Many smallholder farmers in Assam observe that integrating piggery with rice and fish farming and duck farming with fish farming guarantees year-round income and sustenance. Not with standing these benefits, there are still issues like poor market integration, little mechanization, and no real-time monitoring. Incorporating AI and IoT can help farmers overcome these obstacles and realize the full potential of IFS.

3. Role of AI and IoT in Agriculture

AI and IoT technologies changing the decision-making in agriculture. AI systems evaluate the continuous data collected by IoT devices, such as wearable livestock monitors and soil moisture sensors, to produce insights that can be put to use. Many farmers in Japan, China and outside India are using this technique. But now Indian farmers are also using this technique. Timely intervention is made possible by machine learning algorithms that identify early indicators of animal or crop disease. Weather impacts are predicted by predictive models, which help determine when to sow and harvest. AI and IoT enable farmers to optimize multiple businesses at once, supporting sustainability and productivity in areas like Northeast India that are dominated by smallholder farms.

4. AI and IoT Applications in Integrated Farming Systems

Crop Management: Soil sensors measure moisture, nutrient levels, and pH, allowing precise application of fertilizers and water. Drones provide aerial views to identify pest infestations or growth problems early. In Assam, rice fields surveyed by drones have seen pest outbreaks controlled before they spread widely.

Livestock Management: Wearable sensors monitor activity, temperature, and feeding behaviour. AI-based feeding systems optimize rations, reducing costs and supporting healthy growth. Predictive analytics can warn farmers of potential disease outbreaks, enabling pre-emptive measures.

Aquaculture: Sensors track water temperature, pH, and oxygen levels. Automated feeders provide consistent nutrition, and computer vision estimates fish growth, guiding harvest schedules.

Poultry and Pig Farming: Environmental sensors maintain optimal temperature and ventilation. Image analysis detects abnormal behaviour, signalling stress or illness early. Predictive AI models forecast disease likelihood, enhancing farm biosecurity.

By connecting previously disconnected farm activities into a coherent system, AI and IoT help farmers make informed decisions in real time, increasing productivity and sustainability.

5. Commerce and Market Linkages

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Profitable links between farms and markets are made possible by technology. Access to digital marketplaces is made possible by AI and ICT platforms, which lessen reliance on middlemen. In order to increase revenue and lower post-harvest losses, cooperatives in Assam use smartphone apps to sell fish, eggs, and vegetables straight to towns. IoT-enhanced logistics allow for traceability and maintain product quality. AI-powered credit scoring makes insurance and loans available to smallholder farmers. By using predictive analytics to guide marketing and planting choices, integrated farms are made to be both economically strategic and productive.

6. Teaching, Training, and Knowledge Dissemination

Adopting AI and IoT requires knowledge. ICT platforms deliver training via mobile apps, video tutorials, and online courses. Extension officers provide real-time guidance through virtual consultations, reducing the need for physical visits.

Higher education institutions expose students to smart farm simulations, precision agriculture models, and decision-support tools. Farmer cooperatives share data and insights collectively, enhancing community learning. Embedding AI and ICT into education ensures that current and future farmers are prepared to manage advanced integrated farms effectively.

7. Challenges and Limitations

IoT and AI have real-world obstacles despite their potential. Rural internet connectivity can be erratic, and equipment costs are high. Farmers might not be able to decipher complicated data. Data security and privacy are further issues. It can be challenging to apply research-based solutions to a variety of field conditions. Governments, tech companies, and local communities must work together to address these problems and create workable, secure solutions.

8. Future Directions

Future innovations may include digital twins that simulate farm operations, AI-driven predictive models for disease and pest outbreaks, and blockchain systems that enhance supply chain transparency. Climate-adaptive AI models can support resilience against extreme weather, and shared digital platforms can reduce costs through cooperative infrastructure. These developments suggest a future where agriculture is efficient, resilient, and environmentally sustainable.

9. Conclusion

Agriculture can become more resilient, profitable, and sustainable by incorporating AI and IoT into Integrated Farming Systems. Farmers can maximize output and diversify revenue streams by integrating crops, livestock, aquaculture, and poultry through predictive analytics and ongoing monitoring. Market access is strengthened by digital tools, and communities are empowered to embrace these innovations through education. Smart integrated farming has the potential to significantly contribute to food security, rural livelihoods, and environmental control with the help of cooperative platforms, supportive policies, and continuing research.

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Chapter-7: From ChatGPT's Ghibli to Gemini Nano Banana: A survey on emerging trends and ethics in AI-Driven Image Editing Tools

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Abstract

Artificial Intelligence (AI) is no longer limited to traditional domains such as scientific research, industrial automation or data analytics. Its influence has now reached far beyond these conventional boundaries, making a significant impact on fashion, creativity, and cultural expression. With the advent of advanced multimodal AI models has accelerated innovations in image editing tools, enabling sophisticated style transformations, photo re-imaginings, and creative compositions. Two prominent recent trends are OpenAI's ChatGPT "Ghibli-style", a conversational trend influenced by Studio Ghibli's narrative approach, and Google Gemini upgraded image editor, "Nano Banana", a data-driven AI tool that analyses and forecasts saree fashion trends. This study evaluates the capabilities of these tools, looks at their features, user uptake, controversies, and ramifications, and talks about social, ethical, and copyright issues. This study looks at various case studies and shows how AI may adjust to consumer behaviour, cultural innovation, and customized experiences.

Keywords: Artificial Intelligence, OpenAI, Google Gemini, ChatGPT, Ghibli-style, Nano Banana.

Introduction

In 2025, AI image editing has moved beyond simple filters toward more flexible, conversational, and high-fidelity transformations. Users not only want stylized results, but also preservation of identity/likeness, coherence over multiple edits, mixing styles, and blending multiple sources (e.g. photos and backgrounds). ChatGPT and Google Gemini are the two major performers in this arena.

A viral "Ghibli-style" transformation was provided by OpenAI's ChatGPT (via GPT-4o), influenced by Studio Ghibli's narrative approach. Studio Ghibli is a Japanese animation studio co-founded by Hayao Miyazaki, known for its distinct hand-drawn animation, soft color palettes, whimsical characters, natural settings, and emotional storytelling. This AI trend engages users in rich, imaginative interactions that shape popular culture and storytelling preferences. It illustrates the potential for AI not only to assist in practical tasks but also to actively participate in cultural innovation, guiding artistic direction and consumer engagement. Soon after release, users discovered it could render Ghibli-style images well; the trend spread rapidly.

Similarly, Google's Gemini AI app has image generation and editing capability; as of August 26, 2025, Google DeepMind introduced "Nano Banana", an upgraded image editing model (Gemini 2.5 Flash Image), integrated into the Gemini app. The Google Gemini Nano Banana saree trend is a data-driven AI platform that analyzes large datasets of consumer preferences, social media patterns, and historical fashion trends to forecast upcoming saree designs. By

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doing so, it enables designers and retailers to align their collections more closely with anticipated consumer demand, offering a personalized and culturally relevant shopping experience.

Literature Review

In 2024-2025, generative image models gained popularity; yet, in early-mid-2025, two swift cultural waves solidified discussions on platform governance, cultural significance, and creative value. The first is the creation of images by ChatGPT users that mimic Studio Ghibli's visual style, or the "Ghibli trend". The second is the quick uptake of Google Gemini's Gemini 2.5 "Flash Image" model, which resulted in viral stylized 3D figurines and retro-styled edits and was incorporated into a variety of creative toolchains (such as the Gemini app, WhatsApp, and Photoshop beta). These occurrences demonstrate how social sharing, model design, and simple user interface accessibility come together to produce swift cultural dissemination and governance issues.

Comparative review

A comparative summary of what each tools offers, based on present information. Style transformation or stylization in the Studio Ghibli style can be accomplished by letting users provide prompts to change photos into Ghibli-style. Users complained about "close but not quite the same" likeness, and some limitations were noted regarding the maintenance of their identity or likeness. They expected the image to be stylized but clearly replicated. Additionally, users have the ability to provide several prompts and refinements, but blend when merging multiple photos or creatures, and report errors when attempting to complete particular queries owing to content regulations. Initially, ChatGPT's paying members (Plus, Pro, and Team) enjoy more benefits comparatively free users, facing limitations. The Ghibi-style photos quickly gained popularity, but there have been issues with copyright and style constraints; OpenAI is subject to content policy limits as well.

On the other hand, Nano Banana preserves authentic facial features while allowing significant artistic or background modifications. It can merge multiple input photos into a cohesive composition using multi-image fusion, supporting both stylized creative transformations and practical photo editing. Continuous, step-by-step editing is powered by the Gemini 2.5 Flash engine, with enhancements like edge correction, depth consistency, and sharp texture management. The platform integrates with apps such as WhatsApp, Canva, and Photoshop, adapting color tones, exposure, and shadows to varying settings. Users can provide hybrid inputs of text prompts and reference images for precise results. Built-in watermarking (SynthID) ensures AI provenance, while explicit non-consensual facial modifications are prohibited. Nano Banana emphasizes data transparency, AI safety alignment, and equitable representation across skin tones and genders. It allows quick retouching of portraits, creation of product images, and user-controlled adjustments of stylization, background, and focus, with conversational feedback enabling seamless editing, re-editing, and analysis of images.

The effects of AI on the domains of art and design have been examined in earlier research. Anggraini (2024) explores how AI can be used as a tool for artists in the creative process, allowing the exploration of concepts and expressions that were previously challenging to archieve in her article "Collaboration between Artists and AI in Sparking a Wave of

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Creativity in the era of the Digital Art Revolution." Furthermore, the study "Identifying Challenges and Opportunities in the Utilization of Artificial Intelligence Art for Graphic Designers" by Risandhy (2023) emphasizes the opportunities and difficulties graphic designers encounter when incorporating AI into their design processes.

On March 28, 2025, Eric Hal Schwartz wrote in TechRadar that Studio Ghibli intentionally, almost drastically, slow on both style and production in their films. Added, to a humorous extent, these hand-drawn images that are processed and repeated by AI miss the point. He discovered this by attempting this trend, posting a prompt in ChatGPT. A minute later, he saw a picture of himself and his dog that demonstrated the gaps in OpenAI's security measures. Graham, Senior Editor for AI at TechRadar, later stated in a TechRadar article dated May 21, 2025, that he was astonished by the outcome of his pitch for the new Google Gemini against ChatGPT for AI image production. In order to avoid usage constraints, he used Gemini Advanced and ChatGPT Plus accounts to test Gemini against ChatGPT, following their directions. Gemini impressed him with its brightness and level of clarity, and he believes it operates more quickly than ChatGPT. However, he found ChatGPT to be better when there was a lot of text; it generates Ghibli-style images more readily than Gemini does.

Methodology

The trends, features, and moral implications of AI-powered picture editing tools are investigated in this study using a mixed-method qualitative and analytical research approach, with an emphasis on ChatGPT's Ghibli-style and Gemini Nano Banana. To fully comprehend how these technologies impact digital creativity and ethical standards in AI-generated art, the research design combines comparative analysis, user perception studies, and content evaluation.

By looking into the features and results of Ghibli-style or Nano Banana, many concerns arise unlike the other users. I have tried to point out a qualitative review to both styling and editing tools. To look deeply into the accuracy and impacts have collected materials. The public-facing materials published between March 2024 to September 2025 are the focus of this review's targeted systematic search strategy, which includes: a) official product and developer pages (OpenAI and Google Gemini); b) top technology journalism outlets (Forbes, TechRadar, GeekWire, Times of India); c) platform announcements (Adobe/ Phototshop blog); and d) community discussions and instructional content (Medium, Reddit). I gave preference to sources that either: a) explained the integration and capabilities of the model (Gemini manuals, Adobe blog), b) discussed the spread and reception of viral content (Forbes, GeekWire), or c) detailed community practices (Medium, Reddit). All factual claims are supported by representative sources that are cited.

Data will be analyzed using both qualitative and analytical methods:
1. Comparative Analysis: To look at the functional and stylistic distinctions between Nano Banana and Ghibli-style outputs.

2. Thematic Analysis: To decipher recurrent moral and imaginative themes from user reviews and interview transcripts.

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3. Descriptive Statistics: To display survey findings about perceived trust in AI-generated graphics, accessibility, and user pleasure.

4. Content Evaluation: The creative tone, contextual coherence, and realism of the visual outputs produced by both tools will be evaluated.

By obtaining informed approval from each participant and refraining from using identifying or copyrighted personal data during testing, the study fulfils with ethical research standards. Ensuring that references to AI-generated images are transparent and encouraging equitable representation of racial, gender, and cultural diversity in AI-generated samples.

This study admits its limitations:

1. Access to the AI tools' proprietary training data and algorithms is restricted.
2. Evaluation of "artistic quality" is subjective.
3. Possible output variance as a result of timely wording and AI model upgrades.

Discussions

The present section integrates review findings to answer the primary research questions about Ghibli-style and Nano Banana AI-generated imagery. Research conclusions draw on modern scholarly discussions, as well as legal analysis of AI-generated artwork and technical reference materials, to examine the implications of visual art.

1. How do Ghibli-style images (artistic nostalgia) differ in purpose and perception from Gemini's identity-preserving realism?

The goal of Ghibli-style AI visuals is to replicate the cosiness, imagination, and poignant narrative of Studio Ghibli's hand-drawn artwork. They have an emotional and aesthetic purpose, emphasising nostalgia and stylization. Google Gemini's Nano Banana, on the other hand, places more emphasis on photo-realistic augmentation, likeness preservation, and technical precision. Its objective is to ensure that the subject stays true to life even after cuts by combining originality and realism.
Nano Banana serves real-world uses like marketing, design, and personalization, though Ghibli-style outputs appeal to cultural imagination and viral sharing. Ghibli is therefore motivated by art, while Nano Banana is motivated by precision.

2. Is the Ghibli trend primarily cultural, while Nano Banana is technological – or do they overlap?

Global appreciation for Japanese animation's emotive storytelling and aesthetics is reflected in the Ghibli trend, which is mostly cultural and artistic. It makes use of Studio Ghibli's symbolic imagery and general nostalgia. Contrarily, Nano Banana is a technology advancement that emphasizes AI-driven editing realism and efficiency. Nonetheless, there is overlap because both rely on prompt-based creativity and AI diffusion models. The convergence of technology innovation and cultural expression happens when people use Gemini's technical accuracy to construct artistic, culturally inspired visuals.

3. Which raises more ethical challenges – style imitation or identity preservation?

There are significant but different ethical conflicts with both. Ghibli's style imitation poses a risk of copyright or cultural ownership violations because it imitates a protected artistic style. It also brings up questions about cultural appropriation and authorship. Also risks of misuse

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in Nano Banana, including deep fakes, unauthorized likeness altering, and non-consensual content creation, are associated with identity preservation . Nano Banana affects societal trust and individual rights, whereas Ghibli-style art affects intellectual property and cultural ethics. Therefore, while style imitation raises ethical and artistic difficulties, identity preservation raises more profound privacy-related issues.

4. How do these two trends reflect society's desires for both fantasy and authenticity?

As AI turns into a tool for people to see themselves in surreal, cinematic worlds, the Ghibli movement reflects a societal desire for comfort, imagination, and getaway in the digital age. It symbolizes the desire for poignant narratives in society.The urge to preserve reality, credibility, and identity in a world of digital changes, on the other hand, is reflected in Gemini's Nano Banana, which expresses a desire for authenticity and control. It complies with the ethical and professional requirements for accurate digital depiction. They demonstrate that contemporary users are looking for two different kinds of experiences: one that is grounded in self-expression and imagination, and the other in self-preservation and realism.

5. Should OpenAI and Google follow common ethical frameworks for AI-generated art and image editing?

Yes — a unified ethical framework is essential for consistency, fairness, and accountability. Since both companies deal with user likenesses, creative work, and cultural elements, it is essential that they have similar ethical standards. These frameworks must to consist of:

1. Transparent disclosure of AI creation (e.g., watermarking that is visible)
2. Likeness editing based on approval
3. Using style attribution to avoid artistic plagiarism
4. Audits of bias to guarantee cultural equity
5. Prompt, copyright-sensitive moderating

Each platform is free to innovate in its own way, but in order to preserve both creative integrity and public trust, their ethical underpinnings must align. International AI policy development may also be guided by collaboration.

Conclusions

According to the conclusions drawn from a descriptive qualitative study conducted through a survey of the public writings, the arts and entertainment industry has undergone a fundamental transition as a result of utilization of artificial intelligence (AI) to produce Ghibli-style and Nano Banana visual effects. AI demonstrates itself to be able to enhance the productivity and inventiveness of visual producers by speeding up their creative process while developing new avenues for visual exploration. Ghibli-style transformations and Google Gemini's Nano Banana image editing are two instances of how user demand for expressive, styled, identity-preserving, flexible picture editing is driving AI ahead. These two developments foster practical interactions (creative applications) and social trends (viral styles), but it also brings up significant ethical, legal, regulatory issues, most notably copyright/style emulation, consent for likeness, and trustworthy provenance. Technologies that balance user control, technological excellence, ethical transparency, and creative

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freedom are likely to be the most popular and advantageous in the future. Their future potential is found in the creation of immersive cultural experiences in virtual environments, the democratization of digital art production, and sustainable and AI-assisted fashion innovation. However, these developments also call for a more thorough discussion of authorship, ethics, and maintaining cultural authenticity. In the end, these developments in AI represent not only advancements in technology but also a reinterpretation of creativity in the generative intelligence era.

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Chapter-8: A Review of Fuzzy Association Rule Mining Algorithms

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Abstract

Association Rule Mining (ARM) holds a pivotal role in the Data Mining process, generating meaningful associations in the form of rules based on predefined interestingness measures. The integration of the Fuzzy concept enhances usefulness of classical ARM technique. Fuzzy Association Rule Mining (FARM) techniques leverage membership degrees and linguistic terms, ensuring greater accuracy and natural representation of data. This paper delves into the evolution of FARM algorithms and their applications across diverse fields spanning three decades. Through a review of prominent algorithms, essential features are identified, providing valuable insights for further research in this domain.

Keywords: *Fuzzy Association Rule, Data Mining, Membership degree, Linguistic Term.*

Introduction

With rapid increase in the growth of data in every application, converting data into proper knowledge has already become a challenging issue. Knowledge Discovery in Database (KDD) plays an important role in conversion of data into required information. According to Fayyad et al., KDD is a nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data **(**U.M. Fayyad, et.al., 1996) Data mining is a key step of KDD process. Data mining consists of different functions, namely, classification, regression, clustering, summarization, image retrieval, discovering association rules, functional dependencies and rule extraction, etc. (Mitra, S. & Acharya, T., 2005). Rule mining is one of the key functions in data mining practices where rule can be mined or generated from data for the discovery of the relationship among the attributes of a dataset of transactions. Thus, the discovery of association rules is an important area of data mining research in which interesting association relationships among different attributes are described (Agrawal, R., et.al.,1993). In Market-Basket analysis, by applying techniques of association rule mining, buying habits or patterns of customers are analyzed. For this, associations between items bought by customers are found from the sales transactions. To find patterns using association rule mining it needs to detect rules of the form **A→B** in data containing transactions. Such a rule indicates an item containing an attribute A is likely to contain attribute B also, for example, **bread → milk**. However, to generate association rules, two important quality measures viz. support and confidence are required. Depending on data representation, association rules can be classified into different types like Boolean, generalized, quantitative etc. A Boolean association involves binary attributes, a generalized association involves attributes that are hierarchically related and a quantitative association involves attributes that can take on quantitative or categorical values. But all these types of association rules have some limitations to discover nontrivial knowledge. When a database

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contains values between 0 and 1, it is also possible to extend the classical mining algorithm using Fuzzy set theoretical operations to obtain Fuzzy association rules. By using Fuzzy sets imprecise terms and relations commonly employed by humans in communication and understanding can be optimally modelled **(**Delgado, M. et.al.,2003**).** Use of Fuzzy technique has been considered as one of the key components of data mining system because of their affinity with human knowledge representation **(**Maeda, A. et.al.,19*95)*.

Fuzzy sets allow a flexible assignment of membership of elements to a set. While in crisp set theory, an element may or may not belong to a set, in fuzzy set theory many degrees of membership (between 0 and 1) are allowed. For this, a membership function μA(x) is associated with a fuzzy set A, such that the function maps each element of the universe of discourse x (or the reference set) to the interval [0, 1]. For example, a group of students is classified on the basis of the percentage of marks into poor, medium and good in a test. The interval of percentage is fixed as different category like (30%-45%) as poor, (45%-60%) as medium and (60% and above) as good. Now if a student secures 59.5%, he will be categorized as medium quality by using crisp set, though he or she is just 0.5% away from next upper category. Thus, sometimes it may not be a proper and accurate justification with a sharp boundary i.e. only 0 or 1 in a crisp set. To solve this problem and treat data with more accuracy, Fuzzy sets can be used so that data can be converted into grades between 0 and 1 with some membership function. Fuzzy set theory was introduced by L.A. Zadeh (Zadeh, L. A., 1965) to provide an approximate and yet effective way for describing the characteristics of a complex system to admit precise mathematical analysis (Zadeh, L. A. 1975)**.** Fuzzy sets can be viewed as an extension of the classical crisp sets.

Fuzzy set theory is an expansion of traditional crisp set theory, focusing on quantifying and reasoning with natural language. It defines the process of determining whether elements from a universal set are members or non-members of a crisp set using a characteristic or discrimination function. A membership function, denoted by μ(x), represents the membership grades of elements in the set, which can be used to define fuzzy set A. Formally, given a set X of elements x∈X, any fuzzy subset A of X is defined as

$$A = \{x, \mu_A(x)) | x \in X, \mu_A(x) \in [0,1]\} \quad (1)$$

Fuzzy set theory involves membership functions (Deng, J., & Deng, Y. 2021) that determine the degree membership of an element. These functions directly influence the fuzzification process, converting crisp data into fuzzy data. Common types of membership functions include triangular, trapezoidal, gaussian, and sigmoidal. The paper (Jain, A., & Sharma, A. 2020) analyzes techniques for designing optimal fuzzy logic systems using triangular, trapezoidal, and Gaussian functions. Results show that Trimf and Trampf provide the highest accuracy, while Gaussmf shows the most stable accuracy. Fuzzy logic is widely used in industries like automobiles, consumer electronics, image processing, machine learning systems.

Membership degree in fuzzy set theory is a fundamental concept, indicating the degree of an element's membership in a fuzzy set. This degree, unlike binary membership, allows partial

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membership values ranging from 0 to 1, a feature that is crucial for handling vagueness and imprecision in real-world scenarios. The degree is determined using a membership function.

Linguistic terms are descriptive labels used in fuzzy set theory and fuzzy logic to represent qualitative or subjective concepts in human-readable language. They are often connected with fuzzy sets and defined by membership functions. Linguistic terms are crucial in fuzzy control systems, decision-making processes, and expert systems to model uncertainty and vagueness, bridging the gap between human intuition and machine logic.

Performance measures in Association Rule Mining (ARM) assess the quality and relevance of rules, focusing on key factors like support, confidence, and lift. These measures determine the frequency, strength, and co-relation of associations between items, with most algorithms evaluated using the support-confidence framework (Gyenesei A. & Teuhola J., 2001). Support indicates frequency, confidence measure reliability, and lift evaluates independence.

Some key performance measures are defined below:

Support: The support of an item set is the proportion of transactions in the dataset in which the item set appears. It indicates the frequency of occurrence of the item set in the dataset.

$$Support(A) = \frac{Number\ of\ transactionscontaining\ A}{Totalnumberoftransactions} \qquad (2)$$

Confidence: The confidence of a rule A -> B is the proportion of transactions containing A that also contain B. It measures how often items in B appear in transactions that contain A.

$$Confidence(A \rightarrow B) = \frac{Support(A \rightarrow B)}{Support(A)} \qquad (3)$$

Related Works

Rule mining is a key function in data mining practices, where rules are mined or generated from data to discover relationships among attributes of a transaction dataset. Association rule generation is significant in data mining and research activity, as it helps explain interesting relationships among various attributes (Agrawal, R. et.al., 1993). In Market-Basket analysis, associations between items bought by customers are found from sales transactions. Association rules can be classified into different types like Boolean, generalized, and quantitative. However, these types have limitations in discovering nontrivial knowledge. Fuzzy set theory can be used to extend classical mining algorithms for databases containing values between 0 and 1, allowing for optimal representation of imprecise terms and relations (Delgado, M., et.al., 2003). The simplicity of knowledge representation has led to the recognition of fuzzy-based techniques as an important component of data mining systems (Maeda, A., et.al.,1995). IFWARM, an improved version of the standard Fuzzy weighted association rule mining algorithm, provides more stability and effectiveness using the Weighted DCP (Yang, T., & Li, C., 2015). IFWIAR, an algorithm (Sumathi, G., & Akilandeswari, J., 2020) executed based on recommendation models, improves the quality of diagnostic and services in medicine. Fuzzy Expert system (FES) has been applied in diagnosis using different linguistic terms to classify parameters (Allahverdi, N., 2019). An attribute-oriented approach to Knowledge Discovery (KDD) was investigated and applied in

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generalization to reduce computational complexity in database learning processes (Han, J., et.al.,1992).

Fuzzy Association Rule Mining

The Fuzzy concept in data mining is a method that extracts association rules from quantitative databases. It addresses the boundary problem in classification of attributes based on an assumed range of values, such as crisp sets where nearby values are often ignored or overemphasized. Fuzzy sets grade membership to multiple sets, addressing this issue in categorical data. Fuzzy sets also help address the partial membership of an attribute in real-world situations by using proper linguistic terms. However, F-PNWAR (Mangayarkkarasi, K., & Chidambaram, M. ,2017) mining algorithm emphasizes both positive and negative association rule mining, a new addition to rule mining techniques. E-FWARM (Mangayarkkarasi, K., & Chidambaram, M., 2018) is another modified and enhanced fuzzy-based approach that is useful in weighted association rule mining, assigning proper weight of itemset based on significance, leading to more meaningful rule generation from the database. The traditional FARM approach has an interestingness measure framework, but Fuguang Bao and et.al. (Bao, F., et.al., 2021) have analysed the merits and demerits of traditional measures used in classical ARM and proposed new parameters that are found to be more effective. In these situations, Fuzzy technique or fuzzy concept may be more effective, making FARM a mining technique based on fuzzy set theory and fuzzy logic.

Fuzzification is a method that converts crisp values into fuzzy ones to solve the sharp boundary problem between attributes. Fuzzy set theory uses membership functions to map intervals between [0,1] into different linguistic terms. However, using a sharp boundary in a crisp set may not provide accurate justification. Fuzzy set theory was proposed by L.A. Zadeh (Zadeh, L. A,1965) to provide an approximate but effective way for describing complex system characteristics for precise mathematical analysis (Zadeh, L. A, 1975). It has been applied in various aspects of information retrieval (Pasi, G., 2008) including E-Commerce application and development (Lu, J., Ruan, D., & Zhang, G., 2008). Membership Functions are a useful method for fuzzifying values and representing them in different intervals. Fuzziness, a solution to complex fuzzy systems, balances information and uncertainty, offering flexibility and simplicity. This approach connects human reasoning to intelligent systems, simplifying the complexity of fuzzy systems.

Leading FARM Algorithms

Discovering proper association among attributes in transactional data acquired a prime attention of the researchers since the formulation of the problem, often called as “the market-basket problem.” Several algorithms are designed to discover the association rules applying different strategies. Algorithms like Apriori, Apriori TID (Agrawal, R., & Srikant, R., 1994) etc. were developed to improve the previous approaches. However, incorporation of fuzzy set has brought about a substantial transformation in rule mining technique and their corresponding algorithms. Introduction of fuzzy set theory in association rule mining algorithms mostly involves the following steps:

- Pre-processing of raw data as sample dataset and presented as transaction dataset
- Conversion of the transaction dataset into fuzzy dataset using membership function.
- Classification of fuzzified value into linguistic terms.

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- Frequent itemset generation based on the measures of interestingness.
- Generating Fuzzy Association Rules with natural and meaningful representation.

Here, some leading algorithms related to Fuzzy ARM techniques are explained.

F-APACS

Fuzzy Automatic Pattern Analysis and Classification System, commonly known as F-APACS (Chan, K. C., & Au, W. H. 1997) is an algorithm designed to extract Fuzzy Association Rules from quantitative databases. It uses linguistic terms and adjusted difference concepts, which are crucial in data mining as they simplify human knowledge representation. The algorithm uses user-defined interestingness measures like support and confidence to generate association rules, but this can lead to unnecessary noisy rules and irrelevant relationships. To address this, F-APACS introduces new measures like adjusted difference analysis and weight of evidence. The algorithm allows users to extract rules based on positive and negative association, which is a key feature of F-APACS. Most algorithms discover only positive association rules, where an attribute value is represented as a linguistic term. F-APACS is useful for mining linguistic data, as it is easy to understand. The concept of linguistic term is defined based on fuzzy set theory, making F-APACS a unique FARM approach.

FTDA

Fuzzy Transaction Data-mining Algorithm (FTDA) is an important and simple technique in data mining proposed by Hong and his co-researchers. (Hong, T. P., et.al, 1999,2008). This method operates in two main phases: firstly, the quantitative dataset is transformed into a fuzzy dataset using fuzzy membership functions, categorizing values into linguistic terms such as low, medium, or high. Subsequently, the most frequent items from each attribute, determined by their highest scalar cardinality, are chosen for subsequent iterations. An Apriori-based algorithm is then applied to uncover associations among different items, presenting them in the form of rules. To refine the results, various interestingness measures like support, confidence, and lift are utilized, aiding in the extraction of meaningful rules for further recommendation and analysis

FQARM

The Fuzzy Quantitative Association Rule Mining Algorithm is proposed by A. Gyenesei (Gyenesei, A., 2000) applied on quantitative dataset. The method of extracting Fuzzy Association rules involves finding frequent item sets by counting fuzzy support and comparing them with user-specified minimum support. The technique is used to discover association rules in datasets with both quantitative and fuzzy data. It incorporates fuzzy logic into the mining process, allowing for handling imprecise or uncertain quantitative information. The technique considers weighted associations, adding complexity for rules with varying significance levels. The findings offer insights into the integration of fuzzy logic and quantitative data mining, providing a more nuanced perspective on association rule discovery.

CFARM

The CFARM algorithm (Khan, M. S., et.al. 2008) (Sarma, R., & Sarma, P. K. D.,2020). stands out for its ability to handle composite items, where each item comprises several attributes. Composite data item can be defined as combination of several data. The CFARM technique transforms numerical values into fuzzy sets, representing imprecision and

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uncertainty. It uses a comprehensive approach considering individual attributes and combinations to discover intricate fuzzy association rules. The algorithm introduces a new technique for evaluating rule interestingness, ensuring meaningful patterns extraction. It leverages fuzzy logic principles to provide a robust framework for mining fuzzy association rules from composite items

FWARM

The FWARM Algorithm (Muyeba, M., et.al., 2009) is a modified version of the Weighted ARM Algorithm (Khan, M. S., et.al., 2008), which introduces a new concept of assigning weight to items in a transactional dataset. This approach addresses the issue of some items being less important in generating interesting rules. The FWARM Algorithm also addresses the Downward Closure Property, which was not addressed by other quantitative or Boolean algorithms. The property assumes that all subsets are large if the itemset is large, but the FWARM algorithm does not hold this assumption, as each item is assigned by weight, allowing for larger itemset. The algorithm follows the breadth first search traversal method, based on tree data structures and follows the same execution process as the Apriori Algorithm. It also avoids pre-processing and post-processing steps to eliminate additional steps.

Table.19. Summary of leading Fuzzy ARM Algorithms

Sl No	Name of the Algorithms	Authors	Nature	Data Type	Features /observations
1	Fuzzy Automatic Pattern Analysis and Classification System (F-APACS)	Keith C.C.Chan, Wai-Ho Au	FCM based	Categorical, Quantitative	Linguistic terms are applied instead of discretizing the domains of quantitative attributes. Adjusted difference is utilized in place of user-defined measures. The approach enables the discovery of both positive and negative association rules.
2	Fuzzy Transaction Data-mining Algorithm (FTDA)	Tzung-Pei Hong, Chan-Sheng Kuo, Sheng-Chai Chi	Apriori TID-based	Quantitative, Categorical	A refined or degraded membership function can be applied to effectively address conventional data-related challenges. Compared to traditional crisp set mining methods for quantitative data, smoother mining outcomes with improved time complexity can be achieved.
3	Fuzzy Quantitative Association Rule Mining (FQARM)	Attila Gyensei	Apriori-based	Quantitative, Binary	Fuzzy sets can be used to overcome sharp boundary problems. The fuzzy normalization process addresses issues arising from the fuzzy partitioning of quantitative data. Incorporating correlation measures enhances the accuracy of the generated rules.
4	Composite Fuzzy Association Rule Mining (CFARM)	Maybin Muyeba, M. Sulaiman khan, Frans Coenen	Apriori-based	Composite data	The novel concept of *composite items* is introduced, enabling the linkage of related dataset properties and the discovery of associations among those attributes to find rules. The application of the *certainty factor* offers an effective means of identifying correlations among rules.
5	Fuzzy Weighted	Maybin	Weighted-	Quantitative	Based on importance or significance of data items, some value was assigned in

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	Association Rule Mining (FWARM)	Muyeba, M. Sulaiman khan, Frans Coenen	based		weighted ARM and it leads an issue Downward Closure Property (DCP). The issue of invalidation of DCP is addressed within the support-confidence framework, applicable to both classical and fuzzy associations.

Conclusions

This paper provides a survey of various Fuzzy Association Rule Mining (FARM) techniques, presenting algorithms proposed by different researchers over the past three decades. The survey reveals significant opportunities for future research aimed at enhancing the efficiency and performance of these algorithms. With the rapid and continuous growth of data, researchers increasingly require innovative methods to effectively process and analyze large datasets. From this study, several critical issues have been identified, including the reliance on predefined interestingness measures, challenges in dataset representation, the fuzzification process with appropriate membership functions, and limitations of the classical Apriori algorithm. Addressing these challenges through algorithmic improvements and novel Approaches Offers Promising Directions For Future Work.

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Chapter-9: A Comparative Study of Instructional Design Models with Special Reference to Dick and Carey Model for E-content Development

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Abstract

Creating effective E-content is essential for preparing pre-service teachers with modern pedagogical skills. Instructional design models provide structured frameworks for developing engaging and impactful digital learning contents. The purpose of this study is to compare four leading models—ADDIE, Morrison, Ross and Kemp, Dick and Carey, and Seels and Glasgow—to determine the most suitable framework for E-content development aimed at pre-service teacher education. The comparison examined aspects such as model structure, procedural flexibility, learner-centeredness, and support for innovative teaching. Results indicated that the Dick and Carey model is the most appropriate due to its systematic, linear, and interconnected components. Its focus on instructional goals, formative evaluation, and learner analysis makes it especially effective in crafting E-content that addresses the changing pedagogical needs of pre-service teachers. The study concludes that the Dick and Carey model is the optimal framework for creating innovative, structured, and learner-centered E-content. Its systematic design process guarantees both instructional quality and adaptability, meeting the requirements of 21st-century digital learning environments.

Keywords : *Instructional Design Models, Dick and Carey model*, *E-content*

Introduction

The rapid integration of digital technology in education has led to an increasing reliance on E-content to enhance teaching and learning. With advancements in digital pedagogy, instructional resources have evolved from static text-based materials to interactive, multimedia-rich digital content designed to facilitate deeper engagement and comprehension (Mayer, 2022). The proliferation of Learning Management Systems (LMS), adaptive learning technologies, and artificial intelligence-driven educational platforms has further transformed instructional delivery, making E-content an indispensable tool for educators and learners alike (Hodges et al., 2020).

According to Darling-Hammond et al., (2017) the preparation of pre-service teachers in Bachelor of Education (B.Ed.) programs demands specialized instructional strategies to equip them with the necessary pedagogical and technological competencies. Traditional teacher training often emphasizes theoretical knowledge without sufficient focus on integrating technology into pedagogy, leading to gaps in digital literacy and instructional effectiveness. Developing effective E-content for pre-service teachers is crucial for fostering digital

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pedagogy skills, improving lesson planning, and enhancing student engagement in classrooms (Koehler & Mishra, 2009). Redecker & Punie (2017) believe that well-designed E-content can provide flexible, self-paced, and interactive learning experiences, preparing future educators to integrate technology seamlessly into their teaching practices.

Laurillard (2012) noticed that a fundamental aspect of designing effective E-content is selecting an instructional design model that aligns with the principles of innovative pedagogy. As education shifts toward student-centered approaches, E-content must be structured to promote active learning, collaboration, and higher-order thinking skills. Instructional design models offer systematic frameworks for organizing content, ensuring alignment with learning objectives, and incorporating appropriate instructional strategies (Branch & Kopcha, 2014). However, the diversity of these models necessitates a careful evaluation to determine which one best supports the development of learner-centered, engaging, and pedagogically sound E-content for pre-service teacher training.

Reiser & Dempsey (2018) identified, selecting a suitable instructional design model is critical to ensuring the effectiveness of E-content in pre-service teacher education. Models such as ADDIE, Morrison, Ross and Kemp, Dick and Carey, and Seels and Glasgow each offer distinct processes and principles for designing instructional materials. A comparative evaluation of these models can provide insights into their advantages and challenges in the context of teacher training, helping educators and instructional designers make informed decisions about the most effective approach. By selecting the most appropriate instructional design model, resource person can enhance the quality of E-content, improve teacher preparation, and ultimately contribute to more effective and technology-integrated teaching practices in schools.

Objectives of the Study

The following objectives were taken for the present inquiry-

1. To adress the limitations of conventional Teacher Education
2. To examine instructional design models in relation to innovative pedagogy for enhancing learner-centered E-content development
3. To conduct a comparative study of four instructional design models—ADDIE, Morrison, Ross and Kemp, Dick and Carey, and Seels and Glasgow—for developing E-content tailored to pre-service teacher training.

Methodology

This study employed a comparative analysis of four prominent instructional design models—ADDIE, Morrison, Ross, and Kemp, Dick and Carey, and Seels and Glasgow—within the context of E-content development for pre-service teacher education. The goal was to identify the model that most effectively supports innovative pedagogy while addressing the unique needs of pre-service teachers. Comparative evaluation was chosen as it enables a structured analysis of the strengths, limitations, and applicability of each model.

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The study relied on secondary data collected from existing academic literature, books, and peer-reviewed journal articles that discuss the principles, processes, and applications of the selected instructional design models.

Findings and Discussions

1. Adressing the limitations of Conventional Teacher Education through the use of E-content:

Beare et al., (2012) while discussing traditional teacher education models, often reliant on lectures, textbooks, and limited practical experience, may not fully prepare pre-service teachers for the complexities of modern classrooms. Dorner (2010) and Voogt (2013) noticed that these models frequently fall short in equipping future educators with essential technological skills, limiting their ability to integrate digital tools effectively into their teaching practices. Without adequate technology training, pre-service teachers struggle to engage diverse learners and address varying learning styles, which are essential in today's heterogeneous classrooms (Lin, 2008). Additionally, Milman (2005) traditional models often lack authentic assessment methods, such as real-world teaching simulations, which hinders the development of both practical skills and deep pedagogical knowledge. The absence of these opportunities creates a gap between theoretical learning and practical application, leaving many pre-service teachers lacking confidence as they enter the profession.

Lin (2008) as a scholar noted that the increasing diversity of student populations further necessitates culturally responsive teaching, an area where traditional teacher education has often been inadequate. Many programs fail to sufficiently address issues of equity, inclusion, and differentiated instruction, leaving new teachers unprepared to meet the varied needs of their students. Given that teacher quality is a key factor influencing student success (Beare, 2012), it is critical to improve teacher preparation by addressing these limitations. On the other hand, with technology becoming central to education, teachers must develop not only technical proficiency but also an understanding of how digital tools enhance learning. However, many traditional models lack the infrastructure and resources to provide this type of training, compounding the challenges faced by pre-service teachers.

E-content presents a promising solution to these challenges by offering flexible, interactive, and engaging learning experiences. Frehywot (2023) believe high-quality E-content can incorporate multimedia, simulations, and collaborative activities to support diverse learning styles. According to Baidoo-Anu (2023) It also enables personalized learning pathways, allowing pre-service teachers to focus on areas where they need the most support. Additionally, E-content provides opportunities for authentic assessment through virtual classroom simulations and project-based activities, allowing for the application of theoretical knowledge in realistic settings (Milman, 2005). Digital resources further expose pre-service teachers to innovative pedagogical strategies, enhancing their readiness for modern classrooms. According to Dengel et al., (2022) the flexibility of E-content also supports self-paced, asynchronous learning, making teacher preparation more accessible and effective.

2. Instructional Design Models

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Instructional design (ID) refers to a structured methodology for developing educational and training programs in a systematic and reliable manner (Gustafson & Branch, 2002). This approach ensures that learning materials are created effectively to achieve specific learning goals. The concept of instructional design traces its roots to Silvern (1965), who applied systems thinking to solve instructional challenges. A system consists of interconnected elements that function collectively to achieve a common objective.

Let's discuss the four instructional Design Model one by one:

i. ADDIE Model (1975)

The center for Educational technology of Florida State University developed ADDIE Model in the Year 1975. The chief purpose to construct this model is to create a systematic guideline for developing instructional System for US Army. It follows of five phases:

1. **Analysis** – Identifies learning goals, audience characteristics, and instructional needs.
2. **Design** – Defines learning objectives, instructional strategies, and assessment methods.
3. **Development** – Creates instructional materials such as E-content, multimedia, and interactive resources.
4. **Implementation** – Delivers the instructional content to learners and facilitates engagement.
5. **Evaluation** – Assesses the effectiveness of instructional materials through formative and summative evaluations and makes necessary revisions.

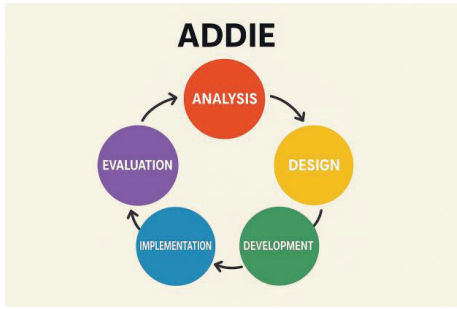

Figure 2: The ADDIE Instructional Design Model

The ADDIE model is particularly beneficial for designing learner-centered E-content for pre-service teachers, as it ensures a logical, systematic, and adaptable instructional approach.

ii. Dick and Carey Model (1978)

The Dick and Carey Model (DC) was published in the year 1978 by Walter Dick and Lou Carey. The model was discussed in the book titled "The Systematic Design of instruction". This model follows a structured instructional design approach based on behaviorist principles. It is similar to the ADDIE model but provides a more detailed and prescriptive sequence of steps. This model consists of ten interrelated components:

1. Identifying learning needs and goals.
2. Conducting instructional analysis.

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3. Assessing learner characteristics and learning contexts.
4. Defining performance objectives.
5. Developing assessment methods.
6. Designing instructional strategies.
7. Creating and selecting instructional materials.
8. Conducting formative evaluation to refine instruction.
9. Revising instructional content based on feedback.
10. Conducting summative evaluation to assess overall effectiveness.

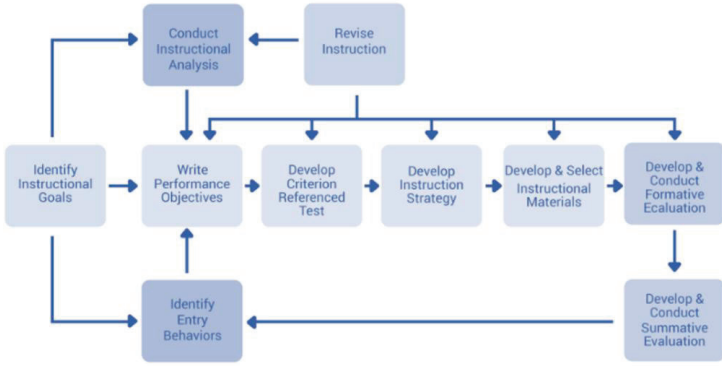

Figure 3: The Dick & Carey instructional design model

This model is less flexible than ADDIE model. This model is effective in course development as it is more focused on effective content making.

iii. Morrison, Ross, and Kemp (MRK) Model (1994)

The Morrison, Ross, and Kemp Model (MRK) was introduced by Jerrold Kemp with Gary Morrison and Steven Ross in 1994. This model is a learner-centered instructional design framework that follows a circular, non-linear process. Different from ADDIE and Dick and Carey, this model allows for greater flexibility in instructional design. It consists of nine interdependent steps:

1. Identifying instructional problems and defining learning objectives.
2. Analyzing learner characteristics.
3. Identifying subject content and breaking it into manageable units.
4. Defining clear instructional goals for learners.
5. Organizing and sequencing content logically.
6. Designing instructional strategies for mastery learning.
7. Planning instructional delivery.
8. Developing assessment and evaluation tools.
9. Selecting learning resources to support instructional activities.

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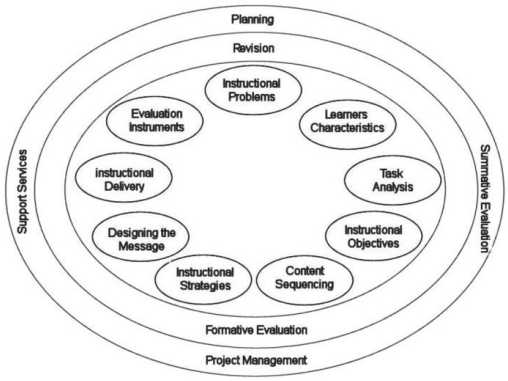

Figure 4: Morrison, Ross & Kemp (MRK) model

This model is particularly effective for personalized learning and adaptive instruction, making it ideal for teacher training programs that require dynamic and evolving content.

iv. Seels and Glasgow Model (1990)

The Seels and Glasgow Model was developed in the year 1990 by Barbara Seels and Zita Glasgow. This model is a project-based instructional design framework that focuses on systematic planning and implementation. It is commonly used in large-scale instructional projects, including e-learning and digital content development. The model follows three major phases:

1. Needs Analysis and Planning – Identifies instructional goals, learner requirements, and project constraints.
2. Design and Development – Structures content, selects instructional strategies, and creates multimedia-based learning materials.
3. Implementation and Evaluation – Deploys instructional content, trains facilitators, and conducts continuous assessment to improve learning outcomes.

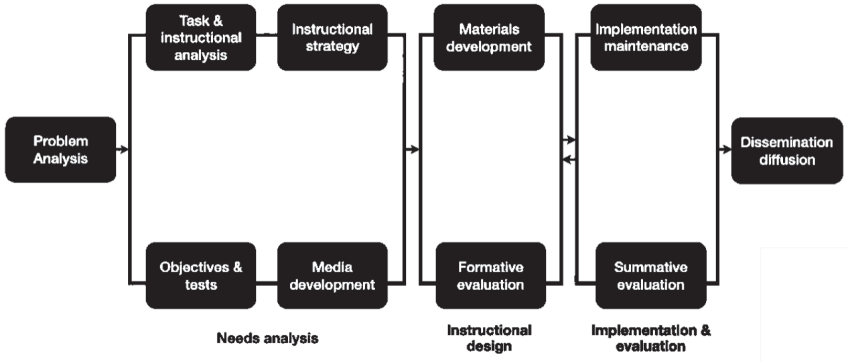

Figure 5: Seels and Glasgow Model of Instructional Design

This model is particularly useful for pre-service teacher training as it ensures a well-organized, technology-driven, and systematically designed learning experience.

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3. Comparative Study of four ID Models towards developing effective E-content for Teacher Education.

Various ID models, including ADDIE, Morrison, Ross, and Kemp (MRK), Seels and Glasgow, and Dick and Carey (DC), offer structured frameworks for designing and implementing instructional content. This paper critically evaluates these four models, highlighting their strengths, limitations, and suitability for E-content development. While all four models follow a systematic approach, they differ significantly in orientation, flexibility, learner focus, and project management.

Model	Orientation	Approach	Primary Output	Goal	Flexibility	Learner Focus	Evaluation
ADDIE	Systemic	Systematic	Course or curriculum	Develop structured instruction	Moderate	Strong	Extensive in evaluation phase
MRK	Classroom	Holistic	A few hours of instruction	Improve a piece of content	High	Strong	Moderate
Seels & Glasgow	Product	Systematic	Instructional package	Improve efficiency of production	Medium	Moderate	Extensive in materials development phase
Dick & Carey	System	Systemic & Systematic	Course or curriculum	Create an instructional system	Medium	Moderate	Extensive throughout

3.1 Flexibility and Framework

Gustafson & Branch, (2001) points out a major distinction among these models is their degree of flexibility. The ADDIE and DC models follow a linear structure, guiding instructional designers step-by-step from analysis to evaluation. This structured approach ensures consistency but may be too rigid for adaptive learning environments.

Morrison et al., (2004) noticed that the MRK model follows a curvilinear process, allowing greater interaction between design components and non-linear development. The Seels and Glasgow model, while systematic, is organized into three project management phases, providing some degree of adaptability while maintaining structure (The Herridge Group, 2004).

3.2 Emphasis on Learner Needs and Personalization

According to Siragusa (2006) Learner need, engagement and adaptability are crucial for effective content development. The MRK and ADDIE models place a strong emphasis on learner-centered approaches, ensuring content customization and interactive learning. ADDIE, in particular, follows an iterative cycle, allowing for continuous improvements based on feedback.

In contrast, the Seels and Glasgow and DC models focus more on content production efficiency rather than individualized learning experiences. While learner characteristics are

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analyzed in both models, their rigid structures may limit real-time adaptability in instructional design (Setiawan, 2005).

3.3 Advantages and Challenges in E-content Development

Each model presents unique advantages and challenges for developing effective e-learning content:

i. **ADDIE Model**
- *Advantages:* Structured, iterative, widely applicable to various instructional settings.
- *Challenges:* Can be time-consuming, requires continuous evaluation for effectiveness.

ii. **MRK Model**
- *Advantages:* High flexibility, strong learner focus, allows customized and interactive E-content.
- *Challenges:* Less structured project management, requiring more design expertise.

iii. **Seels and Glasgow Model**
- *Advantages:* Strong project management focus, balances structure and adaptability.
- *Challenges:* Moderate learner focus, prioritizes production efficiency over customization.

iv. **Dick and Carey Model**
- *Advantages:* Comprehensive, ensures alignment with instructional goals.
- *Challenges:* Fixed in approach and framework oriented.

3.4 Summary of the Comparative Findings

After considering the all the structure, Strengths and limitations we can summarise the findings as follows:

- One of the key strengths of the Dick and Carey Model is its emphasis on a systematic and learner-centered approach to instructional design.
- The Dick and Carey Model is the most suitable for E-content development among the given models because of its systematic, linear structure, and effectiveness-driven approach.
- Unlike the ADDIE Model, which is broad and generic, Dick and Carey provides a structured framework with interrelated components, ensuring step-by-step content development. Compared to the MRK Model, which focuses mainly on motivation, Dick and Carey emphasizes instructional alignment, assessment, and evaluation, making it ideal for structured E-content Development.
- The Seels and Glasgow Model is more suited for large-scale instructional systems, while Dick and Carey's modular nature makes it highly adaptable for E-content in mathematics pedagogy. Its nine interconnected stages, from identifying goals to formative evaluation, ensure high-quality, engaging, and effective learning materials.
- DC model integrates learner need, learning theories, instructional strategies, and feedback mechanisms, making it the best choice for developing well-structured E-content that enhances pre-service teachers' learning experiences.

Conclusions

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Choosing an instructional design model for E-content development should match the need of the learner, goals of teaching, and the flexibility required. More than 100 instructional design models, the ADDIE model is popular because it uses a step-by-step process and allows continuous improvement. The MRK model focuses on keeping learners motivated and adaptable, which makes it useful for interactive and learner-centered e-learning. The Seels and Glasgow model helps in creating content in a structured and project-based way, balancing efficiency with effectiveness.

The Dick and Carey model is different because it is very systematic, linear in structure and goal-oriented. It also includes assessment, alignment, and evaluation as key parts of the instruction making process. Some researcher think it is too rigid, but its connected steps provide a strong framework supported by research. This model is structured yet flexible, making it a great choice for E-content development. It ensures better teaching quality and keeps learners more engaged.

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Chapter-10: Leveraging MOOC's for Teacher Training : Opportunities and Challenges

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Abstract

This chapter explores the potential of Massive Open Online Courses(MOOC's) in teacher training, highlighting both opportunities and challenges. MOOC's offer scalable, flexible, and cost effective for professional development opportunities for teachers, providing access to experiencing knowledge and skills. However, challenges such as low competition rates, limited interaction, and quality assurance issues need to be addressed. Effective design and implementation strategies, including clear learning, objectives, inter active elements, support mechanisms and continues evaluation can mitigate these challenges. The chapter also examines case studies and examples of successful MOOC's for teacher training, providing insights into best practices and future directions for development. By harassing the potential of MOOC's, we can support teachers in developing their skills and knowledge, ultimately enhancing student learning outcomes and improving the quality of education.

Keywords: MOOC's, Teacher Training, Online Learning, Scalability, Flexibility, Cost-effectiveness, Quality Assurance, Interactive Learning, Educational Technology, Professional Development.

Introduction

The world of education is undergoing a significant transformation, driven by advances in technology, changing learner needs, and the increasing demands for quality education. Teachers, as the backbone of the education system, play a critical role in shaping the minds of future generations. However, the teaching profession is not static, and teachers require ongoing training and development to stay updated with best practices, technologies and curriculum developments.

Traditional teacher training methods, such as workshops and conferences, have limitations in terms of scalability, accessibility and cost effectiveness. The Open Online Courses (MOOC's) has opened up a new possibilities for teacher professional development, offering flexible, accessible and affordable learning opportunities. MOOC's have the potential to reach a large number of teachers, transcending geographical boundaries and providing them with skills and know ledge needed to enhance students learning outcomes.

This chapter explores the potential of MOOC's in teacher training, examining the benefits, challenges and best practices in designing and implementing MOOC's for teacher professional development. By harnessing the power of MOOC's, we can support teachers in

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developing their skills and knowledge, ultimately enhancing the quality education and improving student learning outcomes.

Benefits of MOOC's in Teacher Training-

MOOC's offer numerous benefits for teachers training, making them an attractive option for professional development. Some of the key benefits include:

1. Scalability: MOOC's can reach a large number of teachers, transcending geographical boundaries and allowing for wide spread dissemination of knowledge and skill.
2. Flexibility: Teachers can access MOOC's at their own pace, anytime and from any location, providing flexibility and convenience.
3. Cost-effectiveness: MOOC's reduce costs associated with traditional face to face trainings, such as travel accommodation and venue rental.
4. Personalization: MOOC's, offer teachers the opportunity to choose topics and learning paths that suit their needs and interests.
5. Access to Expert Knowledge: MOOC's can be designed and delivered by experts in their field, providing teachers with access to high quality knowledge and skills.
6. Self directed Learning: MOOC's allow teachers to take ownership of their learning, setting their own pace and learning style.
7. Collaboration and Community: MOOC's can facilitate collaboration and community building among teachers, providing opportunities for peer support and networking.
8. Just-in-time learning :MOOC's, can provide teachers with just-in-time learning opportunities ,allowing them to apply new skills and knowledge immediately.
9. Data-driven instruction: MOOC's can provide teachers with data and analytical on their learning, helping them identify areas for improvement.
10. Enhanced pedagogical skills: MOOC's, can help teachers develop enhanced pedagogical skills, such as instruction, design, curriculum management and assessment.

Some Additional Benefits:

1. Increased Teacher Confidence: MOOC's can help teachers feel more confident in their abilities leading to improved teacher morale and job satisfaction.
2. Improved Student Outcomes: By providing teachers with the skills and knowledge they need. MOOC's, can ultimately lead to improved student learning outcomes.
3. Addressing teachers shortages : MOOC's, can help address teacher shortages in specific subjects or regions by providing training and supports to teachers.
4. Supporting teachers induction : MOOC's, can provide new teachers with the support and guidance they need during the induction period.

Overall, MOOC's, offer arrange of benefits for teacher training, from scalability and flexibility to cost-effectiveness and personalization. By leveraging these benefits. MOOC's, can help support teachers professional development and ultimately improve student learning outcomes.

Challenges and Limitation:

MOOC's for teacher training have several limitations and challenges including :

1. High Attrition Rates: Many students struggle to complete MOOC, due to lack of motivation, flexibility on incentives. Research shows that only about% of enrolled students complete the course.

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2. Limited interaction: MOOC's often lack face-to-face interaction, making it difficult for students to get special attention from tutors on engage with peers.
3. Technological Barriers: Some learners may face challenges accessing MOOC's due to technological limitation ,such as poor internet connectivity or lack of access to necessary devices.
4. Equity issues: MOOC's may not be accessible to all, particularly those with disabilities, such as visual impairments, or those from disadvantaged backgrounds.
5. Quality and Credibility: Ensuring the quality and credibility of MOOC's can be a challenge, particularly with varying course standards and assessment method.
6. One-Size-Fits-All Approach: MOOC's often adopt a standardized Approach, which may not cater to individual learning needs or styles.
7. Limited Feed back and Support: With large numbers of students, providing personalized feedback and support can be difficult.
8. Cost and Certification: While many MOOC's are free, some may require payment for certification or course materials.

Despite these challenges, MOOC's can be an effective tool for teacher training, offering flexibility, accessibility and cost effectiveness. To overcome the limitations, strategies such as:

1. Setting clear Goals: Encouraging learners to set achievable goals and commit to a regular study schedule.
2. Active Engagement: Fostering engagement through discussion forums, peer interaction and feedback.
3. Personalized support: Providing additional support for learners, who need it, such as special accommodations for students with disabilities.

MOOC's have the potentials to democratise education, making high-quality educational resources available to a diverse population of learners worldwide.

Effective Design and Implementation:

Effective design and implementation of MOOC's for teacher training involve several key consideration :

Design considerations :

1. Clear learning objectives: Define specific skills or knowledge teachers will gain.
2. Modular content: Breakdown complex topics into bite-sized modular.
3. Multimedia content: Incorporate videos, podcasts, in fographics and interactive simulations.
4. Real-World Applications: Use case studies, scenarios,or projects relevant to teachers everyday experiences.
5. Assessment and Feedback: Regular quizzes, assignments and peer review to track progress.

Key Features:

1. Discussion Forums: Encourage peer-to-peer learning and support.
2. Live sessions: Host webinars or Q&A sessions with experts.
3. Collaborative projects: Pair teachers to work on projects, promoting teamwork.
4. Badges and certificates: Offer recognition for completing modules or achieving milestones.

Implementation strategies:

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1. Blended Learning: Combine online MOOC content with in-person sessions.
2. Mentorship: Pair participants with experienced educators or coaches.
3. Technical support: Ensure reliable platform access and responsive support.
4. Continuous Evaluation: Regularly assess and refine the MOOC's based feedback.

By incorporating these design and implementation strategies, MOOC's can effectively support teacher professional development, enhancing their skills and confidence in the classrooms.

Case Studies and Examples:

Some case studies and exemplar that can be used in Mooc's for teacher training:

Case study 1:

Flipped classroom:

Description : A high school math teacher uses a MOOC to flip her classroom, where students watch video lectures at home and work on problems in class.

Challenges : Ensuring students complete pre-class work, managing classroom time effectively.

Solutions: Teacher uses online quizzes to track student progress, creates collaborative activities for in-class work.

Case Study 2:

Descriptions: An elementary school teacher uses a MOOC to create personalised learning plans for students with different learning styles and abilities.

Challenges: Managing different learning paths, ensuring students stay on track.

Solutions: Teacher uses online tools to track student progress, creates flexible, groupings and one-on-one support.

Case Study 3:

Technology Integration:

Description: A middle school science teacher uses a MOOC to learn how to integrate technology into her classroom, including, simulations and virtual labs:

Challenges: Ensuring technology is used effectively, meaning technical issues.

Solutions: Teacher uses online resources to troubleshoot technical issues, creates backup plans for lessons.

Case Study 4:

Differential Instruction:

Description: A special education teacher uses a MOOC to learn strategies for differentiating instruction for students with divers needs.

Challenges: Meeting individual student needs managing classroom behaviour.

Solutions: Teacher uses online resources to create customized lesson plans, incorporating Universal Design for Learning (UDL) principles.

Case Study 5:

Online collaboration:

Description: A group of teachers from different schools collaborate on a MOOC project, creating a shared online resource for teaching a particular subject.

Challenges: Managing different work styles, ensuring effective communication.

Solutions: Teachers use online collaboration tools, set clear expectations and deadlines

Examples Activities:

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1. Discussion Forums: Teachers participate in online discussions, sharing experiences and insights on teaching strategies.
2. Peer Review: Teachers review and provide feedback on each other's lesson plans or projects.
3. Case-Based Learning: Teachers analyze and discuss case studies of teaching challenges and solutions.
4. Project-Based Learning: Teachers work on projects that apply teaching strategies and technologies learned in the MOOC.

These case studies and examples illustrate the potential benefits and challenges of using MOOC's, in teacher training and highlight the importance of effective design, support and implementation.

Conclusions

In conclusion, MOOC's offer a flexible accessible and collaborative way to support teacher training and professional development. By leveraging case studies, examples and interactive activities, MOOC can help teacher develop new skills, share, best practices and enhance student learning outcomes. Effective implementation and support are crucial to realizing the full potential of MOOC's in teacher training.

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Chapter-11: ICT and Preservation of Indigenous Arts and Heritage: Insights from Assam and Northeast India

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Abstract

In today's world, Information and Communication Technologies (ICTs) have become powerful instruments for documenting and safeguarding indigenous culture. From digitizing manuscripts to promoting handicrafts through e-commerce, ICT provides opportunities to preserve traditions that are at risk of fading away. This paper focuses on Assam and the wider Northeast India, a region rich in cultural diversity yet vulnerable to rapid socio-economic change. By drawing on specific examples—such as the Assam Archive, community-led digital repositories, museum initiatives, and online promotion of handloom and handicrafts—this study highlights both the possibilities and challenges of using ICT for cultural preservation. The discussion emphasizes the importance of community participation, sustainable infrastructure, and ethical practices to ensure that ICT contributes not only to documentation but also to cultural continuity and livelihoods.

Keywords: *ICT, indigenous heritage, Assam, Northeast India, digital preservation, handloom, oral traditions*

Introduction

Assam and the Northeast of India represent a vibrant cultural mosaic, where each community possesses its own distinct art forms, weaving techniques, oral traditions, music, and rituals. These rich cultural expressions, however, are increasingly under threat due to rapid urbanization, migration, globalization, and environmental challenges such as floods and soil erosion. Traditionally, cultural knowledge and practices were preserved through oral transmission and manual documentation, but with changing times, these methods are proving insufficient. In recent years, Information and Communication Technology (ICT) has emerged as a vital bridge connecting tradition with modernity. This paper seeks to explore how ICT can play a significant role in preserving the indigenous arts and heritage of Assam and the Northeast, drawing upon real-life examples from the region to analyze their effectiveness, challenges, and future possibilities.

Background and Literature Context:

The discourse on the role of Information and Communication Technology (ICT) in heritage preservation has gained significant academic and practical attention over the past few decades. Globally, ICT has transformed the ways in which cultural materials are safeguarded, accessed, and transmitted. Digitization projects have played a vital role in preserving fragile manuscripts, rare photographs, traditional art forms, and oral traditions that were once vulnerable to decay or loss. Initiatives such as UNESCO's "Memory of the World" programme and the European digital platform

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have demonstrated how technology can bridge the gap between the past and the present by providing open access to cultural heritage resources.

In the Indian context, the integration of ICT in heritage preservation has been steadily growing. Major national institutions—including libraries, museums, and archives—have undertaken large-scale digitization drives to protect and disseminate their valuable collections. The National Mission for Manuscripts and the National Digital Library of India are noteworthy examples that aim to conserve rare texts and make them available to scholars and the public through digital platforms.

In Assam and the broader Northeast, similar discussions have emerged within academic and policy circles. Scholars and cultural activists have highlighted the urgent need for creating digital repositories to safeguard rare manuscripts, ancient scripts, and traditional knowledge systems. More recently, the scope of ICT-based preservation has expanded to include oral narratives, indigenous crafts, folk music, and ritual practices—elements that represent the living and dynamic dimensions of heritage.

Government agencies and institutions such as the Centre for Development of Advanced Computing (CDAC) have been instrumental in supporting ICT-based documentation initiatives in the region. These institutional efforts are complemented by community-driven digital archives, where indigenous groups themselves actively record, curate, and upload their histories, songs, and oral traditions. Such grassroots initiatives not only democratize heritage preservation but also ensure that cultural ownership remains within the community. The coexistence of institutional frameworks and community-led digital movements thus reflects a growing recognition that cultural heritage in the twenty-first century must exist and evolve both offline and online, bridging tradition with technology.

Examples from Assam and the Northeast :

~ The Project - Digitizing অসম

The project is a pioneering attempt to digitize rare Assamese books and journals. By scanning and uploading these texts, the project not only reduces wear and tear of fragile originals but also makes them accessible worldwide. Researchers, students, and Assamese diaspora can now read works that were once confined to libraries. Concurrently, the Assam State Archives is actively engaged in preserving official public records through digitization, microfilming, and creating digital reference tools.

~ Visual Histories and Photography Collections

Projects like Visual Histories of Northeast India have digitized old photographs of tribal life, festivals, and landscapes. These collections preserve moments of history that might otherwise be forgotten, while also raising questions of representation—who owns these images, and how should they be shared?

~ Community-Led Archives

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One of the most inspiring developments has been the creation of community-driven digital archives which are crucial for preserving the cultural and linguistic traditions of indegenous people, particularly for communities with strong oral traditions. For example, the Bodo Dimasa Heritage Digital Archive (BDA) initiatives by the Dimasa and Bodo communities, which is entirely community-based involve training local youth to record songs, stories, and even traditional instruments. This ensures that culture is not just "studied" but preserved by the people themselves.

~ **Handloom and Handicrafts in the Digital Age**

The Northeast region of India is home to more than 1.6 million handloom weavers, forming one of the largest concentrations of traditional artisans in the country. In Assam, the silk industry—particularly known for its exquisite Muga and Eri varieties—continues to symbolize the region's rich cultural identity and craftsmanship. In recent years, Information and Communication Technology (ICT) has brought new opportunities for these artisans. Through e-commerce platforms, digital exhibitions, and online catalogues, many weavers and craftsperson's are now able to reach wider markets and showcase their work beyond local boundaries. For example, The North Eastern Handicrafts and Handlooms Development Corporation (NEHHDC) launched the e-commerce portal Purbashree.com to sell handloom and handicraft items directly to consumers across India and abroad as well.

However, the benefits of this digital shift have not reached everyone equally. Studies and field reports indicate that a significant number of artisans still remain disconnected from such digital platforms. Poor internet connectivity, lack of infrastructure, and limited digital literacy continue to pose major challenges. As a result, while ICT has the potential to transform the handloom and handicraft sectors, its success largely depends on inclusive access, training, and sustained institutional support.

~ **Local Museums and Colleges**

Institutions like Gargaon College in Sivasagar have set up museums that display traditional looms, masks, and instruments. Importantly, these are being catalogued digitally so that researchers and students can access them online. This blending of physical museums with digital records strengthens education and awareness.

Opportunities of ICT for Heritage :

The use of Information and Communication Technology (ICT) has opened up several promising opportunities for the preservation and promotion of cultural heritage.

One major advantage is documentation at scale—fragile manuscripts, rare photographs, and oral traditions can now be digitized and stored for future generations, ensuring their survival beyond physical decay.

ICT has also enabled global visibility for regional cultures. Assamese crafts, traditional music, and textiles can now reach audiences far beyond the state through digital exhibitions, online platforms, and social media. This not only enhances appreciation for local heritage but also connects artisans and performers to a wider network of admirers and consumers.

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Another important aspect is community empowerment. By creating and managing their own digital archives, local communities can take ownership of their cultural resources, reducing dependence on external institutions and ensuring that representation remains authentic and inclusive.

Moreover, ICT contributes to livelihood support by expanding market access. E-commerce platforms and online marketing tools provide artisans, weavers, and performers with new economic opportunities, helping them sustain traditional practices in a modern economy.

Finally, ICT enhances educational access. Digital repositories and virtual archives make cultural materials accessible to students, scholars, and researchers across the world, encouraging interdisciplinary study and global cultural exchange.

Together, these opportunities demonstrate how ICT can act as a bridge between tradition and modernity—preserving heritage while enabling it to evolve and thrive in the digital age.

Challenges and Concerns

While the potential of ICT in preserving and promoting cultural heritage is immense, several challenges and concerns continue to hinder its effective implementation.

First, a significant digital divide persists among artisans, especially in rural and remote areas. Many traditional craftsperson's and performers have limited or no access to reliable internet connectivity, smartphones, or computers. Even when such facilities exist, a lack of digital literacy often prevents them from using online tools, social media, or e-commerce platforms to their full advantage. This gap not only limits participation but also risks widening socio-economic inequalities between digitally literate and non-literate communities.

Second, digitization is not a one-time process—it requires ongoing maintenance, technical upgrades, and financial support. Digital archives, for instance, demand regular data backup, software updates, and secure storage to prevent data loss or corruption. However, many local institutions and community projects struggle to secure consistent funding, resulting in incomplete or outdated repositories.

Another major concern is the lack of standardized metadata and technical guidelines. Without uniform cataloguing methods or metadata frameworks, digital collections often become difficult to navigate or search. This limits their academic and public utility and prevents integration with larger national or global digital heritage databases.

Ethical considerations also play a crucial role. Not all cultural materials are meant for public viewing—certain rituals, songs, or artifacts may hold sacred or restricted significance within specific communities. The question of "what should be digitized" or "who has the right to access it" remains sensitive and complex. Inappropriate digitization or open access can lead to cultural misrepresentation or exploitation.

Finally, the commercialization of culture through digital platforms introduces new dilemmas. While online marketing can empower artisans economically, it also risks reducing traditional and spiritual

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practices into marketable "products." Such commodification can dilute their cultural meaning and transform heritage into a form of consumer entertainment rather than a living tradition.

Thus, while ICT opens up transformative opportunities for cultural preservation, it must be approached with sensitivity, inclusivity, and ethical awareness to ensure that technological progress does not come at the cost of cultural integrity.

Discussion :

The cases from Assam and Northeast India show that ICT works best when communities are at the Centre. Government agencies and institutions provide infrastructure, but long-term success depends on whether people themselves feel ownership. For instance, community-led archives not only preserve heritage but also strengthen identity among younger generations.

On the economic side, handloom and handicraft sectors show how ICT can both preserve and promote culture. If artisans are trained in digital tools and given market access, ICT can improve their livelihoods while ensuring cultural sustainability.

Recommendations :

1. **Training local youth as cultural archivists:**

One of the most effective ways to ensure long-term preservation of indigenous heritage is by involving local communities themselves. Training local youth in basic digital and archival skills can empower them to document their own traditions—be it oral histories, crafts, or rituals. Such training can include photography, video documentation, metadata tagging, and basic editing. This not only creates employment opportunities for young people but also ensures that heritage documentation is done with cultural sensitivity and authenticity.

2. **Developing region-specific digital platforms:**

To make digitization inclusive, there is a need to create digital platforms in local languages such as Assamese and various tribal languages. Many existing heritage platforms are available only in English or Hindi, which limits accessibility for grassroots communities. Region-specific platforms would make it easier for artisans, performers, and researchers to upload, access, and share cultural materials. They would also help bridge the digital divide and encourage wider participation from rural and indigenous groups.

3. **Ensuring sustainable funding and long-term maintenance:**

Digitization initiatives often begin with enthusiasm but fade away due to lack of continued support. Therefore, funding for such projects should go beyond short-term grants. Governments, NGOs, and private institutions should collaborate to create sustainable financial models that ensure regular updates, server maintenance, and technological upgrades. This will make digital repositories reliable and functional in the long run.

4. **Linking artisans with e-commerce and training programs:**

For many traditional artisans, digital exposure can transform livelihoods. However, they often lack the skills to navigate e-commerce platforms or promote their work online. Organizing regular workshops,

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training sessions, and mentorship programs can help artisans learn about online marketing, digital payments, and packaging standards. Such initiatives would not only increase income but also promote cultural industries as viable economic sectors.

5. **Formulating ethical guidelines for cultural representation:**

Digitization must always respect the rights and sentiments of the communities involved. Ethical guidelines are essential to ensure that indigenous groups retain control over how their cultural materials are used or shared. Consent-based sharing, proper attribution, and community-led decision-making should form the foundation of any digital heritage initiative. This approach helps prevent cultural exploitation and promotes respectful representation of living traditions.

Conclusion

Information and Communication Technology (ICT) cannot fully replace the traditional means through which culture has been transmitted across generations—through oral narratives, apprenticeship, and community rituals. However, it can serve as a powerful complement to these practices by enhancing their reach, visibility, and longevity. In Assam and the wider Northeast region, where cultural diversity and artistic traditions are exceptionally rich, ICT has already begun to make a tangible difference. Digital archives now safeguard rare manuscripts and folk songs that were once vulnerable to decay, while online platforms allow artisans and performers to share their crafts with audiences far beyond their local communities.

Yet, the success of such initiatives depends on how responsibly these technologies are implemented. Heritage preservation must not become a one-sided process led by external agencies or technologists alone. Instead, it should involve the communities themselves as active collaborators, ensuring that their voices, values, and cultural rights remain at the Centre of every project. When applied thoughtfully, ICT can act as both a preservation tool and a means of empowerment—bridging the gap between tradition and modernity. In doing so, it can help ensure that the indigenous arts and cultural heritage of Assam and the Northeast are not only protected but continue to thrive and inspire future generations.

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Chapter-12 From Neurons to Convolutions: Understanding ANN and CNN

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Abstract

Two well-known deep learning architectures are Artificial Neural Networks (ANNs) & Convolutional Neural Networks (CNNs). ANNs provide the fundamental framework for modeling complex relationships in data. On the other hand, CNNs are specialized networks designed to handle spatially structured data, like images and videos. By examining these two methods' architectures, underlying theories, uses, advantages, and disadvantages, this chapter provides a comparative analysis. Allthough both of them shares biological inspiration, the two architectures' design objectives and intended uses are very different. This chapter emphasizes on to draw a clear picture for the learners about ANN & CNN,

1. Introduction: The way that machines process information has been completely transformed by artificial intelligence and machine learning in recent time. Neural networks are one of the most important contributors among the different methods. In their most basic form, ANNs are made to simulate non-linear input-output mappings. However, CNNs, which expand ANNs by adding convolutional layers that preserve spatial information, were developed as a result of the quick expansion of computer vision and multimedia applications (LeCun, Bengio, & Hinton, 2015). This discussion explores the similarities and differences between ANNs and CNNs, emphasizing their respective strengths, weaknesses, and application areas.

2. History:

2.1 History of Artificial Neural Networks (ANNs)

a. 1940s–1950s:

In 1943, The McCulloch & Pitts Model came into effect. Warren McCulloch and Walter Pitts put forth a basic model of artificial neurons using binary thresholds, This is considered as Neural network's first mathematical model.

In 1949, Hebbian Learning came to light. Donald Hebb postulated that when neurons fire in unison, synaptic strength rises. That is "Neurons that fire together wire together."

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b. In 1958 the concept of Perceptron arrived and a huge leap in this advancement happened. Perceptron is a single-layer neural network, which were created by Frank Rosenblatt. It was capable of learning linearly separable functions & is regarded as technological breakthrough in the field of AI.

c. Around 1969, Minsky and Papert published a book titled "*Perceptrons*," that outlined the drawbacks of single-layer perceptrons. One such example is their incapacity to solve XOR. This resulted in the first AI Winter, a drop in neural network research.

d. Revival of ANN took place after Rumelhart, Hinton, & Williams made backpropagation widely used in 1986. Backpropagation technique made it possible for multi-layer neural networks (MLPs) to learn. This signaled the revival of ANN research & subsequently led to time series prediction, speech recognition, and OCR applications..

e. During 1990s, with tremendous growth and associated difficulties expanding, applications and theoretical work still had trouble training deep networks. This was primarily because of limited processing power and vanishing gradients.

f. The Deep Learning Era Begins in 2006. Deep Belief Networks (DBNs) were first presented by Geoffrey Hinton, who also demonstrated how layer-wise unsupervised pre-training could aid in the convergence of deep networks. And the deep learning movement began as a result.

2.2 History of Convolutional Neural Networks (CNNs)

1. In 1980, inspired by the visual cortex, Kunihiko Fukushima proposed the Neocognitron. He presented the ideas of subsampling and convolution.

2. In the year 1989, the first CNN, LeNet-5, was created by Yann LeCun to recognize handwritten digits, such as ZIP codes. It introduced convolutional, pooling, fully connected, and backpropagation-trained layers.

3. During 1990s–2000s, CNNs remained in the Shadows because CNNs needed a lot of computation. Training deep CNNs was difficult because of limited GPUs and non availability of large datasets as small datasets were only in hand. They were mostly used for specialized image processing tasks.

4. In 2012, AlexNet brought the breakthrough. Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton developed AlexNet, which won ImageNet 2012 by a large margin compared to other models. Important advances included by them were GPU acceleration, Dropout for regularization, ReLU activation, and deep architecture.

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5. From 2014 till now, CNN architectures have progressed rapidly. Examples include VGGNet (2014), GoogLeNet/Inception (2014), ResNet (2015), which introduced residual connections, DenseNet, EfficientNet, and Vision Transformers (ViTs), which are hybrid and post-CNN models came to existence and forward stride is still on.

CNN Applications: CNNs are used in image and video recognition, object detection, medical imaging, autonomous driving, and natural language processing, such as text classification etc.

Summary table

Era	ANN Milestone	CNN Milestone
1940s–50s	McCulloch-Pitts model, Hebbian learning	—
1958	Perceptron (Rosenblatt)	—
1969	Perceptron limitations (Minsky & Papert)	—
1980	Backpropagation revival	Neocognitron (Fukushima)
1989	MLPs with backpropagation	LeNet-5 (LeCun)
2006+	Deep learning with DBNs (Hinton)	—
2012+	Resurgence with GPU-trained deep ANNs	AlexNet, ResNet, EfficientNet, MobileNet etc.

3. Architecture

3.1 Artificial Neural Network (ANN): ANNs consist of an input layer, one or more hidden layers, and

an output layer. Each neuron in a given layer is connected to all neurons in the next layer, forming a

fully connected architecture (Goodfellow, Bengio, & Courville, 2016).

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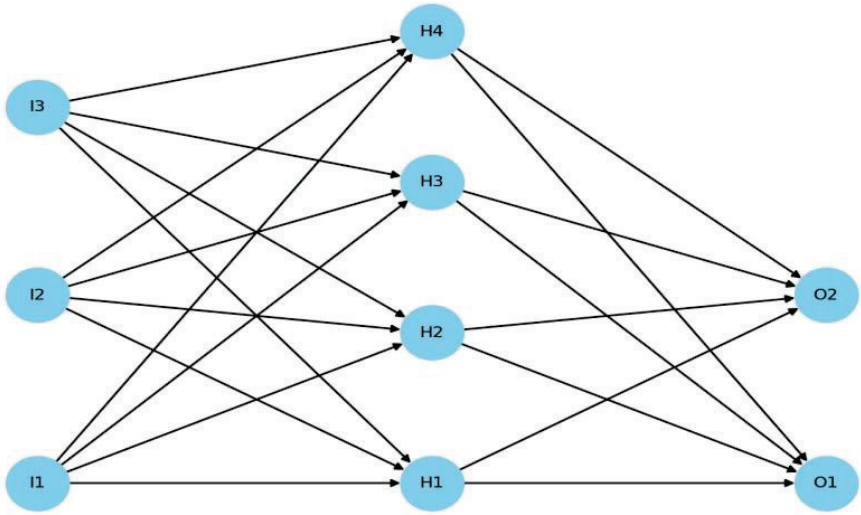
Figure 1. Basic Architecture of an Artificial Neural Network (ANN)



Such networks are very flexible and can represent complex non-linear functions. However, when applied to high-dimensional data like images, they require too many parameters, which can lead to inefficiency.

3.2 Convolutional Neural Network (CNN): CNNs include convolutional and pooling layers along with fully connected layers. Convolutional filters let CNNs capture local patterns such as edges, textures, and shapes (Krizhevsky, Sutskever, & Hinton, 2012).

Pooling layers reduce dimensionality and improve computational efficiency while maintaining essential information. The hierarchical learning mechanism enables CNNs to create more complex feature representations. That makes them ideal for analyzing images and videos.

4. Working Principles

4.1 ANN Operation: The input features appear as a flattened vector. Each neuron computes a weighted sum of inputs and then applies an activation function. The absence of built-in spatial awareness limits ANNs in tasks that involve structured data like images (Schmidhuber, 2015).

4.2 CNN Operation: CNNs process inputs with convolutional filters that preserve spatial relationships among pixels. Pooling layers cut down features to reduce redundancy. The final fully connected layers handle classification or regression tasks. This setup enables CNNs to learn features automatically rather than depending on manually created feature extraction.

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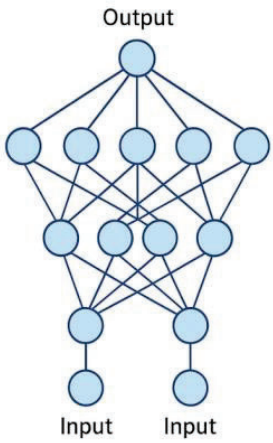
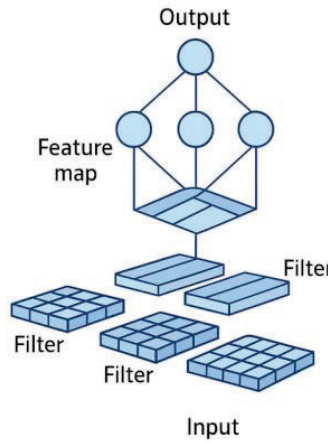
ARTIFICIAL NEURAL NETWORK (ANN)



CONVOLUTIONAL NEURAL NETWORK (CNN)



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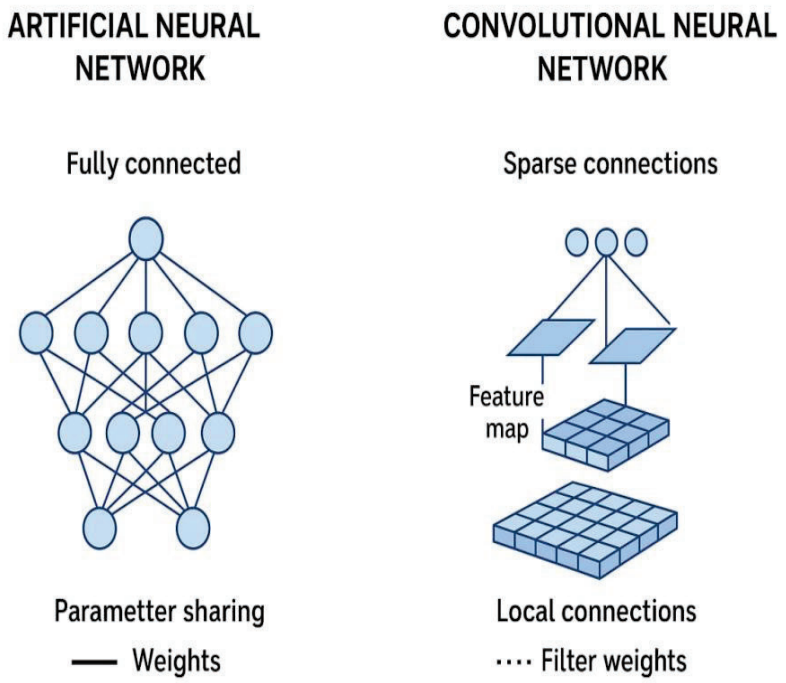

5. Key Differences

Aspect	Neural Network (ANN)	Convolutional Neural Network (CNN)
Data Handling	Treats input as flat vectors	Preserves spatial/temporal structure
Connections	Fully connected	Local connectivity, shared weights
Parameters	Very high for large inputs	Reduced due to weight sharing
Applications	Tabular data, simple prediction	Image, video, speech, NLP
Efficiency	Less efficient for image data	Highly efficient for spatial data

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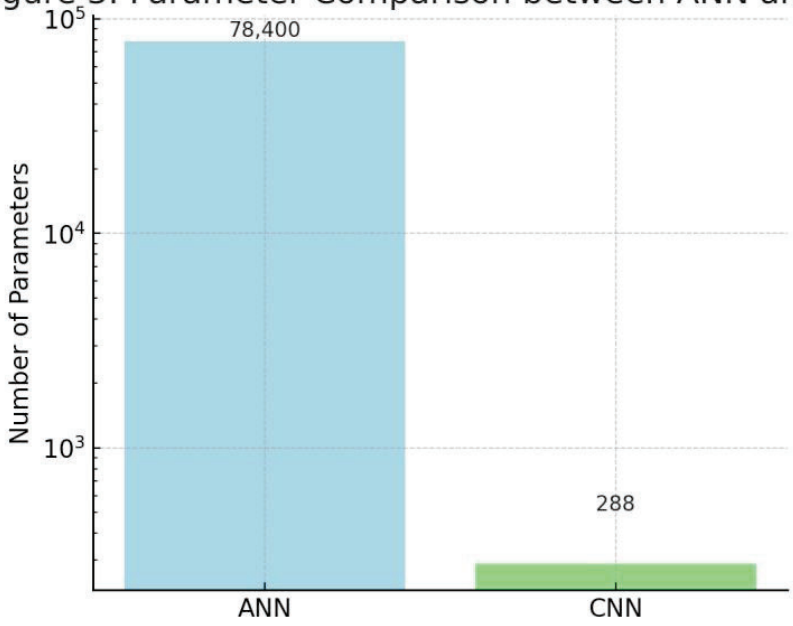
Figure 3. Parameter Comparison between ANN and CNN



6. Applications

6.1 ANN Applications: ANNs are often used in predictive analytics, financial forecasting, customer churn prediction, and healthcare diagnostics. These applications depend on structured tabular datasets (Haykin, 2009).

6.2 CNN Applications: CNNs are the top choice for computer vision tasks such as image recognition, object detection, medical imaging, and autonomous driving. Their ability to learn spatial hierarchies makes them crucial for large-scale vision applications (Rawat & Wang, 2017).

7. Advantages and Limitations

7.1 ANN:

Advantages: It is general-purpose, easy to implement, and effective for small to medium-sized datasets.

Limitations: It has poor scalability for high-dimensional data, lacks built-in spatial feature extraction, and carries a risk of overfitting.

7.2 CNN:

Advantages: Automatic feature extraction, reduced parameter count, and robustness to distortions.

Limitations: Requires large labeled datasets, is computationally expensive, and needs complex hyperparameter tuning.

8. Conclusion

ANNs and CNNs, while inspired by biology, serve different purposes in deep learning. ANNs work best with structured, non-spatial data. In contrast, CNNs are great for spatially

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correlated data, like images and videos. Their complementary roles often lead to hybrid models. In these models, CNNs extract features and ANNs, specifically the fully connected layers, handle the final classification. The decision to use one over the other relies on the data characteristics and the specific problem at hand.

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Chapter-13: The Growth Estimate of Iterated Entire Functions in Terms of (p, q)-th Order

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1. Introduction, Definitions and Notation

Let $f(z)$ and $g(z)$ be two transcendental entire functions defined in the open complex plane **C**. It is well known [1], {[15], p-67, Th-1.46} that

$$\lim_{r\to\infty}\frac{T(r,fog)}{T(r,f)}=\infty \text{ and } \lim_{r\to\infty}\frac{T(r,fog)}{T(r,g)}=\infty.$$

After this Singh [11], Lahiri [7], Song and Yang [13], Singh and Baloria [12], Lahiri and Sharma [8] and Datta and Biswas [3], [4] proved different results on comparative growth property of composite entire functions. In a resent paper [2] Dutta study some comparative growth of iterated entire functions. In this chapter, we investigate the comparative growth of iterated entire functions in terms of its (p,q)-th order. We do not explain the standard notations and definitions of the theory of entire functions as those are available in [5], [14] and [15].

The following definitions are well known.

Definition 1.1. The order ρ_f and lower order λ_f of a meromorphic function $f(z)$ is defined as

$$\rho_f=\limsup_{r\to\infty}\frac{\log T(r,f)}{\log r}$$

and

$$\lambda_f=\liminf_{r\to\infty}\frac{\log T(r,f)}{\log r}.$$

If $f(z)$ is entire then

$$\rho_f=\limsup_{r\to\infty}\frac{\log\log M(r,f)}{\log r}$$

and

$$\lambda_f=\liminf_{r\to\infty}\frac{\log\log M(r,f)}{\log r}.$$

Notation 1.2. [10] $\log^{[0]}x=x, \exp^{[0]}=x$ and for positive integer *m*,

$$\log^{[m]}x=\log(\log^{[m-1]}x),\ \exp^{[m]}x=\exp(\exp^{[m-1]}x).$$

Definition 1.3. The p-th order ρ_f^p and lower p-th order λ_f^p of a meromorphic function $f(z)$ is defined as

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$$\rho_f^p = \limsup_{r\to\infty} \frac{\log^{[p]} T(r,f)}{\log r}$$

and

$$\lambda_f^p = \liminf_{r\to\infty} \frac{\log^{[p]} T(r,f)}{\log r}.$$

If $f(z)$ is entire then

$$\rho_f^p = \limsup_{r\to\infty} \frac{\log^{[p+1]} M(r,f)}{\log r}$$

and

$$\lambda_f^p = \liminf_{r\to\infty} \frac{\log^{[p+1]} M(r,f)}{\log r}.$$

Clearly $\rho_f^p \le \rho_f^{p-1}$ and $\lambda_f^p \le \lambda_f^{p-1}$ for all p and when $p=1$ then p-th order and lower p-th order coincide with classical order and lower order respectively.

Definition 1.4. The (p,q) -th order $\rho_f(p,q)$ and lower (p,q)-th order $\lambda_f(p,q)$ of a meromorphic function $f(z)$ is define as

$$\rho_f(p,q) = \limsup_{r\to\infty} \frac{\log^{[p]} T(r,f)}{\log^{[q]} r}$$

and

$$\lambda_f(p,q) = \liminf_{r\to\infty} \frac{\log^{[p]} T(r,f)}{\log^{[q]} r}.$$

If $f(z)$ is an entire function then

$$\rho_f(p,q) = \limsup_{r\to\infty} \frac{\log^{[p+1]} M(r,f)}{\log^{[q]} r}$$

and

$$\lambda_f(p,q) = \liminf_{r\to\infty} \frac{\log^{[p+1]} M(r,f)}{\log^{[q]} r}$$

where $p \ge q \ge 1$.

Clearly $\rho_f(p,1) = \rho_f^p$ *and* $\lambda(p,1) = \lambda_f^p$.

Definition 1.5. Let $f(z)$ be an entire function of finite p- th order ρ_f^p then we define σ_f^p as

$$\sigma_f^p = \limsup_{r\to\infty} \frac{\log^{[p]} M(r,f)}{r^{\rho_f^p}}.$$

According to Lahiri and Banerjee [6] if $f(z)$ *and* $g(z)$ are entire functions then the iteration of f with respect to g is defined as follows:

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$$f_1(z)=f(z)$$
$$f_2(z)=f(g(z))=f\left(g_1(z)\right)$$
$$f_3(z)=f\left(g(f(z))\right)=f\left(g_2(z)\right)=f\left(g\left(f_1(z)\right)\right)$$
....
$$f_n(z)=f(g(f.....(f(z)\ or\ \ g(z)).....)),$$

according as n is odd or even,

and so

$$g_1(z)=g(z)$$
$$g_2(z)=g(f(z))=g\left(f_1(z)\right)$$
$$g_3(z)=g\left(f_2(z)\right)=g\left(f(g(z))\right)$$
....
$$g_n(z)=g\left(f_{n-1}(z)\right)=g\left(f\left(g_{n-2}(z)\right)\right).$$

Clearly all $f_n(z)$ *and* $g_n(z)$ *are entire functions.*

2. Lemmas

In this section we present some lemmas which will be needed in the sequel.

Lemma 2.1. [5] Let $f(z)$ be an entire function. For $0 \le r < R < \infty$, we have

$$T(r,f) \le \log^+ M(r,f) \le \frac{R+r}{R-r} T(R,f).$$

Lemma 2.2. [1] If $f(z)$ and $g(z)$ are any two entire functions, for all sufficiently large values of r,

$$M\left(\frac{1}{8}M\left(\frac{r}{2},g\right)-|g(0)|,f\right) \le M(r,fog) \le M\left(M(r,g),f\right).$$

Lemma 2.3. [9] Let $f(z)$ and $g(z)$ be two entire functions. Then we have

$$T(r,fog) \ge \frac{1}{3}\log M\left(\frac{1}{8}M\left(\frac{r}{4},g\right)+O(1),f\right).$$

Lemma 2.4. Let $f(z)$ and $g(z)$ be two entire functions of non zero finite (p,q)-th order $\rho_f(p,q)$ and $\rho_g(p,q)$ respectively, then for any $\varepsilon > 0$ *and* $p \ge q \ge 1$,

$$\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n) \le \begin{cases} (\rho_f(p,q)+\varepsilon)\log^{[q]} M(r,g)+O(1) & \text{when } n \text{ is even,} \\ (\rho_g(p,q)+\varepsilon)\log^{[q]} M(r,f)+O(1) & \text{when } n \text{ is odd} \end{cases}$$

for all sufficiently large values of r.

Proof. First suppose that n is even. Then from second part of Lemma 2.2 and Definition of (p,q)-th order, it follows that for all sufficiently large values of r,

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$$M(r,fn)\le M\left(M\left(r,g_{n-1}\right),f\right)$$

$$i.e.,\ \log^{[p+1]}M\left(r,f_n\right)\le\log^{\left[p+1\right]}M\left(M\left(r,g_{n-1}\right),f\right)$$

$$\le(\rho_f(p,q)+\varepsilon)\log^{[q]}M\left(r,g_{n-1}\right).$$

$$So,\ \log^{\left[p+2\right]}M\left(r,f_n\right)\le\log^{\left[q+1\right]}M\left(r,g(f_{n-2})\right)+O(1)$$

$$\log^{\left[p+2-q\right]}M\left(r,f_n\right)\le\log M\left(r,g(f_{n-2})\right)+O(1).$$

Taking repeated logarithms p times, we get

$$\log^{\left[2p+2-q\right]}M\left(r,f_n\right)\le\log^{\left[p+1\right]}M(M(r,f_{n-2}),\mathrm{g})+O(1)$$

$$\le(\rho_g(p,q)+\varepsilon)\log^{[q]}M(r,f_{n-2})+O(1),$$

$$i.e.,\ \log^{[2p+3-q]}M\left(r,f_n\right)\le\log^{\left[q+1\right]}M\left(r,f_{n-2}\right)+O(1)$$

$$\log^{[2p+3-2q]}M\left(r,f_n\right)\le\log M\left(r,f_{n-2}\right)+O(1).$$

Again taking repeated logarithms p times, we get

$$\log^{[3(p+1)-2q]}M\left(r,f_n\right)\le(\rho_f(p,q)+\varepsilon)\log^{[q]}M(r,\mathrm{g}_{n-3})+O(1).$$

Finally, after taking repeated logarithms *(n-4)(p+1)* times more, we have for all sufficiently large values of r,

$$\log^{[(n-1)(p+1)-(n-2)q]}M\left(r,f_n\right)\le(\rho_f(p,q)+\varepsilon)\log^{[q]}M\left(r,\mathrm{g}\right)+O(1).$$

Similarly if n is odd then for all sufficiently large values of r,

$$\log^{[(n-1)(p+1)-(n-2)q]}M\left(r,f_n\right)\le(\rho_g(p,q)+\varepsilon)\log^{[q]}M\left(r,f\right)+O(1).$$

This proves the lemma.

Lemma 2.5. Let $f(z)$ and $g(z)$ be two entire functions of non zero finite lower (p,q)-th order $\lambda_f(p,q)$ *and* $\lambda_g(p,q)$ respectively, then for any

$$0<\varepsilon<\min\{\lambda_f(p,q)\ ,\ \lambda_g(p,q)\}\ \ and\ \ \ p\ge q\ge 1,$$

$$\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)\ge\begin{cases}\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}M\left(\dfrac{r}{2^{n-1}},g\right)+O(1)\ when\ n\ is\ even\\ \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]}M\left(\dfrac{r}{2^{n-1}},f\right)+O(1)\ \ when\ n\ is\ odd,\end{cases}$$

for all sufficiently large values of r.

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Proof. First suppose that n is even. Then from first part of Lemma 2.2 we have for all sufficiently large values of r and for any $0<\varepsilon<\min\{\lambda_f(p,q),\lambda_g(p,q)\}$,

$$M(r,f_n)=M\left(r,f(g_{n-1})\right)$$
$$\geq M\left(\frac{1}{8}M\left(\frac{r}{2},g_{n-1}\right)-\left|g_{n-1}(0)\right|,f\right)$$
$$\geq M\left(\frac{1}{16}M\left(\frac{r}{2},g_{n-1}\right),f\right).$$

$$\therefore\ \log^{[p+1]}M(r,f_n)\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{16}M\left(\frac{r}{2},g_{n-1}\right)\right],$$

using the Definition 1.4,

$$i.e.,\ \log^{[p+1]}M(r,f_n)\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}M\left(\frac{r}{2},g_{n-1}\right)+O(1)$$

$$i.e.,\ \log^{[p+2]}M(r,f_n)\geq\log^{[q+1]}M\left(\frac{r}{2},g(f_{n-2})\right)+O(1)$$

$$i.e.,\ \log^{[p+2-q]}M(r,f_n)\geq\log M\left(\frac{1}{16}M\left(\frac{r}{2^2},f_{n-2}\right),\mathrm{g}\right)+O(1).$$

Taking repeated logarithms p times, we get

$$\log^{[2p+2-q]}M(r,f_n)\geq\log^{[p+1]}M\left(\frac{1}{16}M\left(\frac{r}{2^2},f_{n-2}\right),\mathrm{g}\right)+O(1)$$
$$\geq\left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]}\left(\frac{1}{16}M\left(\frac{r}{2^2},f_{n-2}\right)\right)+O(1)$$

$$\log^{[2p+3-2q]}M(r,f_n)\geq\log M\left(\frac{r}{2^2},f_{n-2}\right)+O(1).$$

Again taking repeated logarithms p times, we get

$$\log^{[2p+2-2q]}M(r,f_n)\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{16}M\left(\frac{r}{2^3},g_{n-3}\right)\right]+O(1)$$
$$\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}M\left(\frac{r}{2^3},g_{n-3}\right)+O(1).$$

Finally, after taking repeated logarithms *(n-4)(p+1)* times more, we have for all sufficiently large values of r,

$$\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{16}M\left(\frac{r}{2^{n-1}},g\right)\right]+O(1)$$

$$i.e.,\ \log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)\geq\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}M\left(\frac{r}{2^{n-1}},g\right)+O(1).$$

Similarly if n is odd then for all sufficiently large values of r,

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$$\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n) \geq \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]} M\left(\frac{r}{2^{n-1}},f\right)+O(1).$$

This proves the lemma.

Lemma 2.6. Let *f(z)* and *g(z)* be two non- constant entire functions, such that $0<\rho_f(p,q)<\infty$ *and* $0<\rho_g(p,q)<\infty$. Then for all sufficiently large *r* and $\varepsilon > 0$,

$$\log^{[(n-1)p+(n-2)(1-q)]} T(r,f_n) \leq \begin{cases} \left(\rho_f(p,q)+\varepsilon\right)\log^{[q]} M(r,g)+O(1) & \text{when } n \text{ is even,} \\ \left(\rho_g(p,q)+\varepsilon\right)\log^{[q]} M(r,f)+O(1) & \text{when } n \text{ is odd} \end{cases}$$

where $p \geq q \geq 1$.
The lemma follows from Lemma 2.1 and Lemma 2.4.

Lemma 2.7. Let $f(z)$ and g(z) be two entire functions such that $0<\lambda_f(p,q)<\infty$ and $0<\lambda_g(p,q)<\infty$. Then for any $\varepsilon(0<\varepsilon<\min\{\lambda_f(p,q),\ \lambda_g(p,q)\})$ and $p \geq q \geq 1$,

$$\log^{[(n-1)p+(n-2)(1-q)]} T(r,f_n) \geq \begin{cases} \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]} M\left(\frac{r}{4^{n-1}},g\right)+O(1) & \text{when } n \text{ is even,} \\ \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]} M\left(\frac{r}{4^{n-1}},f\right)+O(1) & \text{when } n \text{ is odd} \end{cases}$$

for all sufficiently large values of *r*.

Proof. To prove this lemma we first suppose that *n* is even. Then from Lemma 2.1and Lemma 2.3 we get for any $\varepsilon(0<\varepsilon<\min\{\lambda_f(p,q),\ \lambda_g(p,q)\})$ and for all sufficiently large values of *r*,

$$\begin{aligned} T(r,f_n) &= T\left(r,f(g_{n-1})\right) \\ &\geq \frac{1}{3}\log M\left(\frac{1}{8}M\left(\frac{r}{4},g_{n-1}\right)+O(1),f\right). \\ \therefore\ \log^{[p]} T(r,f_n) &\geq \log^{[p+1]} M\left(\frac{1}{8}M\left(\frac{r}{4},g_{n-1}\right)+O(1),f\right)+O(1) \\ &\geq \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{8}M\left(\frac{r}{4},g_{n-1}\right)+O(1)\right]+O(1) \\ &\geq \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{9}M\left(\frac{r}{4},g_{n-1}\right)\right]+O(1) \end{aligned}$$

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$$\geq \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]} M\left(\frac{r}{4},g_{n-1}\right)+O(1)$$

$$\geq \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q-1]} T\left(\frac{r}{4},g_{n-1}\right)+O(1)$$

$$\geq \left(\lambda_f(p,q)-\varepsilon\right)\log^{[q-1]}\left[\frac{1}{3}\log M\left(\frac{1}{8}M\left(\frac{r}{4^2},f_{n-2}\right)+O(1),g\right)\right]+O(1),$$

i.e., $\log^{[p+1]} T(r,f_n)\geq \log^{[q+1]} M\left(\frac{1}{8}M\left(\frac{r}{4^2},f_{n-2}\right)+O(1),g\right)+O(1)$

i.e., $\log^{[p+1-q]} T(r,f_n)\geq \log M\left(\frac{1}{8}M\left(\frac{r}{4^2},f_{n-2}\right)+O(1),g\right)+O(1)$

i.e., $\log^{[2p+1-q]} T(r,f_n)\geq \log^{[p+1]} M\left(\frac{1}{8}M\left(\frac{r}{4^2},f_{n-2}\right)+O(1),g\right)+O(1)$

$$\geq \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{8}M\left(\frac{r}{4^2},f_{n-2}\right)+O(1)\right]+O(1)$$

$$\geq \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]}\left[\frac{1}{9}M\left(\frac{r}{4^2},f_{n-2}\right)\right]+O(1).$$

i.e., $\log^{[2p+1-q]} T(r,f_n)\geq \left(\lambda_g(p,q)-\varepsilon\right)\log^{[q]} M\left(\frac{r}{4^2},f_{n-2}\right)+O(1)$

....
....

$\therefore \log^{[(n-1)p+(n-2)(1-q)]} T(r,f_n)\geq (\lambda_f(p,q)-\varepsilon)\log^{[q]} M\left(\frac{r}{4^{n-1}},g\right)+O(1)$ *when n is even.*

Similarly,

$\log^{[(n-1)p+(n-2)(1-q)]} T(r,f_n)\geq (\lambda_g(p,q)-\varepsilon)\log^{[q]} M\left(\frac{r}{4^{n-1}},f\right)+O(1)$ *when n is odd.*

This proves the lemma.

3. Theorems

Theorem 3.1. Let f and g be two non-constant entire functions of non- zero finite (p,q)-th order and lower (p,q)-th order, also $0<\sigma_f^q,\sigma_g^q<\infty$. Then

$$(i)\quad \liminf_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T(r,f(g))}\leq \frac{4^{\rho_g^q}\rho_f(p,q)}{\lambda_f(p,q)},$$

$$(ii)\quad \limsup_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T(r,f(g))}\geq \frac{\lambda_f(p,q)}{\left(2^{n-1}\right)^{\rho_g^q}\rho_f(p,q)}$$

when n is even and

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$$(iii)\quad \liminf_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T\left(r,g(f)\right)}\le\frac{4^{\rho_f^q}\rho_g(p,q)}{\lambda_g(p,q)},$$

$$(iv)\quad \limsup_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T\left(r,g(f)\right)}\ge\frac{\lambda_g(p,q)}{\left(2^{n-1}\right)^{\rho_f^q}\rho_g(p,q)}$$

when n is odd.

Proof. First we suppose that n is even, then from Lemma 2.4 and the Definition 1.5 we have for all large r and $\varepsilon>0$,

$$\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)\le\left(\rho_f(p,q)+\varepsilon\right)\log^{[q]}M\left(r,g\right)+O(1)$$

$$\le\left(\rho_f(p,q)+\varepsilon\right)\left(\sigma_g^q+\varepsilon\right)r^{\rho_g^q}+O(1). \qquad (3.1)$$

From Lemma 2.3 we get

$$T\left(r,f(g)\right)\ge\frac{1}{3}\log M\left(\frac{1}{16}M\left(\frac{r}{4},g\right),f\right).$$

Since $\lambda_f(p,q)$ is the lower (p,q)-th order of f so for given $\varepsilon(0<\varepsilon<\lambda_f(p,q))$ and for all large values of r,

$$\log^{[p]}T\left(r,f(g)\right)\ge\log^{[p+1]}M\left(\frac{1}{16}M\left(\frac{r}{4},g\right),f\right)+\mathrm{O}(1)$$

$$\therefore\ \log^{[p]}T\left(r,f(g)\right)\ge\left(\lambda_f(p,q)-\varepsilon\right)\log^{[q]}M\left(\frac{r}{4},g\right)+\mathrm{O}(1). \qquad (3.2)$$

Again for a sequence of values of r tending to infinity,

$$\log^{[q]}M\left(\frac{r}{4},g\right)>\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{4}\right)^{\rho_g^q}. \qquad (3.3)$$

Therefore from (3.2) and (3.3) we get for a sequence of values of r tending to infinity,

$$\log^{[p]}T\left(r,f(g)\right)\ge\left(\lambda_f(p,q)-\varepsilon\right)\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{4}\right)^{\rho_g^q}+\mathrm{O}(1) \qquad (3.4)$$

where $0<\varepsilon<\min\{\lambda_f(p,q),\sigma_g^q\}$.

Now from (3.1) and (3.4) we have for a sequence of values of r tending to infinity,

$$\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T(r,\mathrm{f}(g))}\le\frac{\left(\rho_f(p,q)+\varepsilon\right)\left(\sigma_g^q+\varepsilon\right)r^{\rho_g^q}+\mathrm{O}(1)}{\left(\lambda_f(p,q)-\varepsilon\right)\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{4}\right)^{\rho_g^q}+\mathrm{O}(1)}$$

$$=\frac{\left(\rho_f(p,q)+\varepsilon\right)\left(\sigma_g^q+\varepsilon\right)4^{\rho_g^q}+o(1)}{\left(\lambda_f(p,q)-\varepsilon\right)\left(\sigma_g^q-\varepsilon\right)+o(1)}.$$

Since $\varepsilon>0$ is arbitrary,

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$$\liminf_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T(r,f(g))}\leq\frac{4^{\rho_g^q}\rho_f(p,q)}{\lambda_f(p,q)}.$$

Also when n is even then from Lemma 2.5 we get for all sufficiently large values of r

$$\log^{[(n-1)(p-1)-(n-2)q]}M(r,f_n)\geq(\lambda_f(p,q)-\varepsilon)\log^{[q]}M\left(\frac{r}{2^{n-1}},g\right)+O(1).$$

Now for a sequence of values of r tending to infinity, we have

$$\log^{[q]}M\left(\frac{r}{2^{n-1}},g\right)>\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{2^{n-1}}\right)^{\rho_g^q}.$$

Therefore for a sequence of values of r tending to infinity, we get

$$\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)\geq(\lambda_f(p,q)-\varepsilon)\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{2^{n-1}}\right)^{\rho_g^q}+O(1)\qquad(3.5)$$

where $0<\varepsilon<\min\{\lambda_f(p,q),\ \sigma_g^q\}$.

Again by Lemma 2.1 we have for all large values of r, and $\varepsilon>0$,

$$\begin{aligned}T(r,f(g))&\leq\log M(r,f(g))\\&\leq\log M(M(r,g),f).\\\therefore\ \log^{[p]}T(r,f(g))&\leq(\rho_f(p,q)+\varepsilon)\log^{[q]}M(r,g)\\&\leq(\rho_f(p,q)+\varepsilon)\left(\sigma_g^q+\varepsilon\right)r^{\rho_g^q}.\qquad(3.6)\end{aligned}$$

Therefore from (3.5) and (3.6) we have for a sequence of values of r tending to infinity,

$$\begin{aligned}\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T(r,f(g))}&\geq\frac{\left(\lambda_f(p,q)-\varepsilon\right)\left(\sigma_g^q-\varepsilon\right)\left(\frac{r}{2^{n-1}}\right)^{\rho_g^q}+O(1)}{\left(\rho_f(p,q)+\varepsilon\right)\left(\sigma_g^q+\varepsilon\right)r^{\rho_g^q}}\\&=\frac{\left(\lambda_f(p,q)-\varepsilon\right)\left(\sigma_g^q-\varepsilon\right)+o(1)}{\left(2^{n-1}\right)^{\rho_g^q}\left(\rho_f(p,q)+\varepsilon\right)\left(\sigma_g^q+\varepsilon\right)}.\end{aligned}$$

Since $\varepsilon>0$ is arbitrary,

$$\therefore\ \limsup_{r\to\infty}\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T(r,f(g))}\geq\frac{\lambda_f(p,q)}{\left(2^{n-1}\right)^{\rho_g^q}\rho_f(p,q)}.$$

Similarly for odd n we get the second part of this theorem.
This proves the theorem.

Remark 3.2 If f is of regular growth i.e. $\rho_f(p,\ q)\ =\ \lambda_f(p,\ q)$ and n is even then

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$$(i) \quad \liminf_{r\to\infty} \frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,f(g)\right)} \le 4^{\rho_g^q},$$

$$(ii) \quad \limsup_{r\to\infty} \frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,f(g)\right)} \ge \frac{1}{\left(2^n-1\right)^{\rho_g^q}}.$$

Also if g is of regular growth i.e. $\rho_g(p,\,q) = \lambda_g(p,\,q)$ and n is odd then

$$(iii) \quad \liminf_{r\to\infty} \frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,g(f)\right)} \le 4^{\rho_f^q},$$

$$(iv) \quad \limsup_{r\to\infty} \frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,g(f)\right)} \ge \frac{1}{\left(2^n-1\right)^{\rho_f^q}}.$$

Remark 3.3. The conditions non zero lower (p,q)-th order and finite (p,q)-th order are necessary for Theorem 3.1, which are shown by the following examples.

Example 3.4. Let $f(z) = \exp^{[p-q+1]}z, g(z) = \exp^{[p-q]}z$ *and* $2q \ge p+1$. Then $\rho_f(p,\,q) = \lambda_f(p,\,q) = 1$ and $\rho_g(p,\,q) = \lambda_g(p,\,q) = 0$.

Here $f(g) = \exp^{[2p-2q+1]}z$ and

$$3T(2r,f(g)) \ge \log M(r,f(g)) = \exp^{[2p-2q]}r$$

$$i.e.,\ T(r,f(g)) \ge \frac{1}{3}\exp^{[2p-2q]}\frac{r}{2}.$$

$$\therefore\ \log^{[p]} T(r,f(g)) \ge \exp^{[p-2q]}\frac{r}{2} + O(1).$$

Now

$$f_n = \begin{cases} \exp^{\left[n\,p-nq+\frac{n}{2}\right]}z & when\ n\ is\ even \\ \exp^{\left[n\,p-nq+\frac{n+1}{2}\right]}z & when\ n\ is\ odd. \end{cases}$$

So when n is even,

$$M(r,f_n) = \exp^{\left[n\,p-nq+\frac{n}{2}\right]}r$$

$$\therefore\ \log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n) = \log^{[(n-1)(p+1)-(n-2)q]} \exp^{\left[n\,p-nq+\frac{n}{2}\right]}r$$

$$= \exp^{\left[p-2q-\frac{n}{2}+1\right]}r.$$

Therefore

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$$\frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T(r,f(g))} \leq \frac{\exp^{\left[p-2q-\frac{n}{2}+1\right]_r}}{\exp^{[p-2q]_r}} + o(1)$$

$$= \frac{1}{\exp^{\left[\frac{n}{2}-1\right]_r}} + o(1) \to 0 \; not \; gater \; then \; 1 \; as \; r \to \infty.$$

Similarly for odd n,

$$\frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,g\left(f\right)\right)} \leq \frac{\exp^{\left[p-2q-\frac{n-1}{2}+1\right]_r}}{\exp^{[p-2q]_r}} + o(1)$$

$$\to 0 \; not \; gater \; then \; 1 \; as \; r \to \infty.$$

Example 3.5. Let $f(z) = \exp^{[p-q+1]}z, g(z) = \exp^{[p-q+2]}z$ and $2q \geq p+1$. Then $\rho_f(p,q) = \lambda_f(p,q) = 1$ and $\rho_g(p,q) = \lambda_g(p,q) = \infty$.

Here $g(f) = \exp^{[2p-2q+3]}z$ and

$$T(r,g(f)) \leq \log M(r,g(f)) = \exp^{[2p-2q+2]}r$$

$$\therefore \log^{[p]} T(r,g(f)) \leq \exp^{[p-2q+2]}r.$$

Now

$$f_n = \begin{cases} \exp^{\left[n\,p-nq+\frac{3n}{2}\right]_r} z & when \; n \; is \; even \\ \exp^{\left[np-nq+\frac{3n-1}{2}\right]_r} z & when \; n \; is \; odd. \end{cases}$$

So when n is even,

$$M(r,f_n) = \exp^{\left[n\,p-nq+\frac{3n}{2}\right]_r}$$

i.e., $\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n) = \log^{[(n-1)(p+1)-(n-2)q]} \exp^{\left[n\,p-nq+\frac{3n}{2}\right]_r}$

$$= \exp^{\left[p-2q+\frac{n}{2}+1\right]_r}.$$

Therefore

$$\frac{\log^{[(n-1)(p+1)-(n-2)q]} M(r,f_n)}{\log^{[p]} T\left(r,g\left(f\right)\right)} \geq \frac{\exp^{\left[p-2q+\frac{n}{2}+1\right]_r}}{\exp^{\left[p-2q+2\right]_r}}$$

$$= \exp^{\left[\frac{n}{2}-1\right]} r \to \infty \; not \; leas \; then \; 1 \; as \; r \to \infty.$$

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When n is odd,

$$M(r,f_n) = \exp^{\left[\mathrm{n}\,p-nq+\frac{3n-1}{2}\right]}r$$

$$\text{i.e., } \log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n) = \log^{[(n-1)(p+1)-(n-2)q]}\exp^{\left[\mathrm{n}\,p-nq+\frac{3n-1}{2}\right]}r$$

$$= \exp^{\left[p-2q+\frac{n+1}{2}\right]}r.$$

Therefore

$$\frac{\log^{[(n-1)(p+1)-(n-2)q]}M(r,f_n)}{\log^{[p]}T\left(r,g(f)\right)} \geq \frac{\exp^{\left[p-2q+\frac{n+1}{2}\right]}r}{\exp^{[p-2q+2]}r}$$

$$= \exp^{\left[\frac{n+1}{2}-2\right]}r \to \infty \; not\; leas\; then\; 1 \text{ as } r \to \infty.$$

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Chapter-14: Exploring the Concept of Bitranslations in Γ-Banach Spaces

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Abstract

Let $\xi(V) = \{p |\ p: \Gamma \to End(V)$ *is an algebra homomorphism*$\}$ *for given any Γ-Banach space V over F. If* $(x_1\mu x_2)_\gamma q = x_1\mu\big((x_2)_\gamma q\big), \forall\ x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma$ *and* $q \in \xi(V)$ *is a right translation of V (in which case the argument is written on the left and* $(\gamma)q$ *denoted by* ${}_\gamma q$*), and* $r \in \xi(V)$ *is a left translation of V (in which case the argument is written on the right and* $r(\gamma)$ *is denoted by* r_γ*) if* $r_\gamma(x_1\mu x_2) = \big(r_\gamma(x_1)\big)\mu x_2, \forall\ x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma$ *.* $\xi_l(V)$ *and* $\xi_r(V)$ *represent the set of all left and right translations of the Γ-Banach space V, respectively. If for any* $x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma,\ x_1\gamma\left(r_\mu(x_2)\right) = (x_1)_\gamma q)\mu x_2$*, then* $p = (r, q) \in \xi_l(V) \times \xi_r(V)$ *is a bitranslation of V. We investigate some properties of bitranslation of Γ-Banach Spaces in this paper.*

Key Words: Γ- Banach Spaces, strong unities, bitranslation, Amicable, homothetism.

1. Introduction

First used by N. Nobusawa [1], the notation of a Γ-ring was somewhat reduced by W.E. Barnes [2], who also developed the concept of Γ-ring. When J. Luh [3], S. Kyuno [4], and W. E. Barnes [2] investigated the structure of Γ-ring, they found several generalizations that are comparable to related concepts in ring concept. R.C. Kalita, T.K. Dutta, and H.K. Nath [5] investigated the projective tensor product of Γ-Banach Algebras and Γ-derivations. Additionally, we study α-Characteristic Equations, α-Minimal Polynomial of Rectangular Matrices, K-derivation and symmetric bi-k-derivation on Gamma Banach Algebras [6], Operator Banach Algebras of Matrix Gamma Banach Agebras, Tensor product of modules, Gamma modules, and operator modules of Gamma modules. We examine a few characteristics of the bitranslation of Γ-Banach Spaces in this article.

2. Preliminaries

Definition 2.01 [1]Let V and Γ be two additive abelian groups and $V \times \Gamma \times V \to V$ and $\Gamma \times V \times \Gamma \to \Gamma$ be two maps such that

N1. $(x + y)\alpha z = x\alpha z + y\alpha z$, $x(\alpha + \beta)z = x\alpha z + x\beta z$, $x\alpha(y + z) = x\alpha y + x\alpha z$

N2. $(x\alpha y)\beta z = x(\alpha y\beta)z = x\alpha(y\beta z)$ for all $x,\ y,\ z \in V$ and $\alpha, \beta \in \Gamma$.

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N3. If $x\alpha y = 0$ for all $x,\ y \in V$, then $\alpha = 0$.

Then V is called a Γ-ring in the sense of N. Nobusawa.

W. E. Barnes [2] define Γ-ring as follows:

Let V and Γ be two additive abelian groups. If there exists a mapping $V \times \Gamma \times V \to V$ (the image of (x, γ, y) where $x, y \in V$ *and* $\gamma \in \Gamma$, being denoted by $x\gamma y$), satisfying for all $x,\ y,\ z \in V$ and $\alpha, \beta \in \Gamma$:

B1. $(x + y)\alpha z = x\alpha z + y\alpha z$, $x(\alpha + \beta)z = x\alpha z + x\beta z$, $x\alpha(y + z) = x\alpha y + x\alpha z$

B2. $(x\alpha y)\beta z = x(\alpha y\beta)z = x\alpha(y\beta z)$

Definition 2.02 Let V and Γ be additive abelian groups. Then V is called a Γ-Banach space over a field F if the following conditions hold:

1. V is a Γ-ring according to Barnes's definition.
2. V is a Banach space over F with a suitable norm.

Furthermore, according to Nobusawa's definition, if V is a Γ-ring, it is a Γ_N-Banach space over F.

Definition 2.03 A subset I of a Γ-Banach space V is said to be right (left) ideal of V if

(i) I is a subspace of V (in the vector space sense),

(ii) $x\alpha y \in I$ $(y\alpha x \in I)$ for all $x \in I,\ \alpha \in \Gamma,\ y \in V$ i.e. $I\Gamma V \subseteq I$ $(V\Gamma I \subseteq I)$.

A right Γ-ideal which is a left Γ-ideal as well as called a two sided Γ-ideal or simply a Γ-ideal. The notation $I \lhd V$ will mean I is a Γ-ideal of V.

Definition 2.04 Let $\xi(V) = \{p \mid p: \Gamma \to \mathrm{End}(V)$ is an algebra homomorphism$\}$ for given any Γ-Banach space V over F. If $(x_1\mu x_2)_\gamma q = x_1\mu\big((x_2)_\gamma q\big), \forall\ x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma$ and $q \in \xi(V)$ is a right translation of V (in which case the argument is written on the left and $(\gamma)q$ denoted by ${}_\gamma q$), and $r \in \xi(V)$ is a left translation of V (in which case the argument is written on the right and $r(\gamma)$ is denoted by r_γ) if $r_\gamma(x_1\mu x_2) = \big(r_\gamma(x_1)\big)\mu x_2, \forall\ x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma$. $\xi_l(V)$ and $\xi_r(V)$ represent the set of all left and right translations of the Γ-Banach space, respectively. If for any $x_1,\ x_2 \in V;\ \gamma, \mu \in \Gamma,\ x_1\gamma\left(r_\mu(x_2)\right) = (x_1)_\gamma q)\mu x_2$, then $p = (r, q) \in \xi_l(V) \times \xi_r(V)$ is a bitranslation of V. Then, $p = (r, q)$ is consider as a

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linked. $\xi_2(V)$ represents the set of all bitranslations of V. It shall be assumed that a bitranslation p is a double operator with $p(\gamma) = p_\gamma = r_\gamma$ and $(\gamma)p =_\gamma p =_\gamma q$. In particular, for any $x \in V$ define ${}^x p : \Gamma \to \mathrm{End}(V)$ and $q^x : \Gamma \to End(V)$ by ${}^x p(\gamma) = {}^x p_\gamma$ and $(\gamma)q^x =_\gamma q^x$, where ${}^x p_\gamma(y) = x\gamma y$ and $(y)_\gamma q^x = y\gamma x$ for all $x, y \in V$ and $\gamma \in \Gamma$. It is clear that ${}^x p$ is a left translation and q^x is a right translation of V. The pair $({}^x p, q^x)$ is a linked. Hence $({}^x p, q^x)$ is a bitranslation of V which we will denote by $[x] = ({}^x p, q^x)$. The inner bitranslation of V generated by x is the name given to the bitranslation $[x]$ that was constructed above. *I(V)* shall represent the set of all inner bitranslations of V. $E_l(V)$ represents the set of all endomorphisms of the form ${}^x p_\gamma$, while $E_r(V)$ represents the set of all endomorphisms of the form ${}_\gamma q^x$.

Definition 2.05 If for each $\gamma, \mu \in \Gamma$ and $x \in V$, $p_\gamma((x)_\mu q) = (p_\gamma(x))_\mu q$ and $q_\gamma((x)_\mu p) = (q_\gamma(x))_\mu p$, then two bitranslations p and q of V are amicable. A collection of bitranslations of V for which every element is pairwise amiable is known as an amicable set.

Definition 2.06 A double homothetism p of a Γ- Banach space is a bitranslation of V, that is, amicable with itself.

Definition 2.07 A Γ-Banach space V is said to have a left (right) strong unity if there exists some $d \in V$, $\delta \in \Gamma$ such that $d\delta x = x$ $(x\delta d = x)$, for all $x \in V$.

Definition 2.06: A Γ- Banach space V has a left (right) double homothetism strong unity if there exists double homothetism p of V and $\gamma \in \Gamma$ such that $p_\gamma(x) = x$ $((x)_\gamma p = x)$ for all $x \in V$.

3. Main Results

Theorem 3.01 A Γ- Banach space has strong unities on the left and right if and only if it has only inner double homothetisms and left and right double homothetisms strong unities.

Proof: Assume that V has left and right strongly unities, meaning that for any m in V, $x\alpha m = m$ and $m\beta y = m$, where $x \in V, \alpha \in \Gamma$ and $y \in V, \beta \in \Gamma$.Then $[x] \in I(V)$ for every $x \in V$ and $[x]_\alpha(m) = x\alpha m = m$ for all $m \in V$. A left double homothetism strong unity is thus formed by the double homothetism $[x]$ of V and $\alpha \in \Gamma$. In the same way, $\beta \in \Gamma$ and V's double

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homothetism $[y]$ generate a right double homothetism strong unity for V. Consider any double homothetism of V to be p. For $m \in V, \mu \in \Gamma$ we have $p_\mu(m) = x\alpha\left(p_\mu(m)\right) = [(x)_\alpha p]\mu m = [(x)_\alpha p]_\mu(m)$. Also $(m)_\mu p = \left[(m)_\mu p\right]\beta y = m_\mu[p_\beta(y)]$.

Thus $(x)_\alpha p = [(x)_\alpha p]\beta y = x\alpha[p_\beta(y)] = p_\beta(y)$. Because of $(x)_\alpha p = p_\beta(y)$, V has an inner double homothetism p, that is, V only possesses inner double homothetisms.

Let V, on the other hand, has left and right double homothetism strong unities, and only inner double homothetisms are present. Suppose that $\gamma \in \Gamma$ and that p is the double homothetism, such that $p_\gamma(m) = m$. Due to the fact that V only has inner double homothetism, there exists $e \in V$ such that $p = [e]$. Likewise, with q representing the double homothetism and $\mu \in \Gamma$, so that $(m)_\mu q = m$. Since V has only inner double homothetisms, there exists $a \in V$ such that $q=[a]$.

If $m \in V$,then $e\gamma m = [e]_\gamma(m) = p_\gamma(m) = m$ and $m\gamma a = (m)_\mu[a] = (m)_\mu q = m$. Thus the Γ-Banach space V has left and right strong unities.

Theorem 3.02 If V is a Γ-Banach space that has a left or a right strong unity, then V is isomorphic to the Γ-Banach space $I(V)$ of all inner double homothetism of V.

Proof: Define the mapping $f : V \to I(V)$ by $f(m) = [m]$, $m \in V$. Straight forward calculations will show that f is a onto Γ-Banach space homomorphism. Let $e \in V$ and $\gamma \in \Gamma$ form a right strong unity of V. Let $m_1, m_2 \in V$ such that

$$f(m_1) = f(m_2) \Rightarrow [m_1] = [m_2] \Rightarrow [m_1]_\gamma(e) = [m_2]_\gamma(e) \Rightarrow m_1\gamma e = m_2\gamma e \Rightarrow m_1 = m_2$$

Hence f is an isomorphism from V onto $I(V)$. The result follows similarly if V has a left strong unity.

Theorem 3.03 Let V be any Γ-Banach space. V has a left (right) double homothetism strong unity if it can be embedded as an ideal in a Γ-Banach space with left (right) strong unity.

Proof: Assume that V may be embedded as an ideal in a left-strong unity Γ-Banach space U. Then there exist $e \in U$ and $\gamma \in \Gamma$ such that $e\gamma n = n$ for all $n \in U$. Since $e \in U$, so $[e] = ({}^e p, q^e)$ where ${}^e p$ and q^e are left and right translation of U respectively with ${}^e p_\gamma(n) = e\gamma n$ and

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$(n)_\gamma q^e = n\gamma e$ for all $n \in U$. Let $m \in V$. Then ${}^e p_\gamma(m) = e\gamma m \in V$ and $(m)_\gamma q^e = m\gamma e \in V$, because $V \lhd V'$. Hence the restrictions of both ${}^e p$ and q^e to V say ${}^e p|V$ and $q^e|V$ are left and right translations respectively of V. Let $p = ({}^e p|V, q^e|V)$ be a double homothetism of V. Then $p_\gamma(m) = [e]_\gamma(m)$ for all $m \in V$. This demonstrates that the double homothetism p of V, $\gamma \in \Gamma$ forms a left double homothetism strong unity of V. Similar reasoning demonstrates that if U has a right strong unity, then V must also have a right double homothetism strong unity.

Lemma 3.04 For a field F, let V be a Γ-Banach space over a field F. Then, both the sets $\xi_l(V)$ and $\xi_r(V)$ of all left and right translations of V respectively are Γ-Banach space over field F.

Theorem 3.05 A Γ-Banach space V can be embedded as an ideal in a Γ-Banach space with a left (right) strong unity if the Γ-Banach space V has left (right) double homothetism strong unity.

Proof: Assume that V is a Γ-Banach space that has a left double homothetism strong unity. Let E_l be the direct sum of $\xi_l(V)$ (the set of all left translations of $V_{[1]}$) and V, that is, $E_l = \xi_l(V) \oplus V$. Define a map $E_l \times \Gamma \times E_l \to E_l$ by $(p^1,\ m_1)\gamma(p^2,\ m_2) = (p^1\gamma p^2,\ m_1\gamma m_2)$ for all $(p^1,\ m_1)\gamma(p^2,\ m_2) \in E_l$. Since $\xi_l(V)$ and V are both Γ-rings, So $E_l = \xi_l(V) \oplus V$ is also Γ-ring. We can show that E_l is a vector space over F. Next define a norm on E_l by $\|(p, m)\| = \|p\| + \|m\|$.

It can be easily show that $(E_l, \|\,.\,\|)$ is a normed linear space. If $\{(p^n, x_n)\}$ is a Cauchy sequence in E_l, then for given $\varepsilon > 0$ there exists a positive integer n_0 such that for $m, n \geq n_0$, $\|(p^n, x_n) - (p^m, x_m)\| < \varepsilon$

$$\Rightarrow \left\| \left(p^n - p^m, x_n - x_m\right) \right\| < \varepsilon$$

$$\Rightarrow \left\| p^n - p^m \right\| + \left\| x_n - x_m \right\| < \varepsilon$$

$$\Rightarrow \left\| p^n - p^m \right\| < \frac{\varepsilon}{2} \text{ and } \left\| x_n - x_m \right\| < \frac{\varepsilon}{2}$$

$\Rightarrow \{p^n\}$ and $\{x_n\}$ are Cauchy sequence in $\xi_l(V)$ and V respectively.

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Since $\xi_l(V)$ and V are Γ-Banach algebras over F, therefore there exist $p \in \xi_l(V)$ and $x \in V$ such that $p^n \to p$ and $x_n \to x$. Then we can prove easily that $(p^n, x_n) \to (p, x)$. Hence E_l is a Banach space. Hence E_l is a Γ-Banach space.

The subset $U = \{(0, m) | m \in V\}$ of E_l is an ideal of E_l and is isomorphic (as a Γ-Banach space) to V. Let the double homothetism p of V and $\gamma \in \Gamma$ form a left double homothetism strong unity of V. By theorem 6.1, there exists $e \in \mathrm{V}$ such that $p = [e]$ and $e\gamma m = m\gamma e = m$ for all $m \in V$. Then for any $\in \xi_l(V), m \in V, (p\gamma q)_\gamma(m) = \left(p_\gamma \circ q_\gamma\right)(m) = p_\gamma\left(q_\gamma(m)\right) = q_\gamma(m)$.Thus $(p\gamma q) = q$ for all $q \in \xi_l(V)$. Also $(p, e) \in E_l$.

If (q, m) is an element of E_l, then$(p, e)\gamma(q, m) = (p\gamma q, e\gamma m) = (q, m)$.Thus $(p, e) \in E_l$ and $\gamma \in \Gamma$ form a left strong unity of E_l. Hence V can be embedded as an ideal in a Γ-Banach space with left strong unity. Similarly, if V has a right double homothetism strong unity, then V is isomorphic to an ideal of $E_r = V \oplus \xi_r(V)$. Which is a Γ-Banach space with right strong unity, where $\xi_r(V)$ is the set of all right translations of V.

Conclusion: This study is grounded in fundamental concepts of rings, linear spaces, Banach spaces, Banach algebras, Γ-rings, and Γ-Banach space. It Explores the Concept of Bitranslations in Γ-Banach Spaces. The investigation proved to be insightful and contributed to a deeper understanding of the subject. It is hoped that this work will motivate further research in this area. The authors also believe that the findings may be expanded in the future through alternative methods.

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Chapter-15: Investigation of Neutrino Mixing Angles with a Focus on Scaling and Hybrid Texture Models.

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Abstract

In this work, we explore the potential origins of various neutrino mixing angles by examining two distinct types of neutrino mass matrices. Specifically, we analyze the type I seesaw and type II seesaw mass matrices to understand their roles in shaping neutrino mixing angles and mass hierarchy. We treat the type I seesaw as a hybrid texture neutrino model and the type II seesaw as a scaling mass matrix. Our aim is to provide a concise overview of neutrino mass models, incorporating the latest insights into neutrino dynamics.ata.

Keywords: *neutrino, seesaw, scaling, mixing*

I. Introduction

Origin of tiny neutrino masses and their large mixing **[1-5]** is one of the major observed phenomena that the Standard model of particle physics would not explain. Various Neutrino oscillation experiments across the world, namely T2K [6] ,Double ChooZ [7] , Daya-Bay [8,] and RENO [9,] have made the earlier predictions for neutrino parameters precise precisely and also a predicted non-zero value of the reactor mixing θ_{13}. The latest global fit value for 3σ range of neutrino oscillation parameters are given in **[10]** and **[11].** The neutrino oscillation experiments measure only two mass squared differences and therefore the lightest neutrino mass, which remains a free parameter, can be constrained from the upper bound on the sum of absolute neutrino masses from cosmology, $\sum m_i <$ 0.12eV **[12].** In addition to the neutrino mass hierarchy problem, recent neutrino experiments have also not found anything about the nature of the neutrino mass. Therefore, these questions will lead to some different neutrino models to explain those undetermined neutrino parameters. People expected that the extreme smallness of the neutrino masses is most likely related to the seesaw mechanism. Some good works related to seesaw mechanism can be found in **[13, 14]**. All these mechanisms include extra heavy fermionic or scalar fields into the SM.

In this work, we consider a very specific neutrino mass matrix structure proposed a few years ago by the authors of [15-16]. The structure of the neutrino mass matrix is based on the idea of a strong scaling Ansatz, where certain ratios of the elements of the neutrino mass matrix are equal. We consider the scaling mass matrix as the origin of the type I seesaw mechanism in our neutrino model. We also consider some hybrid texture neutrino models [17-20] as the type II seesaw matrix. Here, we combine the scaling neutrino mass matrix and hybrid texture neutrino matrices to generate different neutrino parameters and attempt to correlate them. This paper is organized as follows: In the next section, II, we discuss different possible hybrid texture neutrino mass models and the scaling mass matrix. We discuss the numerical methods in section III. In section IV, we present our results and conclusions.

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II. Scaling mass matrix and hybrid texture neutrino mass matrix

We write the neutrino mass matrix and leptonic mixing matrix

$$M_\nu = \begin{pmatrix} m_{ee} & m_{e\mu} & m_{e\tau} \\ m_{\mu e} & m_{\mu\mu} & m_{\mu\tau} \\ m_{\tau e} & m_{\tau\mu} & m_{\tau\tau} \end{pmatrix}$$

$$U_{PMNS} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix}$$

In terms of matrix element. Type A scaling mass matrix is given by authors

$$M_\nu = \begin{pmatrix} A & B & \frac{B}{S} \\ B & D & \frac{D}{S} \\ \frac{B}{S} & \frac{D}{S} & \frac{D}{S^2} \end{pmatrix}$$

There are three types of scaling neutrino mass matrix **[15]** . Only case A is allowed by current data and in this work we consider the model based on case A only which is given above. If neutrinos are Majorana fermions, as predicted by the conventional seesaw mechanisms, then the 3 × 3 neutrino mass matrix is complex symmetric and hence has six independent complex elements. In literature review Several works related to one-zero and two-zero textures can be found in **[17]** and **[18]** respectively. Another possibility is the so-called hybrid texture defined as combination of one-zero texture and two equal non-zero elements **[17–20].** In this work we consider hybrid texture neutrino mass matrix as the origin of type I seesaw. There are six categories of hybrid texture matrix which make it 39 matrices. We choose only 6 out of 39 hybrid texture matrices in our work which is closely agreed with experimental values. Following are the structure of hybrid texture neutrino matrix we have used in our work.

$$\text{A1:} \begin{pmatrix} 0 & \times & \times \\ \times & \nabla & \nabla \\ \times & \nabla & \times \end{pmatrix}, \text{B1:} \begin{pmatrix} \nabla & 0 & \nabla \\ 0 & \times & \times \\ \nabla & \times & \times \end{pmatrix}, \text{C1:} \begin{pmatrix} \nabla & \nabla & 0 \\ \nabla & \times & \times \\ 0 & \times & \times \end{pmatrix}, \text{D1:} \begin{pmatrix} \nabla & \nabla & \times \\ \nabla & \times & 0 \\ \times & 0 & \times \end{pmatrix}$$

$$\text{E1:} \begin{pmatrix} \nabla & \nabla & \times \\ \nabla & 0 & \times \\ \times & \times & \times \end{pmatrix}, \text{F1:} \begin{pmatrix} \nabla & \nabla & \times \\ \nabla & \times & \times \\ \times & \times & 0 \end{pmatrix}$$

III. Numerical Analysis

The neutrino mass matrix can be obtained by two mass square differences and mixing angles provided by data. The leptonic
mixing matrix or the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) leptonic mixing matrix is given by

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$$U_{PMNS} = U_l{}^{+} U_\nu$$

U_ν, U_l represent neutrino mass and lepton mixing matrix. if we assume charged lepton matrix as a diagonal then the light neutrino mass matrix can be written as

$$U_{PMNS} = U_l{}^{+}$$

Considering the type II seesaw term as the necessary correction to scaling mixing, we write the neutrino mass matrix as

$$M_\nu = M_I + M_{II} = m_D {M_{RR}}^{-1} {m_D}^{T} + M_{II}$$

Where M_I, M_{II} are the scaling and hybrid texture mass matrices. We can write neutrino mass matrix as

$$U_{PMNS} {m_\nu}^{diag} {U_{PMNS}}^{T} = scaling\ mass\ matrix + Hybrid\ texture\ matrix$$

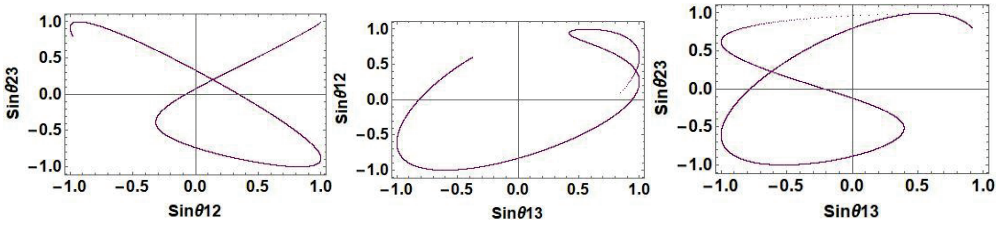
For normal mass hierarchy, the diagonal mass matrix of the light neutrinos can be written as

$${m_\nu}^{diag} = diag(m_1, \sqrt{{m_1}^2 + \Delta {m_{21}}^2}, \sqrt{{m_1}^2 + \Delta {m_{31}}^2})$$

whereas for inverted mass hierarchy it can be written as

$${m_\nu}^{diag} = diag(\sqrt{{m_3}^2 + \Delta {m_{23}}^2 - \Delta {m_{21}}^2}, \sqrt{{m_3}^2 + \Delta {m_{23}}^2}, m_3)$$

In this work, we have not considered the Majorana CP phases; we deal only with the Dirac CP phase of the neutrino mass matrix. We can take m1 as the lightest neutrino mass in the case of NH after substituting the values of mass squared differences [10-11], and in the IH case, we take m3 as the light neutrino mass eigenvalue. We can construct the neutrino mass matrix as a combination of a scaling neutrino mass and a hybrid texture neutrino mass. In this work, we choose some fixed values of the lightest neutrino mass within the cosmological limit given by [12]. In the case of a scaling mass matrix, we have solved for the values of A, B, S, D by comparing with the neutrino mass matrix elements. Now, by comparing each element of this newly constructed mass matrix with the original neutrino mass matrix, we can plot some graphs between different neutrino parameters, considering different hybrid textures models with a scaling matrix. We have shown a few plots of mixing angles from our calculations.



Hybrid texture model	NH	IH
A1	√	√
B1	√	×

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C1	×	×
D1	×	×
E1	×	×
F1	√	×

IV. Results and Conclusions

In this work, we have studied six hybrid texture neutrino mass matrices allowed by the latest experimental data. We also explore a different type of neutrino matrix known as the scaling strong matrix. In the hybrid texture neutrino mass matrix, there exists one zero and two equal non-zero elements. There are three possibilities for the scaling mass matrix; however, in our work, we consider only one that consistently yields an inverted hierarchy (IH) structure. We combine the hybrid texture and scaling mass matrices to construct a neutrino mass matrix that accommodates both normal and inverted hierarchy structures. Since the scaling mass matrix always produces a definitive inverted structure model, we attempt to introduce corrections to the scaling matrix using texture zeros in order to derive a complete neutrino mass matrix. Neutrino mass matrices can originate from different types of seesaw mechanisms. In this study, we consider type I and type II seesaw mechanisms as the origins of the neutrino mass matrix. We equate the type I seesaw with the scaling matrix and the type II seesaw with the hybrid texture. We investigate the variation of the lightest neutrino mass with neutrino mixing angles in both the normal hierarchy (NH) and inverted hierarchy (IH) cases. We have only obtained correct results for the three hybrid texture cases summarized in the table above. The check mark in the table indicates correct neutrino oscillation angles observed in the hybrid texture model, while the cross symbol denotes oscillation parameters that fall outside the acceptable range. From these results, we can constrain the texture models to align with experimental values. In this work, we focus solely on the Dirac CP phase. In the future, we aim to study results incorporating all three phases—Dirac and Majorana—which will be interesting for exploring neutrinoless double beta decay and leptogenesis with these new neutrino models.

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Chapter-16: Radon Exhalation Rates from Some Soil Samples in Some Areas in Bongaigaon District using Solid State Nuclear Track Detector

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Abstract

Radon (Rn, Z=86) is a naturally occurring radioactive noble gas present in soils, rocks, and water, posing health and environmental risks despite its low atmospheric concentration. Although generally inert, radon can react under special conditions and exhibits distinct physical properties such as phosphorescence at low temperatures.

Solid state nuclear track detectors (SSNTDs), particularly CR-39 (PADC), are highly effective for radon estimation and exhalation studies. These detectors, first demonstrated in dielectric solids, have since been widely applied across physics, earth sciences, space sciences, and medical sciences. Applications include nuclear reaction studies, geo-chronology, cosmic ray detection, and medical filtration techniques.

The investigated areas show homogeneous climatic conditions: cold, foggy winters, moderately cool spring and autumn, and hot, humid summers with heavy monsoon rainfall (150–260 cm) from June to September. These climatic patterns strongly influence radon exhalation rates, emphasizing the importance of continuous monitoring and detector-based assessments.

1. INTRODUCTION

There are many known and unknown gases within or around our home, in which radon gas is one of the health concerns. Radon is a naturally occurring radioactive gas found in soils, rock, and water everywhere, with the symbol Rn and atomic number 86. Radon was discovered in 1900 by Friedrich Ernst Dorn, who called it radium emanation. In 1908, William Ramsay and Robert Whytlaw-Gray named it niton (Latin *nitens* meaning "shining"; symbol Nt), isolated it, determined its density, and identified it as the heaviest known gas. Since 1923, it has been called "radon."

In the periodic table, radon occupies a position in Group VIII of Period VI. Its specific gravity, boiling point, and freezing point are 9.73, 211 K, and 202 K respectively (Lange, 1961). As a noble gas, radon was expected to be inert. However, some investigators (Stein, 1969, 1970, and 1972) reported that radon, like xenon, can react with liquid bromine trifluoride and some solid complexes of antimony halides.

When cooled below its freezing point, radon exhibits brilliant phosphorescence, which becomes yellow as the temperature is lowered and orange-red at the temperature of liquid air. A volume corresponding to an activity of 1 picocurie (Pci) of radon is about 6.7×10^{-19} cm^3, with a corresponding partial pressure of less than 10^{-18} atmosphere (Evans, 1969). The average atmospheric concentration of radon is of the order of 6×10^{-18} % by volume (Clark,

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1959). Radon is colourless, odourless, and tasteless, and can only be studied using special equipment.

Fig1.1 : ^{238}U decay chain, including ^{222}Rn and its decay products (Sharma B.K., 1996)

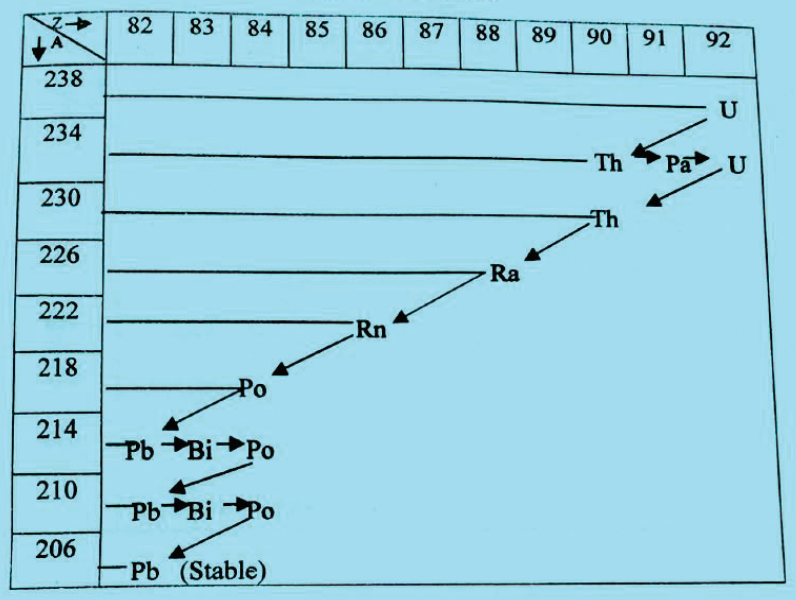

Table1.1: Radioactive series of ^{238}U(Sharma B.K., 1996)

NAME AND SYMBOL	ATOMIC WEIGHT	ATOMIC NUMBER	RADIATION	HALF LIFE PERIOD
Uranium (U)	238	92	α	4.5×10^9 years
Thorium (Th)	234	90	β	24.6 days
Protactinium (Pa)	234	91	β	1.14 min.
Uranium (U)	234	92	α	2.7×10^5 years
Thorium (Th)	230	90	α	8.3×10^4 years
Radium (Ra)	226	88	α	1590 years
Radon (Rn)	222	86	α	3.8 days
Polonium (Po)	218	84	α	3.0 min.
Lead (Pb)	214	82	β	26.7 min.
Bismuth (Bi)	214	83	β	19.7 min.
Polonium (Po)	214	84	α	1.5×10^{-4} sec
Lead (Pb)	210	82	β	22 years
Bismuth (Bi)	210	83	β	4 days
Polonium (Po)	210	84	α	140 days
Lead (Pb)	206	82	-	Stable

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Fig 1.2 : ^{232}Th decay chain, including ^{220}Rn and its decay products (Sharma B.K., 1996)

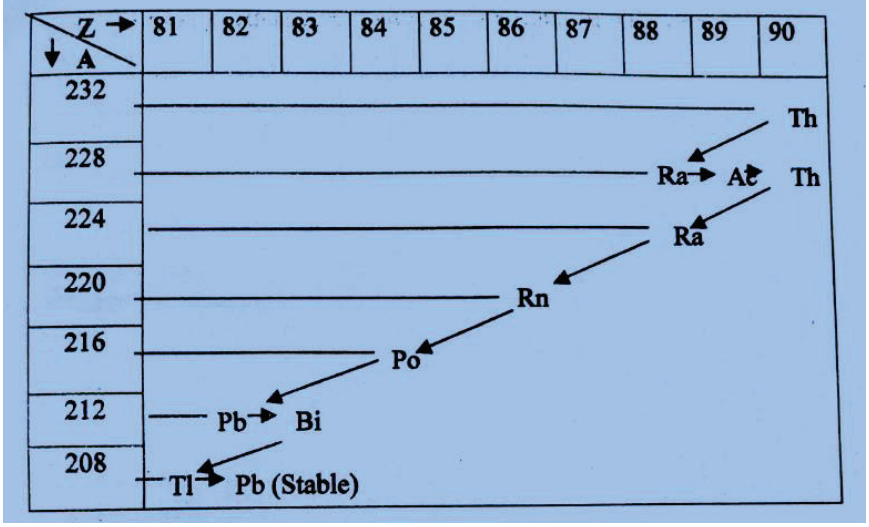

Table1.2 : Radioactive series of ^{232}Th (Sharma B.K., 1996)

NAME AND SYMBOL	ATOMIC WEIGHT	ATOMIC NUMBER	RADIATION	HALF LIFE PERIOD
Thorium (Th)	232	90	α	1.4×10^{10} years
Radium (Ra)	228	88	β	6.7 years
Actinium (Ac)	228	89	β	6.13 hours
Thorium (Th)	228	90	α	1.9 years
Radium (Ra)	224	88	α	3.65 days
Radon (Rn)	220	86	α	55 sec
Polonium (Po)	216	84	α	0.16 sec
Lead (Pb)	212	82	β	10.6 hours
Bismuth (Bi)	212	83	α	1 hour
Thallium (Tl)	208	81	β	3.1 min
Lead (Pb)	208	82	-	Stable

2. SOLID STATE NUCLEAR TRACK DETECTORS

In the present work, I have used solid state nuclear track detectors for radium estimation and radon exhalation rate measurements. The first nuclear track in dielectric solid was observed by Young (1958) in a thick sample of lithium (LIF) under an optical microscope after suitable etching. A year later, Silk and Barners (1959) observed latent damage trails produced in mica by the fission fragments of ^{235}U using a transmission electron microscope.

However, it was Price and Walker (1962), apparently unaware of Young's work, who demonstrated that etching solutions preferentially attack the damaged regions, producing enlarged pits easily observed under an optical microscope, resembling tracks in nuclear emulsions.

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Since then, etchable tracks have been observed in many crystals, glasses, and a wide variety of plastics (Fleischer et al., 1975). Different materials vary considerably in sensitivity: minerals and glasses are the least sensitive, while organic materials are the most sensitive. PADC, also known as CR-39, is by far the most sensitive material, capable of recording alpha particles with a wide range of energies (Cartwright et al., 1978; Henshaw et al., 1982; Durrani and Bull, 1987).

Afterwards, a considerable amount of work was done by various investigators to systematize this pool of information and knowledge (McCorkell, 1974; Fleischer et al., 1975). During this period, the technique was not only developed and strengthened but also applied very successfully in diverse fields (Fleischer et al., 1975).

Applications include:

- **Physics**: Studies of nuclear fission and spallation reactions (Cieslak et al., 1965), and measurement of lifetimes of heavy unstable nuclei (Fleischer et al., 1963; Prevo et al., 1964; Fleischer et al., 1965).
- **Earth Sciences**: Extensively used in geo-chronology estimation and revelation of geothermal history of geological eras (Brill et al., 1964; Fleischer and Price, 1964a, 1964b; Nagpaul et al., 1974; Virk and Koul, 1975; Singh and Virk, 1978).
- **Space Sciences**: Applications in the study of cosmic rays and extraterrestrial materials (Fleischer et al., 1967; Virk, 1977, 1979; Virk and McCorkel, 1979).
- **Medical Sciences**: Selectively etched tracks in thin layers of plastics used as fine sieves for filtration of cancer blood cells (Seal, 1964).

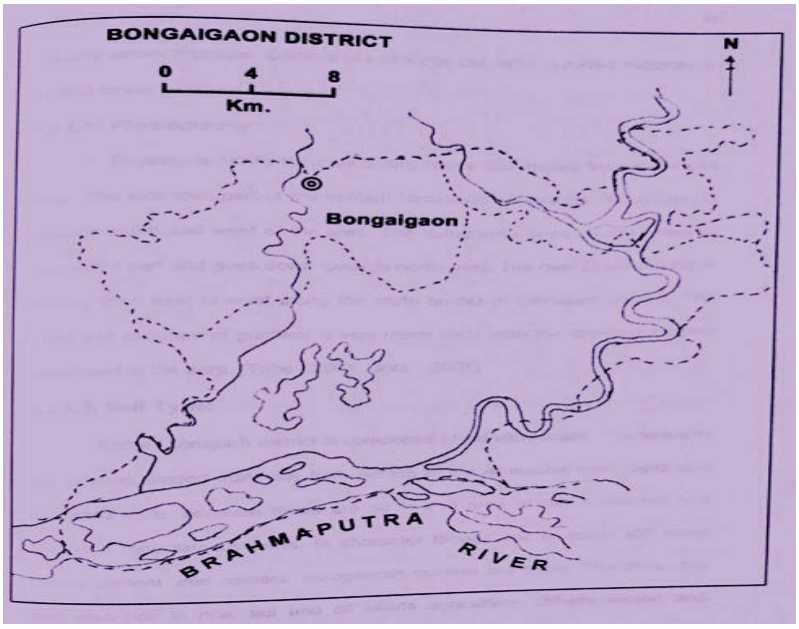

Fig 2.1: Map of Bongaigaon District showing study area

3. CLIMATE OF THE INVESTIGATED AREAS

The climate is homogeneous over the investigated areas. The principal characteristics of the climate are cold and foggy winter, moderately cool spring and autumn, and a fairly hot and humid summer.

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The summer and winter seasons are well marked, with temperature varying between 38°C and 10°C. The summer season starts around June and lasts until early September. During June, July, and August, the weather becomes very hot and humid, with average humidity between 70% and 80%. Summer rainfall is heavy, occurring mainly from late June to early September, with average rainfall ranging between 150 cm and 260 cm. Maximum rainfall generally occurs over a four-month period beginning in early June.

The winter season extends from early December to mid-March, peaking in January. The temperature begins to rise steadily from early March. Dust storms are common from late February to April (Mahanta et al., 2007).

4. RESULTS AND DISCUSSIONS

Village / Location	Sl. No.	Radon Exhalation Rates E_A (mBq $m^{-2}h^{-1}$)	Average Radon Exhalation Rates E_A (mBq $m^{-2}h^{-1}$)
Township (BRPL)	1	162.79	164.61±0.28 *
	2	162.23	
	3	165.03	
	4	168.39	
Sati Gaon	1	138.13	130.61±0.58
	2	128.67	
	3	131.47	
	4	124.20	
Dolai Gaon	1	118.04	109.71±0.80
	2	114.68	
	3	100.70	
	4	105.42	

Fig 4.1: Value of radon exhalation rates (in terms of area) from soil samples in Bongaigaon area (Assam)

- BRPL: Bongaigaon Refinery and Petrochemical Limited
- The error calculated here is statistical error

Table 4.1: Value of Radon exhalation rates in terms of mass in soil sample of Bongaigaon area (Assam)

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Village / Location	Sl. No.	Radon Exhalation Rates E_M (mBq $Kg^{-1}h^{-1}$)	Average Radon Exhalation Rates E_M (mBq $Kg^{-1}h^{-1}$)
Township (BRPL)	1	4.61	4.66±0.01
	2	4.59	
	3	4.68	
	4	4.77	
Sati Gaon	1	3.91	3.69±0.02
	2	3.64	
	3	3.72	
	4	3.51	
Dolai Gaon	1	3.34	3.09±0.02
	2	3.25	
	3	2.85	
	4	2.91	

5. Conclusions

From the present investigation of the Radon exhalation rate and radium concentration in soils collected from Bongaigaon area following conclusions can be drawn-

1. The solid state nuclear track detectors (SSNTDS) are best suited for the measurement of radium concentration and radon exhalation rate in soil samples.
2. Overall a positive correlation has been observed between the radon exhalation rate and the radium concentration of soil samples.
3. In the present investigation it is observed that concentration in soil samples is much lower than the permissible value 370 Bq Kg-1.
4. The radium concentration and radon exhalation rates comparatively higher in BRPL (Bongaigaon Refinery and Petrochemicals Limited), Bongaigaon. These are mainly industrial areas.

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Chapter-17: Bioluminescence Emissions from the Indian Winter Species of Firefly *Diaphanes* sp.

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Abstract

Bioluminescence, the emission of visible "cold" light by living organisms, represents one of the most efficient biochemical light-producing processes in nature. While numerous studies have characterized the emission spectra and flash dynamics of tropical, summer-active fireflies, little is known about species that remain active during winter. This chapter presents the first detailed spectroscopic and temporal analysis of ***bioluminescence in the Indian winter-active firefly Diaphanes sp.****, discovered in Assam, India.*

Steady-state emission spectra were recorded at varying temperatures, and temporal characteristics were analyzed both in captive and free modes. The emission spectra showed a green peak at ***548 nm****, slightly blue-shifted compared to those of summer species such as Luciola praeusta and Asymmetricata circumdata. Increasing the temperature to ~28°C caused a distinct red-shift, suggesting the onset of luciferase enzyme denaturation. Uniquely, Diaphanes sp. exhibited* ***continuous light emission patterns*** *rather than discrete flashes, indicating sustained reaction activity in the lantern tissue. The study demonstrates how cold-adapted biochemical mechanisms support light emission at low temperatures, revealing new insights into the diversity and adaptation of firefly bioluminescence.*

1. Introduction

1.1 Bioluminescence: An Overview

Bioluminescence refers to the biochemical emission of visible light by living organisms, where the enzyme **luciferase** catalyzes the oxidation of **luciferin** in the presence of oxygen, magnesium ions (Mg^{2+}), and adenosine triphosphate (ATP). The resulting excited-state oxyluciferin emits photons upon returning to the ground state. This light production is distinct from fluorescence or phosphorescence because it arises from a **chemical reaction within the organism itself**. The process exhibits remarkably high efficiency—quantum yields exceeding 40% have been reported (Ando *et al.,* 2008)—making it one of the most energetically efficient biological reactions known.

1.2 Firefly Bioluminescence and its Roles

Fireflies (Coleoptera: Lampyridae) use bioluminescence primarily for **communication and mating**. Light patterns differ between males and females, and even among species, functioning as a reproductive isolation mechanism. Some species employ light for predation or defensive mimicry (Lloyd, 1965). Beyond natural ecosystems, bioluminescent systems have found wide applications in **biotechnology**, **molecular imaging**, and **biosensor development** (Fan *et al.,* 2008; Gabriel & Viviani, 2014).

1.3 The Gap in Research: Winter Fireflies

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Globally, most fireflies are active during summer months when ambient temperatures favor enzymatic reactions. However, **winter-active fireflies** represent a rare ecological and biochemical adaptation. The genus *Diaphanes*, distributed across Asia, includes such cold-tolerant species. Prior to this work, no detailed **spectroscopic study** had been conducted on any Indian winter firefly species.

The discovery of a new *Diaphanes* species active during cold months in Assam provided an opportunity to explore how **biochemical light production** adapts to **low temperatures**. This chapter focuses on the emission spectra, temperature dependence, and time-domain behavior of this winter species.

2. Materials and Methods

2.1 Study Area and Specimen Collection

Specimens of *Diaphanes* sp. were collected from the **banks of the Dikrong River**, Lakhimpur District, Assam (27°03′N, 93°57′E), approximately 330 feet above sea level.

The region experiences night time temperatures ranging from **18°C to 7°C** between late November and early February, coinciding with the activity period of the species.

Adults were captured using light traps and hand nets between **6:30 p.m. and 7:30 p.m.** Active males showing intense flashes were selected for analysis.

2.2 Morphological Features

A specimen and its normal flash of this winter firefly is shown in Fig. 1. The average length and width of the firefly were **15 mm** and **4 mm**, respectively. The lantern consisted of two light-emitting segments separated by a small gap (~0.8 mm), a feature not observed in other Indian Species *Luciola praeusta* or *Asymmetricata circumdata*.

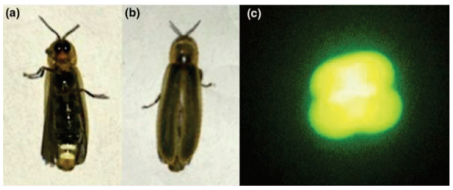

Figure 1. A specimen of the Indian winter firefly Diaphanes sp. showing (a) ventral view, (b) dorsal view, and (c) the luminous abdominal light organ.

2.3 Experimental Setup for Spectroscopy

Each specimen was gently immobilized on soft foam using sellotape and cotton supports. The lantern was oriented toward the input face of a **fiber-optic cable (QP200-2-UV-VIS)** connected to a **calibrated HR4000 Ocean Optics spectrometer**. Emission spectra were recorded via **SpectraSuite software** with an integration time of **2000 ms** due to low light intensity.

Temperatures were controlled using a **2 kW heater**, adjusted to maintain stability within ±0.2°C. Room temperatures ranged from **14°C to 20°C**, and spectra were recorded at **16°C, 20°C, 24°C, 28°C, 35°C, and 38°C.**

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2.4 Flash Waveform Recording

Temporal flash profiles were recorded using a **Hamamatsu H10722 photomultiplier tube (PMT)** linked to a **Tektronix TDS 2022C digital oscilloscope**. Specimens were studied under both **captive** and **free-flight** conditions inside a transparent chamber to compare natural flashing behavior.

3. Results

3.1 Spectral Characteristics

The steady-state emission spectrum at 16°C displayed in Fig. 2. The emission **peak appears at wavelength at 548 nm**, within the **green region of the visible spectrum**, with a **full width at half maximum (FWHM)** of 63 nm (523–586 nm).

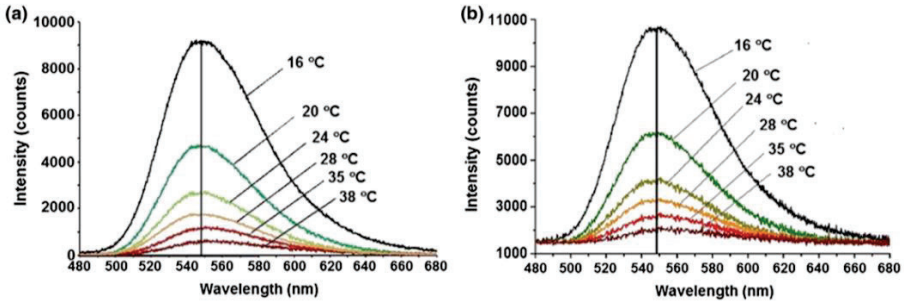

Figure 2. Emission spectra of the firefly *Diaphanes* sp. recorded in the captive mode at temperatures of 16, 20, 24, 28, 35, and 38°C. (a) Spectrum obtained after subtracting the background (no-signal) data. (b) Spectrum without background subtraction. The emission peak appears at 548 nm at 16°C, with a measured FWHM of 63 nm, which remains unchanged up to 24°C. From around 28°C onward, the peak gradually shifts toward longer wavelengths, and at 38°C—the highest temperature used in the experiment—a maximum red shift of 7 nm is observed. A vertical reference line at 548 nm highlights the spectral shift.

3.2 Effect of Temperature on Emission

The emission characteristics remained stable up to 24°C, beyond which a **red-shift** in peak wavelength became apparent. At **38°C**, the maximum observable peak shift was **7 nm**, indicating **partial denaturation of luciferase**. Additionally, overall light intensity declined with increasing temperature, consistent with the reduced quantum efficiency of the enzyme reaction at higher thermal levels.

3.3 Time-Domain Emission Behavior

The time-resolved spectra of this firefly are shown in Fig.3 and Fig. 4. The time-resolved profiles revealed **long-duration flashes** with incomplete dark intervals— a behavior previously unrecorded in Indian species.
In the **captive mode**, flashes appeared as continuous wave trains rather than distinct pulses, implying

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sustained reaction kinetics within the photocytes (Fig. 3). In the **free mode**, flashes were smoother, with durations between **0.9–1.8 seconds (Fig.4)**, indicating longer reaction times and slower oxyluciferin decay rates compared to summer species.

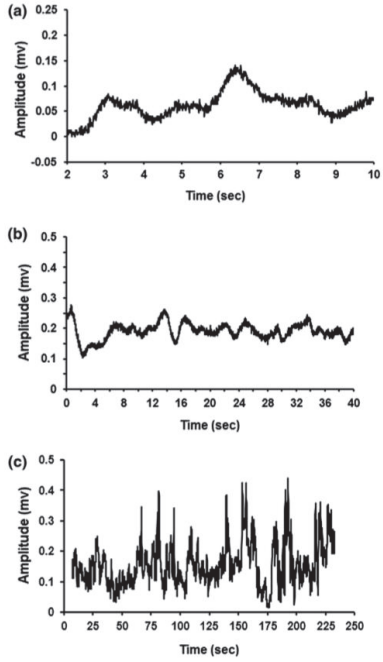

Figure 3. Flashes emitted by the firefly *Diaphanes* sp. under captive conditions at the normal flashing temperature of 16°C. (a) Recorded over a duration of 10 s, (b) over 40 s, and (c) over an extended period of approximately 4 min. The recorded flashes exhibit a noticeably noisy or irregular appearance.

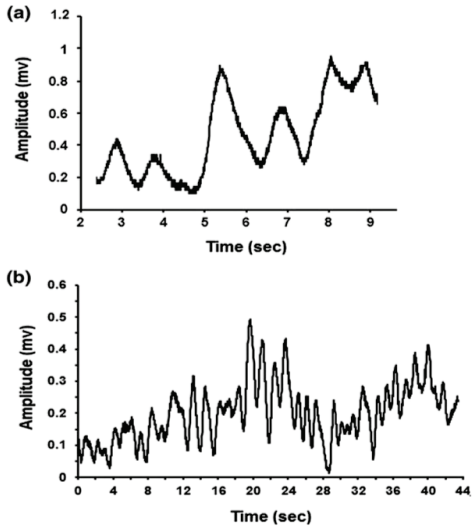

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Figure 4. Typical flashes from a specimen of the firefly *Diaphanes* sp. recorded in free-flight mode at 16°C. (a) Recorded over a 10-s timescale and (b) over a longer duration of approximately 30 s. In contrast to the flashes observed under captive conditions, these signals appear smoother and exhibit longer durations.

3.4 Response to Temperature Variation

The time-resolved spectra at different temperature are shown in Fig. 5. At **28°C**, flash durations shortened noticeably, while at **37–38°C**, flashes became broader and irregular. This confirmed the **thermal sensitivity** of the luciferase-luciferin system and its degradation beyond physiological limits.

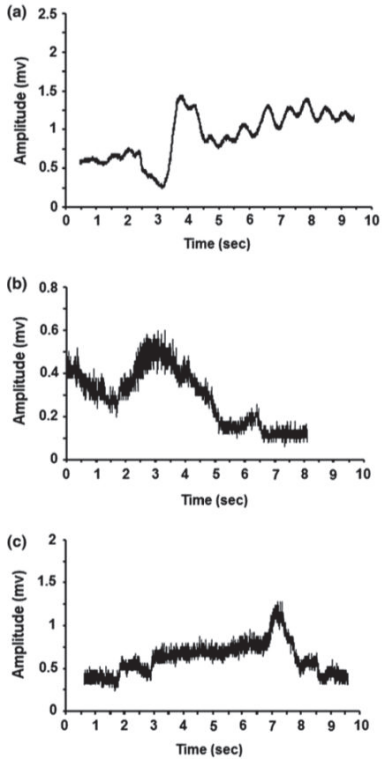

Figure 5. Flashes emitted by a specimen of the firefly *Diaphanes* sp. at elevated temperatures. (a) At 28°C, the flash durations are distinctly shorter than those observed at the typical winter flashing temperature. (b) At 37°C, the flashes become considerably longer compared to those at normal winter conditions. (c) At 38°C—the highest temperature used in the experiment—the flash pattern, similar to that at 37°C, deviates markedly from the usual winter pattern, with some flashes appearing abnormally broadened.

4. Discussions

4.1 Spectral Adaptation

The green-peaked emission (548 nm) corresponds to wavelengths most efficiently perceived by the **compound eyes of fireflies (540–560 nm)**, suggesting optimal visibility for nocturnal communication.

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Such emission profiles are typical of **dark-active species**, corroborating field observations that *Diaphanes* sp. is active only during the darkest hours of the night.

4.2 Temperature and Enzyme Dynamics

Temperature dependence of the emission pattern indicates that *Diaphanes* sp. is adapted to function efficiently at **low ambient temperatures (10–20°C)**.
Luciferase denaturation above 28°C may explain the absence of this species in summer. This biochemical adaptation allows successful communication and reproduction in cooler winter environments, where other species are inactive.

4.3 Unique Flashing Pattern

The continuous flash train pattern observed is unprecedented among Indian fireflies.
It may arise from **overlapping emission events** of multiple oxyluciferin intermediates or sustained neuronal stimulation of lantern photocytes.
Neurochemical control involving **octopamine release** is likely slower at low temperatures, prolonging the light pulses and leading to quasi-continuous luminescence.

4.4 Ecological and Evolutionary Implications

The winter activity of *Diaphanes* sp. reduces predation risk and competition with summer-active species. This temporal isolation could be a form of **seasonal niche differentiation**, enabling coexistence of multiple firefly species in the same region.

4.5 Comparison with Other Indian Species

Species	Season	Peak (nm)	Flash Duration	Remarks
Luciola praeusta	Summer	562	0.3–0.5 s	Bright, rhythmic flashes
Asymmetricata circumdata	Summer	570	0.4–0.6 s	Yellow emission
Diaphanes sp.	Winter	548	0.9–1.8 s	Continuous glow pattern

The lower emission wavelength and prolonged flash of *Diaphanes* sp. clearly distinguish it from the tropical fireflies studied earlier.

5. Conclusion

The **Indian winter firefly *Diaphanes* sp.** exhibits several unique bioluminescent characteristics:

- A **green emission peak at 548 nm**, narrower and cooler than summer species.
- **Temperature-sensitive emission**, with a red-shift beyond 24°C and luciferase denaturation near 28°C.
- **Continuous flash-train emission pattern**, suggesting slow enzymatic turnover and persistent neural control.
- Adaptation to **cold environments**, facilitating activity in the winter months when competitors are absent.
- This study establishes *Diaphanes* sp. as a **cold-adapted bioluminescent model** and opens new avenues for biochemical and ecological research on thermal adaptations in luminescent organisms.

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6. Future Perspectives

- **Molecular characterization** of *Diaphanes* luciferase to identify structural motifs responsible for cold adaptation.
- **Comparative genomics** with tropical species to reveal evolutionary divergence.
- **Applications** in low-temperature biosensing and luminescent tagging due to the enzyme's stability at reduced temperatures.
- **Conservation efforts**, as habitat disruption and artificial lighting threaten the survival of firefly populations.

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Chapter-18: Leveraging Machine Learning for Accurate Determination of N_{part} in Heavy-Ion Collision Events

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Abstract

This work explores the prospects of using of Machine Learning techniques in determining the value of number of participant nucleons (N_{part}) in ultra-relativistic heavy-ion collisions. Several machine learning models were trained on AMPT simulated Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV to reconstruct the N_{part} values from raw experimental observables like charged-particle multiplicity at mid-rapidity and the average transverse momentum of charged particles. The study demonstrates that the ML approach significantly achieves higher prediction accuracy in N_{part} estimation on an event-by-event basis compared to traditional methods.

Keywords: *Heavy-ion collisions, N_{part}, Machine Learning*

1 Introduction

The primary objective of ultra-relativistic heavy-ion collision experiments is to study the phase structure of strongly interacting matter governed by the theory of quantum chromodynamics (QCD), particularly the transition to and the properties of the Quark-Gluon Plasma (QGP) (*Bass et al., 1999*). The QGP is a state of the deconfined color partons, believed to have existed shortly after the Big Bang. The nature and the subsequent space-time evolution of the created matter in these collision experiments depend strongly on the initial collision geometry. One of the key parameters characterizing the geometry in such collisions is the number of participant nucleons (N_{part}), defined as the number of nucleons that undergo at least one inelastic interaction during the collision. Along with the impact parameter (b) and the number of binary nucleon–nucleon collisions (N_{coll}), it forms the basis for determining the centrality of an event which quantifies the nuclear overlap and, hence, the initial geometry of heavy-ion collisions. However, one cannot directly measure these quantities in an experiment. Instead, the Glauber model (*Miller et al., 2007*) is used to calculate centrality theoretically using the final state observables.

In recent years, artificial intelligence (AI) has emerged as a powerful tool in high-energy physics for complex tasks, especially for centrality determination (*Li et al., 2020; Mallick et*

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al., 2021; Kuttan et al., 2021; Xiang et al., 2022). While the majority of works determine centrality in terms of the impact parameter, our previous work (*Basak and Dey, 2023*) showed that centrality can be estimated in terms of N_{part} using Deep Learning (DL). In this work, ML techniques have been used to determine the centrality of Au+Au collisions at $\sqrt{s_{NN}}$ = = 200 GeV in terms of N_{part}.

2 Machine Learning Models

ML, a subset of artificial intelligence, learns complex correlations between the input and target variable from training data. In this study, we employed four different supervised ML models for the regression task.

2.1 Polynomial Regression (PR)

PR (*Peckov, 2012*) is a higher-order extension of linear regression model. Here the original input features are converted into a higher-dimensional space and then training is done on the transformed features using linear model. Regularization using Ridge regression was applied to prevent overfitting.

2.2 K-Nearest Neighbor (KNN)

KNN (*Taunk et al., 2019*) is a supervised, non-parametric, instance-based machine learning technique. It is a simple algorithm that predicts the value of a target variable by averaging the values of the *k* of its closest (nearest) neighbors in the feature space.

2.3 Decision Trees (DT)

Decision Trees (*Saltykov, 2020*) are tree-based models that recursively partition the feature space through a series of binary splits based on threshold values of individual features to reduce the variance in the target variable within each subset. This process continues until a stopping criterion is met. The model predicts a continuous value at the leaf node, which corresponds to the average of the target values in that node.

Table 1: Results of hyperparameter optimization

ML-Model	Hyperparameters	Values and Ranges	Optimal Hyperparameters
PR	poly_degree	[2, 3, 4, 5, 6, 7, 8]	5

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	ridge_alpha	[0.01, 0.1, 1, 10, 100]	1
	ridge_solver	['auto', 'svd', 'cholesky', 'lsqr']	'auto'
KNN	algorithm	['auto', 'ball_tree', 'kd_tree', 'brute']	'auto'
	metric	['euclidean', 'manhattan', 'minkoski']	'euclidean'
	n_neighbors	[1 - 100]	56
	weights	['uniform', 'distance']	'distance'
DT	max_depth	[None, 5, 10, 15, 20]	5
	max_features	[None, 'sqrt', 'log2']	None
	min_samples_leaf	[1, 2, 4]	1
	min_samples_split	[2, 5, 10]	2
LightGBM	learning_rate	[0.1, 0.05, 0.01]	0.05
	max_depth	[3, 5, 7, 10]	5
	n_estimators	[100, 200, 500,600]	200
	num_leaves	[31, 50, 70]	31

2.4 Light Gradient Boosting Machine (LightGBM)

LightGBM (*Ke et al., 2017*) creates an ensemble of weak decision trees through gradient boosting, where each tree corrects errors from previous iterations. LightGBM employs leaf-wise tree growth and advanced techniques including Gradient-based One-Side Sampling and histogram-based splitting for enhanced efficiency and accuracy.

3 Event Generator

We employed A Multi-Phase Transport Model (AMPT) (*Lin et al., 2005*) to simulate minimum bias Au+Au collision events. AMPT is a widely used hybrid transport model for simulating heavy-ion collisions at relativistic energies. The AMPT model consists of four main components that sequentially describe different phases of the collision: (i) Initial Conditions, (ii) Partonic Interactions, (iii) Hadronization, and (iv) Hadronic Rescattering. We used the string melting version of AMPT to generate training and testing datasets for our machine learning models.

4 Methodology

4.1 Data generation and feature selection

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The dataset used in this study was generated using AMPT for Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. A total of 50K events were generated, with an 80:20 split between training and test sets. Each generated event contains both the target variable (N_{part}) and various final-state observables, enabling supervised learning. Two experimentally measurable final-state observables namely charged particle multiplicity at mid-rapidity $\langle dN_{ch}/d\eta \rangle$ and the average transverse momentum of charged particles $\langle p_T \rangle$ were used as inputs or features for training the ML models. Only the charged hadrons within mid-rapidity ($|\eta| < 1$) and a transverse momentum cut ($p_T > 0.2$ GeV/c) were taken into consideration during input preparation. Prior to training, all input features were standardized using z-score normalization to ensure they were on the same scale.

4.2 Hyperparameter Optimization

To achieve optimal performance and prevent overfitting, each machine learning model was fine-tuned through GridSearchCV with 5-fold cross validation on the training set. Table **1** shows the optimized hyperparameters for each ML algorithm. All the ML-models were implemented using the Scikit-Learn libraries (*Pedregosa et al., 2011*) in python.

Table 2: Performance of the ML models.

ML-Model	MAE	RMSE	R^2
PR	8.4557	11.9622	0.9879
KNN	8.9093	11.8987	0.9881
DT	8.9809	12.1730	0.9875
LightGBM	8.5203	11.6212	0.9886

5 Result and Discussion

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All the ML models, after hyperparameter optimization, were trained with 40K AMPT-generated events and the performance of the models was evaluated using the rest 10K events. The primary metrics were used to quantify the performance and precision of the N_{part} prediction for all models. They are−Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Coefficient of Determination (R^2) value. A summary of the quantitative results is provided in Table **2** which shows that all four models were successfully trained to predict N_{part} from the simulated observables. The LightGBM model achieved the best overall performance, with the smallest errors and highest R^2 value, demonstrating its ability to capture complex nonlinear dependencies among observables. Figure **1** plots the correlations between the true values of N_{part} against the ML predicted values. It is evident that they are in agreement as shown by the overall diagonal distribution. Figure **2** shows the ratio of N_{part} predicted with ML models to the true values as a function of true values of N_{part}. Except for central and peripheral collisions, the predicted values are in good agreement with the true values.

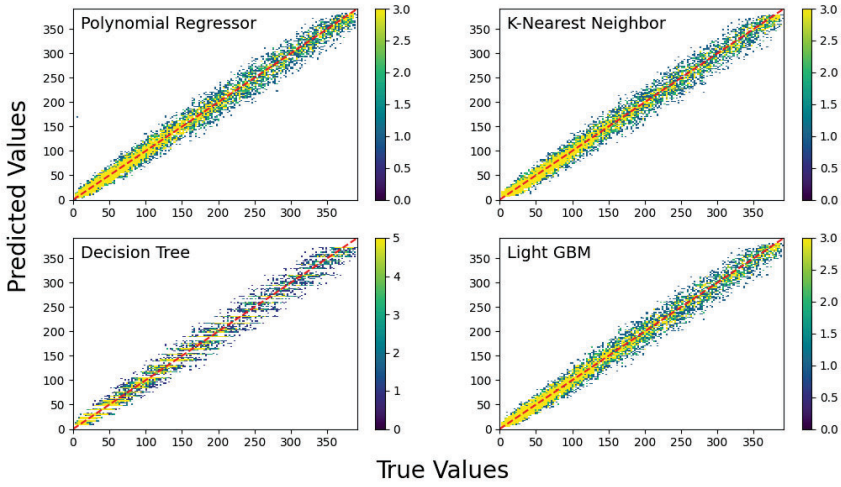

Figure 6: Correlation plot between the true values of Npart and the ML predicted values.

6 Summary

In this work, we have demonstrated a data-driven framework for estimating the number of participant nucleons (N_{part}) in high-energy heavy-ion collisions using machine learning regression techniques. Raw observables from the AMPT-generated data were employed as input features, and several regression algorithms-Polynomial Regression, K-Nearest Neighbors, Decision Trees, and Light Gradient Boosting Machine were systematically trained. The results show that machine learning methods can accurately reproduce N_{part} with

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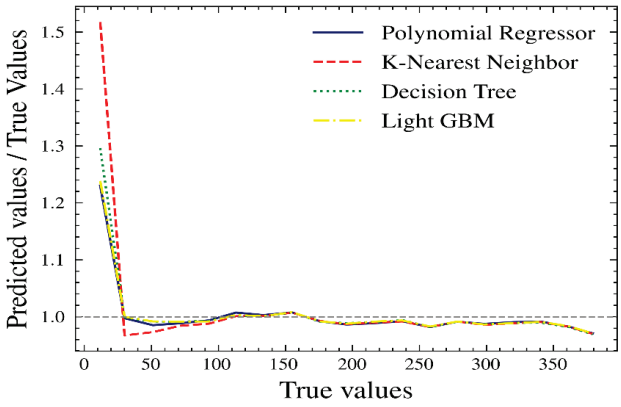

Figure 7: Ratio of ML predicted values of Npart to the true values.

minimal bias across the entire centrality range except for very central and peripheral collisions. Among the models studied, LightGBM achieved the highest predictive performance (R^2 = 0.9886). The strong correlation between predicted and true values, together with low residual errors, confirms that ML-based models effectively capture the nonlinear relationships between final-state observables and the underlying collision geometry.

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Chapter-19: Astronomy and Science-Behind the Myth

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Abstract

Most of the mythological scholars are from the background of languages and literature. So the inner scientific meanings of various facts are masked. Only the knowledge of science more precisely Astronomy can give a correct interpretation. The correct interpretations are very revealing and make many unknown notions to light. Such types of innumerable insights are strewn across the ocean of literature. From the detailed analysis it has been shown that indeed these were known a long back this period and most of the concepts are in fact inherited from the earlier legacy.

1. Introduction

The word Myth can be traced to the word 'Mithya' the Sanskrit word, literally it means untruth. Most of our Indian mythology was written as poetic and allegorically descripted and based on scientific and astronomical events and facts [1,2,3]. Unfortunately, our most of the mythological scholars are from the background of languages and literature. So the inner scientific meaning of various facts are masked. Only the knowledge of science more precisely Astronomy can give a correct interpretation. The correct interpretations are very revealing and make many unknown notions to light.

2. Astronomical Chronology of Events

In Rig Veda, the oldest extant Indo European literature, where various hymns were attributed to Sunashepa, literally it was the tail of the dog [4]. From the hymns it was appeared that Sunashepa was to be sacrificed to heaven as promised by Sunashepa's father. He was bound by the three pegs. At the time of sacrifice Sunashepa implored the Gods and finally was spared though instead of sacrifice he had to accept the head of an animal. Similar myth occurred later in the other tradition also. Orion the Hunter with the three stars in his belt and the dog star Sirius trailing behind and trying to enter Zodiacal belt of the heaven. Interestingly, the stars near the Orion's head, in Sanskrit which is called Mrigasira or it literally means head of an animal.

The story of Sunashepa appeared in Hindu Epic in two different forms. First is the story of Trishanku in Ramayana literally with the three pegs was a mythical king and he tried unsuccessfully to enter the heaven means the zodiac in the human form. Trishanku was not admitted and left hanging in midway. Apart from this mythological representation of the

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constellations, it also gives astronomical chronology which enables one to date this events and epics.

Another mythological character appeared as the king Yudhishthira, in the later epic Mahabharata. After losing all his near and dear Yudhishthira started the lonely trek to heaven accompanied by a faithful dog. At the gate of heaven he was welcomed but he was informed that there is no permission for the dog to come in. As the dog was abandoned so he rejected the invitation to heaven. This event also refers to constellations Orion the hunter and trailed by Sirius the dog these are just outside the zodiacal belt which is the path of the Sun or the abode Vishnu.

The Ramayana is the one of the oldest epic of India which is created around the story of Rama who was an embodiment of moral and just. Rama or Ramachandra, the meaning of Chandra is the Moon and moon is wedded to Sita. Sita is the symbol of perfection and she is the daughter of King Janaka literally means the king of man. Sita was found in the farming field while Janaka ploughing. If anyone go through these symbolism and imagery, it is clear that it relates to fast agricultural practice by human and left hunter gatherer lifestyle. Sita is the production of Earth which is the harvest and is wedded to Moon that is symbolises months and seasons. In this way earliest calendar started on the basis of lunar months. For the necessity of agricultural activity humans are forced to invent calendar. Chronologically, there is agreement with the modern estimate of start of the agricultural activity, which is actually the epi- paleolithic age.

In Ramayana we find description of various events which took place parallely when human coexisted with a species of sub human called Vanaras, literally means not fully human, in myth it is considered as monkeys. Vanaras used stone weapons unlike the human who used the Bows and arrows. The archaeological excavations in Nevali Cori shows exactly this type of coexistence [5]. Stone age implements can be found along with the megalithic structures like Carved pillars, Halls and well planned habitations and various complicated sculptures. The date of archaeology of this civilization is approximately 7500 BC, this date coincides with astronomical chronology of the author of portions of Rig- Veda and Ramayana. We should remember that the culture generally coexists with succeeding culture, before it dying out. The Mahabharata describes various events which took place much later in the iron age.

In Ramayana the two different interesting facts are- the first fact is related to the Ancient Indian mythological concept of ten manifestations or Avatars. This corresponds very closely to the evolutionary patterns of life on earth. The first manifestation/ avatar was the fish which symbolises the origin of lives in the sea. The second manifestation/ avatar was the tortoise

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which symbolises the amphibious character of next stage of the evolution. The third manifestation/ avatar was a boar which which symbolises a mammal's appearance. Next we move to pygmies. It is mentioned in Ramayana that human Parshurama was a manifestation and axe was his weapon. The axe-wielder Parashurama who lived upto the manifestation of Rama, in this manifestation bows and arrows were used. The symbolical fact that the stone axe of stone age turned into more modern bows and arrows. The Rama avatar was turned into Krishna who was one of the heroes of Mahabharata. Krishna avatar belonged to the early prehistoric periods and to the iron age. In fact Krishna used various iron weapons. It is explicitly mentioned that Rama and Krishna are to different manifestation of two succeeding eras.

In Ramayana the second correlation is that the bridge which was built by Rama and the forces of Vanaras, between India and Sri Lanka. It is very surprising that from evidence of satellite imaging technique, it is clear that indeed there is a bridge like formation which connects India and Sri Lanka exactly at the same place as described in Ramayana.

Indeed a thorough study of some of ancient Indian literature reveals surprisingly an accurate knowledge not only about the sky but also about geography. As for example, in Markandeya Purana [6] it is described that the earth is flattened at the poles in one hand, on the other hand it describes many lands including samar Kanda, the Samarkanda of present day and various rivers including some of the nearly forgotten rivers of India like Vansadhara and Nagavalli.

Various mythological depictions actually describe the drama in heavens that was guessed in the 19th century [7]. For example, the Goddess Saraswati riding a swan and plays the stringed musical instrument. Celestial Saraswati is actually the Milky- Way flowing over Swan the Cygnus with instrument Lyra the Harp. Another example The Goddess Durga appears as a virgin rides a lion, can be identified with the Constellation Virgo the virgin on Leo the lion and so on.

A very interesting mythological story was that an ancient Indian king named Bhageerath who saw the souls of many of his ancestor are in a grieving state. They were the children of king Sagara, literally means the sea. They requested Bhageerath to bring the water of celestial Ganga to them for their redemption. To bring Ganga is a very beautiful tale that describes many tribulations and travails which Bhageerath had undergone to fulfill the desire of his ancestors. At first Bhageerath had to convince the Ganges to come down to earth. But then he came to know that the earth would be broken up with some impact. He then plead and persuade God Shiva to take this impact onto himself. God Shiva agreed to do but very soon got annoyed, and tied up this falling water of Ganga in his hair knot or Sikhara, literally

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means peak. Bhageerath then plead and persuade once again God Shiva to release the water of Ganga. After this travails finally Bhageerath was able to bring Ganga to his ancestors that is to the sons of Sagara means sea at the Bay of Bengal. Every year this day is celebrated there. This is the mythological tale how water falls down on Himalayas and it gets frozen on the lofty peaks of Himalaya, one of the peaks is known as Shivalik Mountain range till today. The snow of Himalayas then melts and the water falls down and flow as Ganga with many tributaries. In fact, the river Ganga feeds drying up tributaries that are Bhageerath's ancestors, the sons of the sea. Finally the river Ganga ends up in Bay of Bengal.

In Mahabharata, it is mentioned that Arjuna accompanied by Krishna encounters an 'Asura' named as Maya. They acted as friend with Maya and in return of friendship Maya built a castle for Arjuna. Indian mythology says that the planet Venus(Sukra) is the preceptor of Asuras while the planet Jupiter(Brihaspati) is the preceptor of Arjuna and his folk. According to Mayan legend, the people of dark and fair visited them- literally Arjuna means fair and literally Krishna means dark. Mayan legends also suggested that the fair warrior is ambidextrous- that infact Arjuna is known by this name. Final insight of the meaning of all has come from two different facts. According to Varahamihira's Panchasiddhantika, C.500A.D, a compiled five calendar of astronomical traditions could be known [8] that the Asuras are antipodal people- actually Mexico and India are on the opposite side of the earth's meridian. Moreover, the ancient people of Mexico are known that they were obsessed with Venus, also they had the detailed informations about this planet and preserved till today in Dressden Codex. But India follows sixty years Jovian cycle of planet Jupiter. Moreover both the cultures having the same period of early prehistory. Thus the legends of mythological Mahabharata describe the encounter of the two cultures. The above discussion would explain the puzzle of the presence of some of the Hindu motifs, for example, the elephant or a tortoise carries twelve pillars, in the Mexican symbolism. As mentioned in the above discussion, the composers of both the myth had surprising knowledge about the various physical events, even including the water cycle. In Aditya Hrudayam or in Hymn of Sun, the Sun drinks water on earth and again it pours down the water back to the earth.

3. Conclusion

Such type of innumerable insights are strewn across the ocean of literature. Some scholars concluded, without a proper evidence that even the concepts such as zodiacal constellation and the other constellation were of the Greco- Babylonian origin. From the detailed analysis it has been shown that indeed these were known a long back this period and most of the concepts are in fact inherited from the earlier legacy.

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Chapter-20: Indium Oxide-Catalyzed Synthesis of Diaryl Disulfides from Aryl Halides

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Abstract

An efficient and general method for the synthesis of Aryldisulfides using indium (III) oxide as a catalyst is reported. Reaction of various organyl halides afforded the desired disulfide in good yields.

1. Introduction

Disulfide bonds are ubiquitous in many naturally occurring substances. For example, diallyl disulfide, ajoene, S-allylmercaptocysteine, and allicin are found in garlic.[1–4] These compounds have shown promising anti-infective properties.[5] Disulfides are also used in the synthesis of various organosulfur compounds.[6] Industrially, disulfides are employed as vulcanizing agents for rubbers and elastomers to increase their tensile strength.[7] Due to their importance, various strategies have been reported in the literature for the synthesis of disulfides. Among them, the oxidation of thiols to disulfides using various reagents and catalysts under controlled conditions is the most common.[8] Other methods include the conversion of alkyl halides to disulfides using Na_2S/S and the reductive coupling of sulfonyl chlorides.[9–10] However, these methods have several disadvantages. They often produce the desired disulfides along with solid waste by-products. Other drawbacks include the use of toxic reagents and metal oxidants, low yields, long reaction times, and high reaction temperatures.[11]

Thus, there exists a need for an efficient and simple method for the synthesis of disulfides without the formation of by-products. In this view, we have employed indium(III) oxide as a catalyst for the conversion of aryl halides into their corresponding disulfides. The method affords disulfides in good yields. The reaction is straightforward and involves simple work-up steps (Scheme 1).

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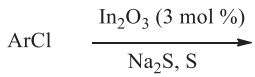
Indium(III) oxide has been chosen as a catalyst for the following reasons:
i. It is an easily recyclable and reproducible catalyst.[12]
ii. It is active, stable, and non-toxic.[13]
iii. Indium(III) compounds are mild and water-tolerant.[14]
iv. Moreover, their application in organic transformations is still limited.[15]



where Ar = m-$(NO_2)_2C_6H_3$, 2-C_5H_3N, o-$NO_2C_6H_4$, m-$ClC_6H_4NO_2$
o-C_6H_4COOH, m-$C_6H_5CH_2$, p-C_6H_5, o-$NO_2C_6H_4$

Scheme 1. Synthesis of symmetrical disulfides.

2. Results and Discussions

In a general procedure, chlorobenzene (in ethanol) was refluxed with a solution of sodium disulfide (in ethanol) in the presence of varying amounts of catalyst. The effect of catalyst loading on the reaction system was examined. It was observed that when 3 mol% of the catalyst was used for the conversion of chlorobenzene to diphenyl disulfide, the yield of the desired product was high (78%). The results are summarized in Table 1.

Table 1: Effect of amounts of Indium (III) oxide on the synthesis of dipenyl disulfide

Entry	Substrate	Disulfide	Catalyst	Amount (mol %)	Yield[a] (%)
1	8a	8a	In_2O_3	1.0	25
2	8a	8a	In_2O_3	2.5	64
3	8a	8a	In_2O_3	3.0	78
4	8a	8a	In_2O_3	5.0	70
8	8a	8a	No catalyst	-	35

Reaction conditions: A mixture of sulfur powder (0.16 g, 5 mmol), sodium sulfide (0.39 g, 5 mmol) and ethanol (10 ml) was stirred at room temperature for 15 min. The mixture was

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added to a solution containing substrate (6 mmol) and ethanol (10 ml) and 3 mol % of indium (III) oxide. The resulting mixture was refluxed for 48 min.

[a] Isolated yields. The potential of various solvents were also examined in the synthesis of diphenyl disulfide. Ethanol was found to be effective for the reaction system (Table 2).

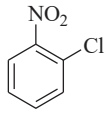
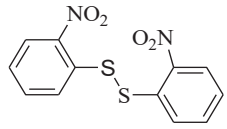
Table 2. Effect of various solvents on the synthesis of diphenyl disulfide

Entry	Substrate	Disulfide	Solvent	Yield[a] (%)
1	8a	8a	DMF	50
2	8a	8a	C_6H_6	39
3	8a	8a	CH_2Cl_2	55
4	8a	8a	CH_3Cl	60
5	8a	8a	C_2H_5OH	78

[a]Isolated yield

The protocol was extended for the conversion of several aromatic halides to their corresponding disulfides (Table 3). All were converted into corresponding disulfides giving good yields of the disulfides. Disulfides are the only products in the reaction condition.

Table 3. Synthesis of disulfides using In_2O_3 as catalyst

Entry	Substrate (**1**)	Product (**2**)	Reaction Time (min)	Melting Point (^{0} C)	Yield[a] (%)
1			30	193	85

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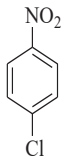
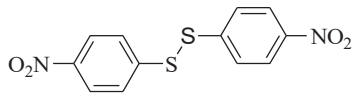
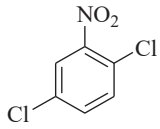
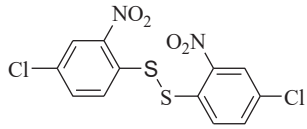
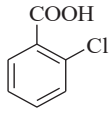
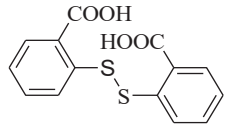
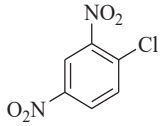
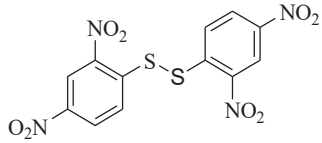
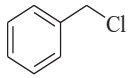
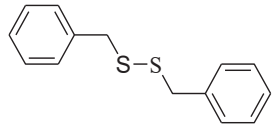
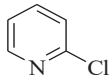
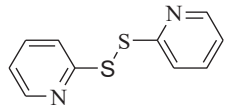
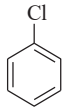
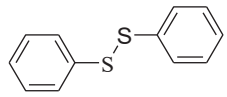
2			40	176	89
3			45	203	70
4			45	288	83
5			10	233	90
6			47	68	70
7			60	57	60
8			48	59	78

Reaction conditions: A mixture of sulfur powder (0.16 g, 5 mmol), sodium sulfide (0.39 g, 5 mmol) and ethanol (10 ml) was stirred at room temperature for 15 min. The mixture was added to a solution containing substrate (6 mmol) and ethanol (10 ml) and 3 mol % of indium (III) oxide. The resulting mixture was refluxed.

[a] Isolated yield.

Factors such as the presence of substituents in aryl chlorides influence the course of the reaction. For example, aryl chlorides containing nitro groups react rapidly to form the desired

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disulfides (entries 1, 2, and 5), while the presence of a chloro group in aryl chlorides decreases their reactivity toward disulfide formation (entry 3). On the other hand, aryl chlorides without substituents react more slowly (entries 6, 7, and 8).

It was also observed that the catalyst could be reused up to three times after washing with ethyl acetate or water, followed by drying under vacuum.

3. Conclusions

In conclusion, we have developed a new and efficient method for the synthesis of disulfides using indium(III) oxide as a catalyst. By applying this methodology, a variety of disulfides were synthesized in good yields.

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Chapter-21: A Comparative Analysis of different Genes with regard to Phylogenetic Utilization

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Abstract

Phylogenetic analysis is a very important aspect in biological sciences since it reveals the closest wild relatives of many crop plants for genetic and molecular studies which can be used in comparative studies and transfer of useful genes for crop improvement. In this study DNA sequence data from nuclear ITS1-5.8S-ITS2 region and chloroplast matK gene of seven different wild species of Solanum commonly found in Meghalaya are used. Molecular characterization of the sequences have been made on basis of conserve sites, variable sites, GC content, indels, transitions, transversions, parsimony informative sites etc. These are the parameters which indicate the evolutionary rate, so comparison of these parameters provides valuable information regarding efficiency of these regions in phylogenetic study. The result shows that both the two regions are useful for phylogenetic study in lower level, but the comparison indicates that matK is more phylogenetically informative in this case.

Keywords: *Solanum*, *ITS*, *matK*, Phylogeny

1. Introduction

According to most systematists and evolutionary biologists phylogeny should be the central underpinning of research in much of biology. Zuckerandle and Pauling (1965) suggested usage of macromolecular sequence data in phylogenetics and also gave the idea that phylogeny may be deduced from mutations. So in present days various genomic regions are exploited by different systematists to infer phylogeny according to their suitability to phylogenetic research. In case of plant phylogenetics different nuclear genes are used and among them the most extensively used are 18S rDNA and *rrn* ITS regions. This is because of its ubiquitous presences across the tree of life. It also exhibits similar phylogenetic signals at equivalent taxonomic ranks (Hillis and Dixon, 1991; Embley *et al*., 1994; D. Soltis and Soltis, 1995). The first major effort to apply 18SrDNA data to angiosperm phylogeny was undertaken in the late 1980s and based on direct RNA sequencing of portions of both the 18S and 26S regions (Hamby and Zimmer, 1988, 1992; Zimmer *et al.,* 1989). Subsequent studies (Nickrent and Franchina, 1990; Boulter and Gilory, 1992; Bharathan and Zimmer, 1995) contributed a small subunit database, with the trend toward complete 18S DNA sequences. ITS sequences have been utilized for reconstruction of phylogenetic relationship in angiosperms (Baldwin *et al*., 1995), algae (Bakker *et al*., 1995; Coleman *et al*., 1994). ITS

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sequences have also been used to infer phylogeny at lower taxonomic levels in a diverse array of organisms.

Among the chloroplast genes the commonly employed are *rbc*L (ribulose 1,5- bisphosphate carboxylase), *rps*4 (encoding a chloroplast ribosomal protein), *ndh*F (which possibly encodes a dehydrogenase) and *mat*K (encoding a maturase), *atp*B etc. Chase *et al*., 1993 has provided a database for *rbc*L, Nadot *et al*., 1994 used *rps*4 in Poaceae to infer phylogeny, *ndh*F used on Scrophulariacea by Olmstead and Reeves, 1995, and in Solanaceae by Olmstead and Sweere, 1995, *atp*B used on Lardizabalaceae by Hoot *et al.,*1995.

Both nuclear DNA Internal Transcribed Spacer region (ITS1-5.8S-ITS2) and chloroplast DNA *mat*K region are used to infer phylogeny among lower taxonomic groups. In the present study an effort has been taken to characterize Internal Transcribed Spacer region (ITS1-5.8S-ITS2) of the 18S-5.8S-28S nuclear ribosomal cistron and chloroplast *mat*K gene region, as well as comparison of their perspective for phylogenetic utility in context to some *Solanum spp.* of Meghalaya.

2. Materials And Method

Plant material and taxon sampling

Solanum aculeatissimum, *Solanum sisymbriifolium*, *Solanum aethiopicum*, *Solanum kurzii*, *Solanum clavatum*, *Solanum nigrum* and *Solanum torvum* were collected from forests around Shillong, Meghalaya (North- East India) (Table 1). Voucher specimens are lodged in the Herbarium of Botany Department, North Eastern Hill University.

Species	Specimen voucher[a]	ITS	*mat*K
Solanum khasianum Clarke	NEHU-11928	KC535792	KC535798
Solanum sisymbriifolium Lamk.	NEHU-11929	KC535789	KC535799
Solanum gilo Req. ex Dunal	NEHU-11931	KC535795	KC535801
Solanum kurzii Brace ex Prain	NEHU-11934	KC535794	KC535800
Solanum clavatum Rusby	NEHU-11933	KC535790	KC535796

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Solanum nigrum L.	NEHU-11930	KC535791	KC535797
Solanum torvum Sw.	NEHU-11932	KC535793	KC535802

Table1. Specimens voucher, accession numbers of deposited sequences of all the seven *Solanum* spp. collected. ([a] Specimen vouchers deposited at the Herbarium, Department of Botany, North Eastern Hill University.)

DNA extraction, amplification and sequencing

Genomic DNA was isolated from fresh leaves using CTAB method (Doyle and Doyle, 1987). Primers were designed targeting two regions of the genome- nuclear ITS region and chloroplast region *matK* (Table 2).

Primer name	Sequence
SITSF	5'AAACCTGCACAGCAGAACGAC3'
SITSR	5'GGTCGCGGTCGGAGCGCG 3'
SmtKF	5'CACAAACTAGACGAAGCTC3'
SmtKR	5'TATGCACTTGCTCAGGATC3'
Smtk1	5' AATATATTTCTATGGAAAAAG3'
Smtk2	5' ATCAAAGGATCCTTGAATAAC3'

Table 2. The primers designed and used in this study and their sequences.

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Amplification of *rrn* ITS, and *matK*

Each reaction mix contained 2.5 µL of 10X PCR assay buffer, 2.5 µL of $MgCl_2$ (25mM), 3 µL each of the individual dNTP (1.25 mM), 1.5 µL of each primer pair (5 pM), 0.3 µL of *Taq* polymerase (3 Units/ µL), and the final volume was made up to 25 µL by adding ultra pure water., Polymerase chain reaction was carried out targeting the genes using the respective primer pairs (Table 2). The thermalcycler was programmed with the following parameters: premelt at 94 ^{0}C for 5 min followed by 35 cycles consisting of denaturation at 94 ^{0}C for 30 sec, annealing for 1 min at 65^{0}C and 64^{0}C for *rrn* ITS and *matK* respectively and extension at 72 ^{0}C for 1 min. The main programme was followed by a final extension step of 72 ^{0}C for 10 mins. Internal primer pairs namely Smtk1, Smtk2 were used for sequencing purpose of *matK* .Amplified PCR products were purified using Himedia Quick gel extraction kit. Sequencing was carried out by 3130 Genetic Analyzer (Applied Biosystems) in North Eastern Hill University.

Sequence alignment and Sequence characteristics

Sequences of both the two regions were subjected to Multiple Sequence Alignment using the CLUSTAL X (2.0) program (Thompson et al., 1997) with default settings.

Sequence characteristics of both the studied regions were calculated before performing phylogenetic analyses by using both MEGA version 5 (Tamura et al., 2011) and Seqstate v.1.21 (Müller, 2005). The two data sets were analyzed separately as shown in the table 3.

RESULTS AND DISCUSSIONS

The sequences of both ITS and *mat*K of all the species of *Solanum* were aligned with Multiple Sequence Alignment using CLUSTAL X program separately. The numbers of characters for each regions, the percentage of conserved sites, variable sites, parsimony informative characters, GC content, transitions, transversions, indels etc. were analysed and are described in Table 3, as the analyses of these characters are very important in phylogenetic point of view. Both the two regions namely ITS and *matK* showed variable sequence lengths. The sequence length of ITS for all the seven species studied ranged from 575-619bp, while *mat*K sequence length ranged from 1282-1302bp. They have an aligned sequence length of 641 and 1356 characters for ITS and *mat*K respectively. ITS has lowest percentage of conserved sites (51.48%) than *mat*K (85.69%) and thus ITS has the most variable region (46.49%) generating highest number of parsimony informative sites (17.32%) than that of *matK* (10.46%) which provides 1.80% of parsimony informative sites. The % GC content is higher in case of ITS (61.2%) than *mat*K (32.4%). Among the two regions studied total transitions and transversions were higher in case of ITS than that of *mat*K. The highest number of indels were recorded in ITS (19.81%) followed by *mat*K (8.0%). Average number of base substitutions per site is recorded higher in case of *mat*K as seen in table 3 which is 0.058 than ITS where average number of base substitution per site is 0.03. Retention index and consistency index are two important criterion on basis of which the intensity of homoplasy can be assumed in a given array of DNA sequence. So in our study it has been seen that (Table 3) *mat*K is occupying higher position in case of both retention index (0.85)

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and consistency index (0.84) than ITS where retention index is 0.58 and consistency index is 0.65.

Dataset characteristics	*ITS*	*matK*
Genome	Nuclear	Chloroplast
Range of raw length	575-619	1282-1302
Aligned length	641	1356
Conserved sites (%)	51.48	85.69
Variable sites (%)	46.49	10.46
Parsimony informative sites (%)	17.32	1.80
Transitions	71	15
Transversions	47	19
Indels (%)	19.81	8
Retention index (RI)	0.58	0.85
Consistency index (CI)	0.65	0.84

Table 3. Sequence information and comparison of data sets from two nuclear regions and two chloroplast regions.

To infer phylogenetic relationship at different taxonomic levels both chloroplast DNA (cpDNA) and nuclear ribosomal DNA (nrDNA) are used (reviewed by Palmer *et al*., 1988; Hamby and Zimmer, 1992). Nuclear ribosomal ITS and chloroplast *matK* are two regions which are extensively used to infer phylogenetic relationship at lower taxonomic levels. ITS is a noncoding region and that is why it is prone to rapid evolutionary changes but though cp *matK* is a coding region it is the most rapidly evolving coding region found so far within chloroplast genome (Neuhaus and Link, 1987; Olmstead and Palmer, 1994). So in the present study both the two regions were amplified and sequenced for all the seven species of *Solanum* so that a comparison can be made in respect to their phylogenetic utility. From the

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results it has been seen that ITS contains more variable sites than *matK*. Insertions and deletions (indels) are also more common in case of ITS. As expected ITS provide more parsimony informative characters as was also reported by Shaw *et al*., 2005. The nuclear ITS data set had higher percentage of variable sites together with higher parsimony informative characters than *mat*K, which suggests its higher level of homoplasy. Alvarez and Wendel (2003) also reported that ITS shows higher level of homoplasy as compared to other DNA sequence data sets. This is due to orthology/paralogy conflation, compensatory base changes, problem in alignment due to indel accumulation, sequence errors, and some combinations of these phenomena. The chloroplast *mat*K gene was found to be more informative having both a high percentage of Parsimony informative characters as well as high Consistency and Retention indices which suggests a low level of homoplasy. Mort *et al*., 2007 also reported similar type of results suggesting that homoplasy in ITS was relatively high compared to the cpDNA loci. According to Alvarez and Wendel (2003), despite the universal usage of ITS sequence data in plant phylogenetic studies, its complex and unpredictable evolutionary behavior reduce its utility for phylogenetic analysis. Thus from the above results and discussions it can be concluded that *mat*K is more efficient to resolve phylogenetic relationship compared to that by ITS in this case.

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Chapter-22: Herbal Medicine in the Management of Liver Diseases

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Abstract

Liver diseases remain a global health challenge, with conventional drugs often limited in efficacy and sometimes caused hepatotoxicity. Herbal medicines offer promising alternatives due to their safety, potency and cost-effectiveness. Phytoconstituents such as flavonoids, polyphenols, glycosides and essential oils have demonstrated the hepatoprotective effects by reducing oxidative stress, enhancing antioxidant defenses and regulating liver enzyme activity. The major medicinal plants with reported hepatoprotective potential include C. sinensis, A. paniculata, S. marianum, Z. officinale, C. pepo, C. reticulata and P. crispum. The therapeutic efficacy of herbal formulations often arises from synergistic interactions among multiple constituents. Advanced techniques like high-performance liquid chromatography and microdialysis aid in characterizing these compounds, while understanding their pharmacokinetics is crucial for optimizing dosage and safety. Plant-based biomolecules thus represent a promising source for the development of effective hepatoprotective drugs.

Keywords: *Liver, herbal medicine, liver diseases, medicinal plants, hepatoprotective drugs.*

1. Introduction

Currently, phytochemicals from natural resources are being adopted as alternative treatment options to treat several acute to chronic diseases. Despite considerable advancements in modern medicine, a shortage of proper and potent hepatoprotective agents has remained a chronic concern (Hasan et al., 2018). Many conventional medications have been removed from the market due to reports of drug-induced liver injury, and serious cases of liver dysfunction can require liver transplantation or lead to death (Au et al., 2011). Modern drugs provide little relief for liver disorders are primarily treated using plant-based formulations. Herbal drugs have grown in importance and popularity in recent years due to their potency, purity and cost-effectiveness. Therefore, an attempt has been made to address herbal medicine for the treatment of liver diseases, which are widely used for the therapeutic purpose. A number of chemical constituents, such as phenols, organic acids, lignans, monoterpenes, alkaloids, flvonoids, glycosides, coumarins, lipids, and xanthenes, have been identified in hepatoprotective plants (Bhawna and Kumar, 2010). A wide range of plants are thought to have hepatoprotective efficacy, suggesting that the advancement of plant-based hepatoprotective drugs on the global market should be prioritized (Abu et al., 2017).

Across the world, liver disorders, such as jaundice, cirrhosis, fatty liver, hepatosis, drug-induced hepatitis, alcohol-induced hepatitis, non-alcoholic steatohepatitis and hepatocellular carcinoma, create conditions in which the functions and structure of the liver become impaired, and liver failure is the fifth most common cause of death globally, behind only heart failure, stroke, chest disease and cancer, making liver disease a public health issue (Azab and Albasha, 2018). The worldwide incidence of chronic liver disease is 18.5% and the prevalence of cirrhosis is 4.5%–9.5%, with 2 million people dying every year (Islam and

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Alam, 2019). According to the World Health Organization (WHO), deaths due to liver disease in India reached 268,580 in 2020, accounting for 3.17% of total deaths. Chronic liver diseases, including cirrhosis, were the eighth leading cause of death in 2022, a significant increase from previous years (Swaroop et al., 2024). Hepatic disorder is associated with the disruption of the liver structures, tissues and function, which may be caused by biological origins, including bacteria, viruses, parasites and autoimmune diseases, induced by various conventional drugs acetaminophen, nimesulide and hepatotoxins, which are primarily metabolized by the enzymes cytochrome P450 and glutathione S-acyltransferases mixed oxidases; and the excessive consumption of alcohol (Kumar et al., 2011; Madrigal-santill´an et al., 2014; Mishra et al., 2014). The present study discusses major medicinal plants with significant hepatoprotective properties and their contributions to the management of liver diseases.

2. Methodology

Different types of electronic bibliographic databases such as Web of Science Master Journal List, SpringerLink, ScienceDirect, Google Scholar, PubMed, Scopus, Wiley Online Library, Taylor & Francis, ResearchGate, and NISCAIR Online Periodicals Repository were extensively searched to obtain scientific information on “hepatoprotective traditional medicinal plants” by applying specific keywords. The keywords used included “plants against hepatoprotection,” “herbal medicine for liver problems,” “phytotherapy for liver disease,” and “plants and hepatoprotective effects.” The research articles were downloaded from various scientific journals and thoroughly examined for their relevance, authenticity, data quality and validity.

3. Medicinal Plants for Hepatic Disorders

3.1 *Zingiber officinale*

Z. officinale (Zingiberaceae) is a widely used medicinal plant around the world, commonly incorporated into foods as a spice. Traditionally, it has been an important ingredient in Chinese, Ayurvedic, and Unani herbal medicines for the treatment of various ailments such as catarrh, rheumatism, nervous disorders, gingivitis, toothache, asthma, stroke, constipation, and diabetes (Awang, 1992; Tapsell et al., 2006; Wang and Wang, 2005). The pharmacological effects of ginger have been reported to include antiplatelet, antioxidant, antitumor, anti-rhinoviral, anti-hepatotoxic, anti-arthritic, and anti-inflammatory activities (Lantz et al., 2007; Patel et al., 2000). The antioxidant activity of gingerol and other constituents of ginger has also been confirmed (Aeschbach et al., 1994). It has been reported that different doses of ginger extract cause alterations in biochemical parameters, free radicals, and antioxidant enzymes induced by bromobenzene in a rat model, thereby improving bromobenzene-induced liver toxicity (El-Sharaky et al., 2009). Curcumin, another active component present in ginger, has been found to act as an antioxidant and anti-inflammatory agent, inducing haem-oxygenase-1 and protected endothelial cells against oxidative stress (Motterlini et al., 2000). Furthermore, ginger root extract has shown hepatoprotective effects against aspartame-induced hepatotoxicity by decreasing liver function biomarkers (ALT, AST, ALP, γ-GT), serum total protein, albumin, and total bilirubin levels, while increasing antioxidant enzyme levels and reducing malondialdehyde concentrations (Hozayen and Abou Seif, 2014).

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3.2 *Cucurbita pepo* L.

Pumpkin is frequently reported as a functional food or medicine (Caili et al., 2006). Pumpkin seeds are a rich source of unsaturated fatty acids, antioxidants, and fiber, and are known to have anti-atherogenic, hepatoprotective (Makni et al., 2008), and antidiabetic activities (Al-Zuhair et al., 2000). Phytochemical analyses have revealed that pumpkin is rich in unsaturated fatty acids particularly linoleic and oleic acids as well as tocopherols with very high oxidative stability (Stevenson et al., 2007), carotenoids, and gamma-aminobutyric acid (GABA) in the fruit (Liu et al., 2001; Gossell-Williams et al., 2008). Pumpkin seed oil contains nutrients such as essential fatty acids (omega-6 and omega-9), phytosterols, and antioxidants including carotenoids, vitamin A, and vitamin E (Murkovic et al., 1996). Moreover, pumpkin oil may play an important role in protecting against alcohol and Tramadol-induced hepatotoxicity and oxidative stress (Abou Seif, 2014a; Ekpono et al., 2024).

3.3 *Citrus reticulata*

C. reticulata, also known as mandarin, is a small citrus tree with fruits resembling other orange varieties. Chemically, the plant is rich in vitamin C, flavonoids, organic acids, volatile oils, and rutin (Wang et al., 2008; Luo et al., 2008). In humans, rutin exhibits more potent antioxidant properties compared to quercetin, acacetin, morin, hispidulin, hesperidin and naringin (Chow et al., 2005; Zhou et al., 2016), which are mostly isolated from citrus peel. Hesperidin is another flavanone glycoside found abundantly in citrus fruits that showed an antioxidant, anti-inflammatory, anticarcinogenic activities in vitro study (Farombi et al., 2008; Emim et al., 1994; Tanaka et al., 2000). Both hesperidin and rutin plays an important role in the protection against doxorubicin-induced hepatotoxicity, by alleviating the activities of liver enzymes (ALT, AST, and ALP and GGT) in addition to the amelioration in the levels of total bilirubin, albumin and sialic acid (Hozayen et al., 2014; Elhemiely et al., 2025).

3.4 *Petroselinum crispum* oil

The plant Parsley (Apiaceae) is a native herb of the central Mediterranean region (southern Italy, Algeria, and Tunisia) (Lopez et al., 1999). Various scientific studies have demonstrated its antibacterial and antioxidant activities (Wong and Kitts, 2006; Zhang et al., 2006; Kolarovic et al., 2010). Phytochemical analyses have shown that parsley contains several flavonoids, such as apiin and luteolin, while its essential oil is rich in apiol and myristicin (Alobaidi, 2024; Farzaei et al., 2013; Fusani et al., 2025). Parsley oil plays an important role in improving liver function by modulating enzyme activity, enhancing antioxidation and anti-lipid peroxidation, promoting detoxification, and protecting against glutathione depletion in cases of alcohol-induced hepatotoxicity and oxidative stress (Abou Seif, 2014b).

3.5 *Andrographis paniculata*

A. paniculata (Acanthaceae) is one of the most commonly used plants in the traditional systems of Unani and Ayurvedic medicine, and it is widely known as the king of bitters (Jarukamjorn and Nemoto, 2008). *A. paniculata* has been reported to possess antibacterial (Mishra et al., 2013), antimalarial (Dua et al., 2004), antiviral (Wiart et al., 2005), cardioprotective, antioxidant, anti-inflammatory (Sheeja et al., 2006), antidiabetic, and antitumor activities (Zhao et al., 2008). Treatment with whole-plant extracts of *A. paniculata* has been shown to reduce lipid peroxidation levels and enhance antioxidant enzyme activity,

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likely due to the presence of various flavonoids, phenols, and glycosides in the plant (Subramaniam et al., 2015).

3.6 *Silybum marianum*

Silymarin, derived from the seeds of *S. marianum*, is a member of the sunflower family and is commonly called milk thistle. The plant has been used for centuries as a natural remedy for liver and biliary tract diseases (Abou Seif, 2016). The active biomolecules of milk thistle are flavonolignans, including silybin, silydianin, and silychristin, collectively known as silymarin (Shaarawy et al., 2009). The pharmacological activity of silymarin has been reported to protect liver cells from a wide variety of toxins, including acetaminophen, ethanol, CCl_4 and D-galactosamine (Rasool et al., 2014). Its hepatoprotective efficacy is attributed to several mechanisms, including antioxidation, anti-lipid peroxidation, enhanced detoxification, and protection against glutathione depletion (Pradhan and Girish, 2006). Silybum seeds also contain betaine and essential fatty acids, which may contribute to silymarins' anti-inflammatory effect (Saller et al., 2001).

3.7 *Camellia sinensis*

Green tea leaves produce organic compounds that may be involved in the defense of plants against invading pathogens, and these metabolites are known as polyphenols (Friedman, 2007), which include catechin, epicatechin, epigallocatechin, tannins and caffeine (Wang and Goodman, 1999). Green tea displays antioxidants and free radical scavenger properties (Crespy and Williamson, 2004). The green tea extract and its main catechin polyphenols have medicinal value for the prevention of and therapeutics in several diseases (Ostrowska and Skrzydlewska, 2006). The green tea exerts improvement in liver function by preventing the production of reactive oxygen species (ROS) and enhancing the antioxidant defense system capacity. Thus, green tea extract has protective effects against ethanol toxicity (Bharali and Chetry, 2013; Lodhi et al., 2014).

4. Discussion and Conclusion

Although the number of patients with liver diseases has been increasing rapidly, treatment outcomes are still considered unsatisfactory. Herbal medicine has become a major contributor to the management of liver problems. The growing number of preclinical and traditional studies on various herbal medicines indicates a promising future for drug development from herbal-based products. The success of treating liver diseases with herbal medicines depends on understanding each chemical constituent and their interactions. Currently, a handful of herbal drugs, such as silymarin, rutin, epicatechin, and epigallocatechin, have been extensively studied. These plant-based biomolecules, along with other constituents mentioned in this study, have demonstrated their significance and potential as major treatment modalities for liver diseases.

Unlike conventional drugs, which are composed of known chemical constituents that can be accurately quantified, herbal drugs consist of complex mixtures of ingredients. Due to this complexity, studies face major challenges, with the greatest difficulty being the purification of herbal medicines and the identification and quantification of their individual components. Currently, advanced techniques such as high-performance liquid chromatography, protein precipitation, and microdialysis are being used to separate these chemical constituents.

However, studying the clinical effects of individual chemical constituents in isolation is of limited use for several reasons such as the neutralization of harmful chemicals in a mixture

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by other compounds, as well as the synergistic or inhibitory interactions among constituents that together create an effective in vitro therapeutic combination. Relying solely on information about the pharmacodynamics of herbal medicines in liver diseases provides insufficient detail for developing drugs with similar effects. Factors such as metabolism, absorption, distribution, and the intrinsic concentration of the drug must be accurately understood to determine the appropriate dosage, duration of treatment, and safety margin.

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The authors have nothing to report.

Conflict of interests:
The authors declare that there are no conflicts of interest related to this article.

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Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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Chapter-23:Assessment of Ecosystem Services of Urpad Beel and Its Impact on People's Dependency

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Abstract

The study investigates the ecosystem services provided by Urpad Beel, a wetland of significant ecological importance. The study aimed to identify, assess, and analyze the diverse ecosystem services offered by Urpad Beel, as well as their contributions to the well-being and livelihoods of local communities. Through a comprehensive literature review, field surveys, and stakeholder consultations, this research examines the ecological, economic, and socio-cultural dimensions of the wetland's ecosystem services. The research employs a multi-disciplinary approach, integrating ecological assessments, economic valuation techniques, and qualitative analyses to understand the significance and benefits derived from Urpad Beel. The ecosystem services are classified, quantified, and ranked based on their perceived importance and utilization by local communities. Additionally, the study investigates the temporal dynamics of the wetland's ecosystem services, exploring how they have changed over time and the factors contributing to these changes. Furthermore, this study explores the implications of ecosystem service degradation or loss on the well-being of local communities and highlights the interdependencies between natural and human factors in shaping the wetland ecosystem. The findings of this research will provide valuable insights for policymakers, conservationists, and stakeholders involved in the sustainable management and conservation of Urpad Beel. Overall, this work contributes to the understanding of the ecosystem services provided by Urpad Beel and emphasizes their critical role in supporting the socio-economic well-being and cultural heritage of the local communities. The results will guide the formulation of effective policies and management strategies aimed at the conservation and sustainable use of Urpad Beel's ecosystem services for the benefit of both present and future generations.

Keywords: *Ecosystem services; Urpad Beel; conservation; people's dependence; sustainability*

1. Introduction

Wetlands are among the most biologically diverse and productive ecosystems on Earth, providing essential ecological functions and supporting human well-being. They serve as critical habitats for a variety of plant and animal species, many of which are unique to these ecosystems (Cherry, 2011; Davidson, 2014). According to the Ramsar Convention, wetlands are defined as areas where water is the primary factor controlling the environment and the associated plant and animal life. These ecosystems may be permanently or seasonally waterlogged, natural or artificial, and include both inland and coastal zones. The saturation of land with water in wetlands creates a mosaic of habitats that supports high biodiversity, maintains ecological balance, and provides essential ecosystem services. Globally, wetlands cover approximately 6% of the Earth's surface, and in India, they constitute an estimated 4.6% of the country's total land area, encompassing a wide range of types and ecological

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characteristics (ISFR, 2019; Bhattacharjee et al., 2020). In Assam, a north-eastern state of India, wetlands are critical for local livelihoods, culture, and biodiversity conservation, including species such as the endangered one-horned rhinoceros (Assam State Wetland Authority, 2019). The state has 708 identified wetlands, covering an area of 3,585 km², reflecting the ecological and socio-economic significance of these ecosystems. Wetlands provide numerous benefits, including water purification, flood control, nutrient cycling, carbon sequestration, and habitat for flora and fauna. These services are not only essential for ecosystem functioning but also underpin the livelihoods and cultural practices of local communities that directly depend on wetland resources for subsistence and income.

Ecosystem services from wetlands can be broadly categorized into four types: provisioning, regulating, supporting, and cultural services (MEA, 2005). Provisioning services include tangible goods such as fish, shellfish, water, fodder, fuelwood, timber, and medicinal plants. Regulating services encompass flood mitigation, water purification, nutrient retention, and climate regulation. Supporting services are ecological processes, including habitat provision, nutrient cycling, soil formation, and carbon sequestration, which maintain ecosystem health. Cultural services comprise non-material benefits such as recreation, tourism, aesthetic value, spiritual enrichment, and educational opportunities. These services collectively sustain both ecological integrity and human well-being.

Despite their importance, wetlands worldwide are facing severe degradation due to land-use changes, pollution, over-exploitation of resources, and climate change, leading to alterations in hydrology, biodiversity, and biogeochemical cycles. Such changes directly affect the availability and quality of ecosystem services, with significant consequences for the livelihoods, cultural practices, and resilience of communities that rely on them. For example, modifications in wetland hydrology can disrupt water supply for agriculture and domestic use, while declines in biodiversity can undermine traditional knowledge and resource-based livelihoods.

This study focuses on Urpad Beel, a lesser-known wetland in Assam, North-East India, to assess its ecosystem services and examine their contribution to local livelihoods. It aims to identify and rank the wetland's provisioning, regulating, supporting, and cultural services, while also evaluating the impacts of ecosystem service changes on community dependency. The research highlights both the ecological and socio-economic dimensions of wetland management, explores challenges such as siltation, invasive species, and flooding, and identifies opportunities for conservation, sustainable use, and livelihood enhancement. By emphasizing the interconnections between ecosystem services and human well-being, this study provides critical insights for policymakers, conservationists, and local stakeholders to ensure the long-term sustainability and resilience of Urpad Beel and its surrounding communities.

2. Materials and methods

***Study site*:** The study site for this research is Urpad Beel, a wetland located in the Goalpara district of Assam, India. Urpad Beel is situated at approximately 26.1750° N latitude and 90.5708° E longitude, with a total area of approximately 649.38 ha. It is about 12 km from Goalpara town, the district headquarters and is approximately 150kmfrom the state capital i.e. Guwahati. ***Methodology*: A** case study approach was adopted, and data were collected using both qualitative and quantitative methods. The data for this research was collected using a

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combination of field surveys, household survey, and literature review. ***Field surveys:*** Field surveys were conducted to collect primary data on the physical and biological characteristics of Urpad Beel. The survey included mapping the wetland, identifying the different wetland zones, and wetland vegetation based on peoples' perception. ***Household survey*****:** An initial rapid assessment was conducted in five villages surrounding Urpad Beel, namely Chamaguri, Genderapara, Paharkata, TNT, and Sutradharpara, to determine the level of household dependency on wetland resources. To gather more detailed information on the impact of wetland degradation on these households, a semi-structured questionnaire was developed based on previous works in the same field. The questionnaire focused on the ecosystem services provided by the wetland, the level of household dependency on these services, the drivers of change, and the impacts on the ecosystem services. ***Data Collection*****:** Data was collected through face-to-face interviews with the head of the household or the primary decision-maker in the household. The interviews were conducted in the local language and were administered by trained enumerators. ***Data Analysis****:* The data collected through the household survey was analyzed using descriptive statistics and cross-tabulations. The findings were presented using graphs and tables, which helped to summarize and visualize the data. Ethical considerations: Ethical considerations were taken into account during the research process, including obtaining consent from stakeholders before conducting interviews and ensuring confidentiality of the collected data.

3. Results

Socio-economic assessment**:** Based on the comprehensive personal interviews conducted in five distinct regions of the study site, a meticulously designed questionnaire was employed to assess the socio-economic characteristics of the area under investigation. The respondents exhibited a predominance of males, accounting for 52.5% of the sample. Among the participants, three distinct age groups were identified, namely 25–45 (40%), 46–65 (32.5%), and 66–85 (27.5%). In terms of marital status, the majority of respondents, namely 67.5%, were married, while the remaining portion was unmarried. An examination of educational attainment among the villagers revealed a noticeable dearth of individuals with higher education credentials. Only a meagre proportion, approximately 5% each, identified as graduates or post-graduates. The literacy rate within the community can be characterized as low, as the majority of respondents, totalling 55%, had not progressed beyond the matriculate level. Among the various educational levels, the highest percentage, amounting to 17.5%, represented individuals who had completed their higher secondary education. The primary occupation of the local populace was primarily cantered around agriculture, with 52.5% of respondents identifying themselves as farmers or fishermen. Government employees constituted a mere 7.5% of the sample, while students comprised an equivalent proportion. Wage earners accounted for 12.5% of respondents, and businessmen constituted 20% of the study population.

These findings underscore the socio-economic profile of the study site, highlighting the gender disparity, age distribution, marital status, educational background, and predominant occupations within the community. The overrepresentation of males in the sample indicates the need for targeted strategies to ensure the inclusion and participation of women in future research and development initiatives. Moreover, the limited presence of individuals with

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higher education underscores the importance of promoting educational opportunities and increasing literacy rates in the study area. Efforts to diversify occupational opportunities beyond agriculture may be warranted to address potential vulnerabilities associated with the dependence on a single sector. By elucidating these socio-economic dimensions, this research contributes valuable insights into the unique characteristics of the study site, providing a foundation for evidence-based policymaking and targeted interventions aimed at improving the well-being and livelihoods of the local population. Further exploration is encouraged to gain a more comprehensive understanding of the factors influencing socio-economic dynamics in the region.

Ecosystem Services: Uses and Ranking

A total of 13 key ecosystem services were identified through household survey (Table 1), FGDs and key informants interviews for the Urpad Beel. Among them, 8 were provisioning, 6 regulating, 2 supporting and 5 were cultural services.

Table 1. Ecosystem services identified from the study area

Ecosystem service categories	Ecosystem services recorded
Provisioning (8)	Fish, livestock grazing, Irrigation, Macrophytes, Edible plants Water for drinking, NTFPS, Fodder
Regulating(6)	Water regulation, Flood control, Nutrient Cycling Siltation Regulation, Pollination, Air purification
Supporting (2)	Habitat for fauna and flora, Nursery for fishes
Cultural (5)	Tourism, Recreational value, Bird watching, Educaional & research, Spritual value

Through the survey conducted with local communities, the top ranked service was *habitat for biodiversity* followed by *fishing, tourism, livestock grazing, water, grass collection*. Eight out of 13 were provisioning services, while two were supporting services and five was a cultural service. These services were ranked based on their use at their household and/or ability to sell them in the market for economic returns. The top 8 services with details on their use by local people are given in **Table 2.**

Table 2. Ranking of the ecosystem services based on peoples' perception.

Ecosystem Servives	Ranking	Uses
Habitat for biodiversity	1	Supporting biodiversity of global significance.
Fishing	2	Food/Selling in market.
Tourism	3	Employment generation/Source of income.

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Livestock Grazing	4	Use by local people to food their animals.
Water	5	Drinking / Irrigation
Grass collection	6	For decoration of stores,houses.
Edible plants	7	Collection for personal use in daily diet and to sell in the local market.
Nursery for fishing	8	Breeding of indigenous/local fishes.

People's Dependency on Ecosystem Services

The investigation yielded a comprehensive understanding of livelihood strategies, uncovering a total of six distinct approaches pursued by the local population. It was observed that approximately 57% of the respondents engaged in the intertwined activities of fishing and agriculture, while the remaining individuals were involved in diverse occupations such as teaching, business, and labour. Notably, a significant proportion of approximately 25% of households primarily relied on fishing as their occupation.

Further analysis revealed that a subset of nine respondents exhibited complete dependency on fishing for their sustenance. The Focus Group Discussions (FGDs) shed light on the economic aspect of these livelihood strategies, with participants reporting an average daily earning of Rs. 600.Agriculture, encompassing horticultural practices, emerged as the second most prominent livelihood strategy within the study site. This finding highlights the significance of cultivating crops and fostering sustainable agricultural practices to ensure the overall well-being of the local community. In addition to fishing and agriculture, other viable livelihood strategies identified in the area, as illustrated in Figure 2, encompassed tourism, business ventures such as boat services and small-scale hotels, labor-intensive occupations, and teaching positions within government institutions. The data indicated that tourism employment, involving activities like guiding for bird watching and providing boat services, has been gaining traction as a promising alternative livelihood option, particularly among the younger generation. This emerging trend underscores the potential of tourism to generate income and foster economic growth while simultaneously preserving the ecological integrity of the region. Among the six identified livelihood strategies, four demonstrated a direct reliance on ecosystem services. Fishing, agriculture, livestock grazing, and tourism, including business enterprises such as hotels, guides, and boat services, were found to be entirely dependent on the invaluable services provided by the Beel. The symbiotic relationship between these livelihood strategies and the ecosystem exemplifies the interdependence of human activities and the natural environment. Understanding the intricate dynamics and interconnections among these livelihood strategies is crucial for formulating effective policies and interventions that promote sustainable development in the area. Moreover, recognizing the diverse range of occupations pursued by the local population highlights the importance of fostering a multifaceted and inclusive approach to economic growth.

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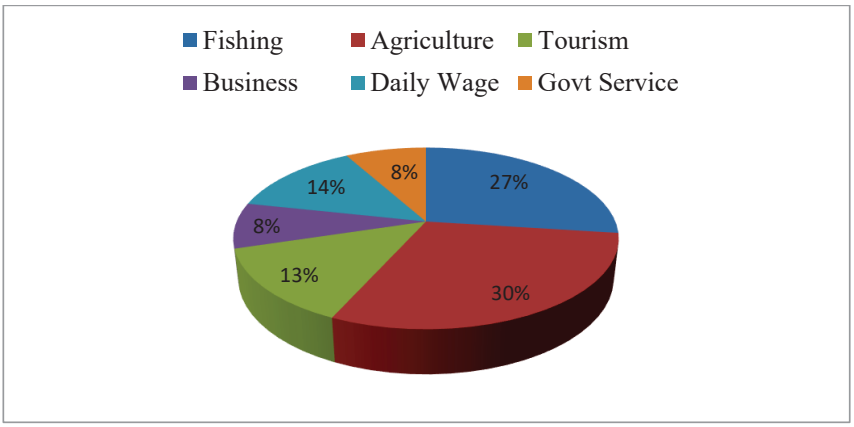

Figure 1. Livelihood strategies of the locals in Urpad Beel

Drivers of ecosystem services change

Urpad Beel is a wetland ecosystem where the community members are dependent on ecosystem services for their livelihood. To identify the drivers of ecosystem services change in Urpad Beel, a survey was conducted with personal interviews, and a focused group discussion with the community members. Based on their perceptions, various drivers of ecosystem change were identified and prioritized according to the perceived impact on the ecosystem (Figure 2). The highly prioritized drivers of ecosystem change in Urpad Beel include siltation, over-exploitation of resources, deforestation, and invasive alien species. These drivers have a significant impact on the ecosystem and are causing negative effects on people's livelihood. For example, siltation can reduce the water storage capacity of the wetland, leading to floods during the monsoon season. Over-exploitation of resources such as fish and timber can reduce the biodiversity of the ecosystem, leading to a decline in ecosystem services that are important for people's livelihoods. The drivers that have intermediate effect on the ecosystem change in Urpad Beel include climate change, erosion and landslide, use of chemical fertilizers, use of advanced fishing equipment, flood, sewage, and other pollution. These drivers can have negative impacts on the ecosystem, but their effects are not as significant as the highly prioritized drivers. The drivers that are least prioritized by the community members of Urpad Beel include encroachment, imbalance in water regulation, chemical poisoning, and river cutting. These drivers are not perceived as having a significant impact on the ecosystem, and their effects are not as severe as the highly prioritized drivers.

It is important to note that some drivers, such as burning of forest ground, are not considered by the community members as drivers of ecosystem change. This may be because the effects of these drivers are not immediately visible, or because the community members are not aware of their impact on the ecosystem. Overall, the drivers of ecosystem services change in Urpad Beel are complex and multifaceted, and addressing them requires a holistic approach that considers the ecological, social, and economic dimensions of the ecosystem.

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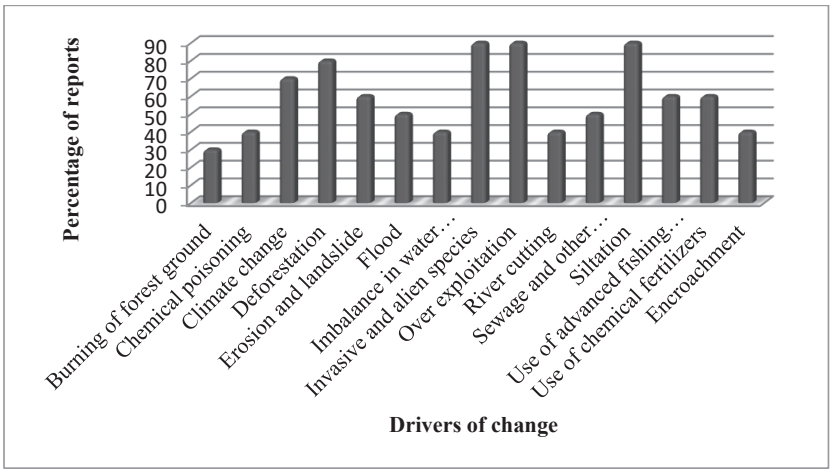

Figure 2. Drivers of change of ecosystem services

Impacts on Ecosystem Services and People's Dependency

The study revealed that both direct and indirect drivers of change exerted significant influences on ecosystem services and the local population's reliance on the surrounding ecosystems. The effects of these drivers were multifaceted, with implications for various aspects of people's lives. Notably, approximately 98% of respondents in the household survey reported a substantial decline in fish stocks, accompanied by a noticeable decrease in available fodder. Given the direct connection between ecosystem services and individuals' livelihood strategies, alterations in these services had profound effects on people's dependency, particularly in fishing and agriculture activities.

Although only 40% of participants reported water pollution resulting from chemical and fertilizer usage in agricultural fields and sewage, this issue emerged as a concerning factor. Over-exploitation emerged as a major cause contributing to the decline in bird migration by 30% and the reduced movement of elephants. Additionally, the invasion of non-native species negatively impacted siltation and led to a decrease in oxygen levels within the water.

Another significant driver of change identified in the study was flooding, which had detrimental effects on people's livelihoods. Flooding resulted in a reduced availability of fodder and hindered collection efforts. Interestingly, the rise in tourism, despite being associated with a decline in migratory bird populations, renowned for their presence in the area, provided economic growth opportunities for the local population. Furthermore, climate change-induced transformations had both direct and indirect impacts on the lives of the individuals residing in the area.

In conclusion, this research highlights the intricate interplay between direct and indirect drivers of change and their effects on ecosystem services and the well-being of local communities. The decline in fish stocks and fodder availability, coupled with the negative consequences of pollution, over-exploitation, invasive species, flooding, and climate change, underscore the urgent need for conservation efforts and sustainable management practices. By comprehending these complex dynamics, policymakers and stakeholders can formulate

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strategies to mitigate the negative impacts and foster resilient ecosystems and communities in the area.

4. Discussions

The present study from Urpad Beel utilizes the Millennium Ecosystem Assessment (MEA) framework to identify and prioritize 13 distinct ecosystem services, aligning with global standards for assessing ecosystem services (MEA, 2005). This approach builds upon previous research emphasizing the recognition and valuation of wetland ecosystem services as essential for effective conservation and sustainable management (Costanza et al., 1997; Sharma et al., 2016; Ahmed et al., 2018; Borgohain et al., 2018; Ghermandi et al., 2019; Dey et al., 2020; Kalita et al., 2020). In Assam, prior studies by Saikia et al. (2015), Bhatta et al. (2016), Hazarika and Goswami (2019), and Dey et al. (2020) focused on identifying ecosystem services and documenting traditional uses of wetland resources. These studies provided important groundwork but did not comprehensively integrate community perceptions and local conservation practices, which the present study addresses.

To achieve a detailed understanding of ecosystem services, this study employed household surveys and focused group discussions. Drawing on global frameworks (MEA, 2005) and national-level research (Barbier et al., 2008), it captures a nuanced perspective of Assam's wetland landscapes, considering both ecological and socio-cultural dimensions. Integration of insights from local studies (Ahmed et al., 2018; Dey et al., 2020) highlights the ongoing challenges and opportunities for wetland conservation within the region, particularly in balancing human use and ecosystem integrity. The community-based approach adopted here underscores the crucial role of local knowledge and participation in promoting sustainable wetland management practices.

Residents of Chamaguri village demonstrate a strong commitment to conserving Urpad Beel, actively resisting encroachment and maintaining vigilance throughout the year. This reflects findings from Dey et al. (2020) in Goalpara district, which emphasize the importance of community engagement in wetland conservation (Day et al., 2020; Nayak and Bhusan, 2022). In recent years, Chamaguri has emerged as a popular destination for tourists. Activities such as boating and observation from watchtowers demonstrate the wetland's cultural ecosystem service of recreation (MEA, 2005). Globally, studies on ecotourism in wetlands, such as in the Amazon Basin or African savannas, highlight both the economic and cultural benefits of tourism while also pointing out potential ecological impacts (Balmford et al., 2002). Similarly, tourism at Deepor Beel in Assam has contributed to cultural and economic benefits while also raising concerns about environmental disturbance (Ahmed et al., 2018).

The fishermen community of Budhipara practices rituals such as Ganga Puja, reflecting the cultural ecosystem service of spiritual enrichment and reinforcing cultural identity (Chan et al., 2012; Verschuuren et al., 2010). Such rituals exemplify the deep connections between local communities and natural landscapes, showing how cultural practices can foster environmental stewardship. At the same time, tourism activities have disturbed habitats of both indigenous and migratory birds, resulting in reduced arrival rates of migratory species. This illustrates a trade-off between cultural services and biodiversity conservation, emphasizing the need to carefully manage human activities in ecologically sensitive areas (Buckley, 2004). Understanding these interactions between cultural and ecological services is

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essential for holistic wetland management strategies that promote both human well-being and ecological sustainability.

Flooding presents a major challenge in the Urpad Beel ecosystem, leading to siltation, river cutting, and the invasion of alien plant species. In response, the government has constructed a road around the lake to mitigate erosion. However, this development has disrupted an elephant corridor and resulted in a reduction of the lake's overall area. Flooding alters hydrological patterns, affects water quality, and modifies habitat structure (Talbot et al., 2018). Globally, studies on floodplain wetlands, including the Amazon Basin and the Mississippi Delta, highlight the ecological significance of natural flooding cycles for nutrient cycling and biodiversity, while human interventions can disrupt these critical processes (Junk et al., 1989). Infrastructure development in wetlands can fragment habitats, alter hydrology, and disturb wildlife movement (Ramsar Convention Secretariat, 2010; Mitsch and Gosselink, 2015). The reduction in Urpad Beel's area underscores global concerns regarding wetland loss, which threatens biodiversity, water purification, and flood regulation services crucial for human well-being (Davidson et al., 2012; Zedler and Kercher, 2005).

The study also highlights the direct link between ecosystem services and local livelihoods, showing that changes in wetland functions significantly impact fishing and agriculture, consistent with Mitra et al. (2019). For instance, the extinction of the Saal fish due to floods and changes in water quality demonstrates the wetland's role in supporting aquatic biodiversity and sustaining local livelihoods. Despite these challenges, the formation of a conservation committee by local residents reflects proactive community efforts to protect Urpad Beel. Such community-led initiatives, combined with continuous research and adaptive management strategies, are essential to ensure the long-term sustainability of the wetland and the ecosystem services it provides.

Overall, the study of Urpad Beel demonstrates how ecological, cultural, and socio-economic aspects of wetlands are deeply interconnected. By highlighting community participation, cultural values, livelihood dependence, and ecological challenges, this research provides insights necessary for integrated wetland management. It reinforces the idea that preserving wetland ecosystems requires a balance between human use and ecological protection, where local communities play a central role in sustaining these invaluable natural resources.

Conclusion: Based on the findings of the study on Urpad Beel's ecosystem services and its impact on local dependency, several recommendations emerge. Conservation efforts should prioritize establishing protected areas, enforcing strict regulations, and promoting habitat restoration. An integrated management approach involving local communities, government, NGOs, and stakeholders is crucial for sustainable resource use and biodiversity conservation. Providing sustainable livelihoods through eco-tourism and agriculture can reduce dependency on wetland resources. Education and awareness initiatives should highlight Urpad Beel's ecological and cultural significance. Long-term monitoring and research are essential for adaptive management, while policy integration should value ecosystem services in land use and development decisions. Collaboration with stakeholders and international partners enhances conservation effectiveness and knowledge exchange, ensuring the resilience and sustainability of Urpad Beel's ecosystem services.

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Chapter-24: A Study on Fish Diversity in the Ganol River Near the Assam–Meghalaya–Bangladesh Border Regions.

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Abstract

River Ganol (Kalu) a tributary of River Barak is a first order river originating from the eastern side of the Nokrek Biosphere, runs towards the west through Damalgre, Garobadha and Rangapani joining several other tributaries before entering Assam through South Salmara Mankachar District after travelling a distance of 94 km from the origin. The river then enters Bangladesh near Char Aomkhaoa (25^0 31' 45.22" N 89^0 51' 18.02" E) and flows a major distance, which joins the Barak near Munshiganj and ultimately falls in the Bay of Bengal after joining with the Brahmaputra drainage traveling a distance of 655.5 km.

The present study highlights the rich and diverse ichthyofauna of the Ganol River, particularly along the ecologically sensitive border stretches of a 5 km segment in Assam–Meghalaya and Assam–Bangladesh. A total of 50 species were recorded, and classified under 10 orders and 26 families. This species richness reflects the ecological integrity and biological productivity of the riverine ecosystem.

From a conservation perspective, although the majority of species fall under the Least Concern category in the IUCN Red List, the presence of few Vulnerable and Near Threatened species calls for proactive conservation planning. Human-induced pressures such as overfishing, habitat modification, pollution, and cross-border developmental activities pose potential threats to the ecological integrity of the river. Without timely management interventions, these pressures could lead to the decline of sensitive species and overall biodiversity.

Keywords: Brahmaputra, Barak, Ganol, Bangladesh, India, Ichthyofauna, Fish Diversity

Introduction

The Ganol river, also known as the Kalu, is a first-order river originating from the eastern side of the Nokrek Biosphere. It flows westward through Damalgre, Garobadha, and Rangapani, joining several other tributaries before entering Assam through the South Salmara-Mankachar district, after traveling a distance of 94 km from its origin. The river then enters Bangladesh near Char Aomkhaoa (25°31'45.22" N, 89°51'18.02" E) and continues for a considerable distance, eventually joining the Barak River near Munshiganj. Ultimately, it merges with the Brahmaputra drainage system and empties into the Bay of Bengal, covering a total distance of 655.5 km. The river originates in hilly terrain, and its reach type ranges from pool-and-riffle to braided. The riverbed is composed mainly of bedrock, boulders, cobbles, and gravel, creating suitable feeding and breeding grounds for hill stream fishes. (Hussain 2012)

As it journeys across these diverse ecological and political regions, the river supports a rich and complex aquatic ecosystem. This transboundary nature of the Ganol River makes it an important site

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for ecological studies, particularly in understanding how fish diversity is shaped by geographical, climatic, and anthropogenic factors across regions.

Freshwater fishes play a crucial role in maintaining ecological balance and supporting local livelihoods, especially in rural border communities that depend heavily on fishing for sustenance and income. The diversity of fish species in a river reflects the health of its ecosystem. However, freshwater ecosystems in Northeast India, including the Ganol River, are increasingly threatened by human interventions such as overfishing, pollution, habitat fragmentation, and climate variability.These factors, combined with a lack of comprehensive documentation, have left many river systems understudied.

Despite the ecological significance of the Ganol River, there exists a noticeable gap in detailed research on its ichthyofauna, especially in the sensitive and biologically rich border stretch between Assam and Meghalaya, and Assam and Bangladesh. The current study seeks to address this gap by focusing on a 5 km segment of the river—from the junction at Assam (India)-Bangladesh border to Assam-Meghalaya. This region is expected to host a unique blend of fish species due to the confluence of different ecological zones and hydrological conditions.

The primary objectives of this study are to document the diversity of fish species found in this stretch of the Ganol River, analyze the distribution patterns of these species, and assess the ecological conditions influencing them. By generating baseline data, this research aims to contribute to the conservation of freshwater biodiversity in the region and provide valuable insight for future studies, especially those focused on transboundary water resource management and sustainable fisheries.

Study Area

The present study was conducted in the Ganol River, a significant freshwater body that originates in the western part of Meghalaya and flows into Assam near the Assam–Meghalaya border, approaching the India–Bangladesh boundary. However, all fish sampling for this study was strictly carried out within Indian territory. The topographic survey of the Ganol River covered a stretch extending from the Bangladesh border near Mankachar (Lat. 25.529793°, Long. 89.865928°) to an upstream point near South West Garo Hills, Meghalaya (Lat. 25.561274°, Long. 89.900626). Geographical coordinates of the sampling sites were recorded using a smartphone equipped with GPS functionality as shown in **Figure 1.**

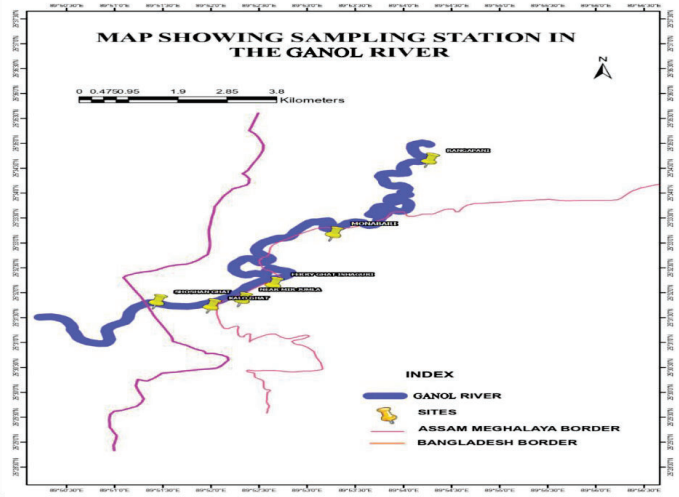

Figure 1: Showing the sampling station in the Ganol river.

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Sampling and Methods for Data Collection:

Field surveys were conducted between January 2025 and June 2025, covering both dry and pre-monsoon seasons to account for potential seasonal variation in fish diversity. Fishes were collected from different sites along the main channel as well as adjoining stream sections of the Ganol River. Most of the sampling activities were carried out during the morning hours between 6:00 AM and 11:00 AM. A variety of sampling methods were employed, including the use of cast nets, scoop nets, gill nets of varying mesh sizes, and methods permissible by the concerned district authority. In addition to direct sampling, specimens were also obtained from local fishermen and villagers familiar with the river system.

Immediately after collection, fishes were photographed in live and then all specimens were preserved in 10% formalin to ensure their structural integrity for further laboratory-based taxonomic studies. Preliminary identification of the fish species was conducted using standard ichthyological literature, including the works of Jayaram (Jayaram, The Freshwater Fishes of the Indian Region, 1999) (Jayaram, The Fresh Water Fishes of the Indian Region. 2010)and Menon (A.G.K 1999). The conservation status of each recorded species was assessed based on information available from the IUCN Red List of Threatened Species (www.iucnredlist.org). Taxonomic classification and scientific nomenclature were verified and cross-checked using multiple authoritative sources, including FishBase (www.fishbase.org).

Result and Discussion :

The present investigation was carried out in the Ganol River, an important freshwater body that originates in the western part of Meghalaya and flows into Assam near the Assam–Meghalaya border before approaching the India–Bangladesh boundary. For this study, all fish sampling was confined strictly within Indian territory. A total of six sampling sites were selected along the main river channel as well as adjoining stream stretches, namely Shoshan Ghat, Ganol Ghat, Mirjumala Ferry Ghat, Monabari, and Rangapani.

The Ganol River and its adjoining streams exhibit heterogeneity of habitat, including shallow pools, riffles, sluggish stretches, and confluences with minor rivulets. The riverbed consists of boulders, cobbles, pebbles, gravels, sand, and fine silt, along with suspended and dissolved organic matter that enrich the aquatic system. Such substrates provide shelter for fishes, serve as substrata for algal attachment, and create diverse feeding grounds. The riparian zones are characterized by dense vegetation with mixed forest cover, which not only stabilizes the riverbanks but also contributes leaf litter and detritus to the aquatic ecosystem. These microhabitats collectively sustain a variety of fish species by offering spawning and breeding grounds, while also supporting the overall ecological balance of the river.

The study reveals a total of 51 fish species. Among these, 50 species were identified and classified using the IUCN Red List (www.iucnredlist.org), while 1 species remained unidentified, suggesting the possibility of a previously undocumented or new species as shown in **Table 1.**

Table 1: Fishes of different orders and families recorded during the present study

Sl. No.	Order	Family	Scientific Name	IUCN Status
1	Osteoglossiformes	Notopteridae	*Notopterus notopterus*	LC
2	Clupeiformes	Clupeidae	*Gudusia chapra*	LC
3	Clupeiformes	Clupeidae	*Tenualosa ilisha*	LC
4	Clupeiformes	Engraulidae	*Setipinna phasa*	LC
5	Cypriniformes	Cyprinidae	*Puntius chola*	LC
6	Cypriniformes	Cyprinidae	*Puntius amphibius*	DD
7	Cypriniformes	Cyprinidae	*Labeo gonius*	LC

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8	Cypriniformes	Cyprinidae	*Gymnostomus ariza*	LC
9	Cypriniformes	Cyprinidae	*Labeo rohita*	LC
10	Cypriniformes	Cyprinidae	*Labeo bata*	LC
11	Cypriniformes	Cyprinidae	*Labeo calbasu*	LC
12	Cypriniformes	Cyprinidae	*Cirrhinus mrigala*	LC
13	Cypriniformes	Cyprinidae	*Labeo catla*	LC
14	Cypriniformes	Cobitidae	*Pangio pangia*	LC
15	Cypriniformes	Cobitidae	*Lepidocephalichthys guntea*	LC
16	Cypriniformes	Danionidae	*Cabdio morar*	LC
17	Cypriniformes	Danionidae	*Amblypharyngodon mola*	LC
18	Cypriniformes	Danionidae	*Amblypharyngodon melettinus*	LC
19	Cypriniformes	Botiidae	*Botia rostrata*	VU
20	Siluriformes	Bagridae	*Mystus cavasius*	LC
21	Siluriformes	Bagridae	*Sperata aor*	LC
22	Siluriformes	Bagridae	*Mystus vittatus*	LC
23	Siluriformes	Bagridae	*Rita rita*	LC
24	Siluriformes	Siluridae	*Wallago attu*	VU
24	Siluriformes	Siluridae	*Ompok pabo*	NT
26	Siluriformes	Sisoridae	*Gagata gagata*	LC
27	Siluriformes	Sisoridae	*Gagata cenia*	LC
28	Siluriformes	Sisoridae	*Gogangra viridescens*	LC
29	Siluriformes	Clariidae	*Clarias batrachus*	LC
30	Siluriformes	Heteropneustidae	*Heteropneustes fossilis*	LC
31	Siluriformes	Ailiidae	*Ailia coila*	NT
32	Siluriformes	Ailiidae	*Eutropiichthys vacha*	LC
33	Siluriformes	Horabagridae	*Pachypterus atherinoides*	LC
34	Mugiliformes	Mugilidae	*Rhinomugil corsula*	LC
35	Beloniformes	Belonidae	*Xenentodon cancila*	LC
36	Beloniformes	Hemiramphidae	*Hyporhamphus limbatus*	LC
37	Synbranchiformes	Synbranchidae	*Ophichthys cuchia*	LC
38	Synbranchiformes	Mastacembelidae	*Macrognathus pancalus*	LC
39	Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	LC
40	Perciformes	Channidae	*Channa orientalis*	VU
41	Perciformes	Channidae	*Channa punctata*	LC
42	Perciformes	Channidae	*Channa striata*	LC
43	Perciformes	Ambassidae	*Chanda nama*	LC
44	Perciformes	Ambassidae	*Parambassis baculis*	LC
45	Perciformes	Nandidae	*Nandus nandus*	LC
46	Perciformes	Anabantidae	*Anabas testudineus*	LC
47	Perciformes	Osphronemidae	*Trichogaster labiosa*	LC
48	Perciformes	Osphronemidae	*Trichogaster fasciata*	LC
49	Gobiiformes	Gobiidae	*Glossogobius giuris*	LC

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50	Tetraodontiformes	Tetraodontidae	*Leiodon cutcutia*	LC

(LC=Least Count, NT=Near Threatened, VU= Vulnerable, DD=Data Deficient)

These 50 identified species were distributed across 26 families under 10 distinct orders. Among them, the order Cypriniformes emerged as the most dominant, comprising 15 species that spanned across four families: Cyprinidae, Cobitidae, Danionidae, and Botiidae. The second most represented order was Siluriformes, consisting of 14 species belonging to six families.

The orders Osteoglossiformes, Mugiliformes, Gobiiformes, and Tetraodontiformes were the least represented, with only one species each recorded. In contrast, the orders Perciformes, Synbranchiformes, and Beloniformes had a moderate number of species among the recorded fish as shown in **Figure 2.**

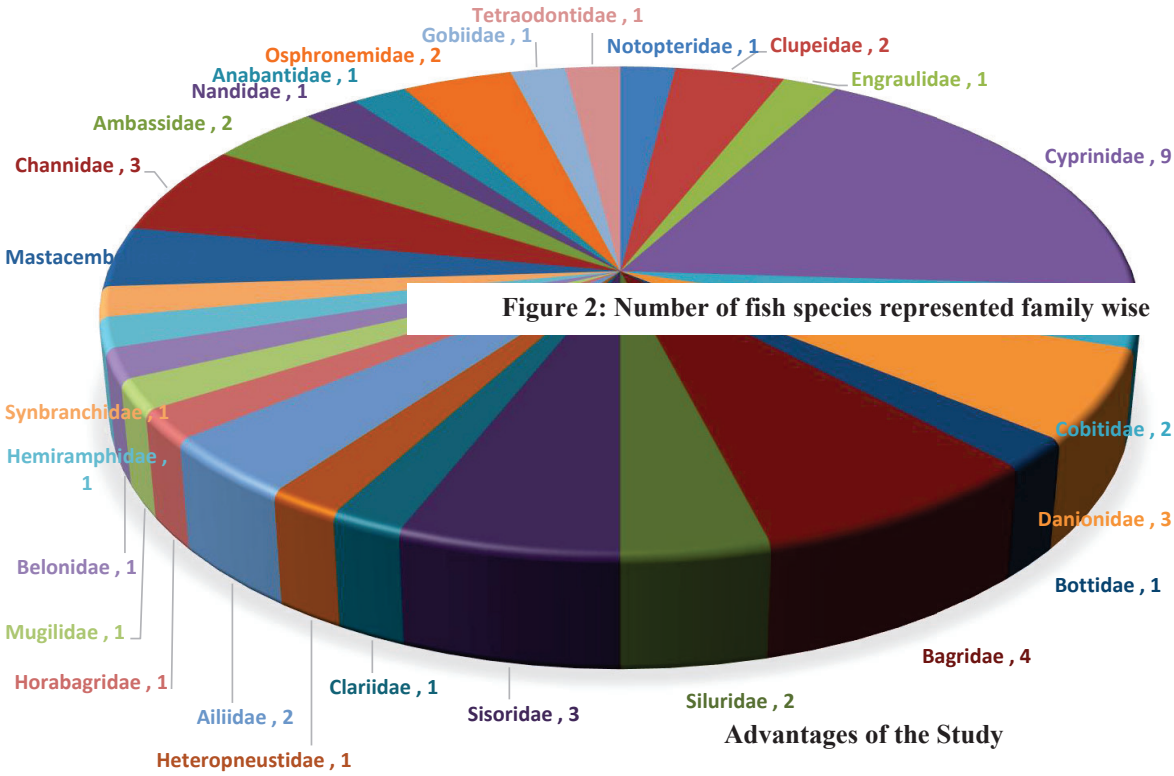

Figure 2: Number of fish species represented family wise

Advantages of the Study

This study on the Ganol River provides one of the first detailed accounts of fish diversity in a transboundary stretch of western Meghalaya and Assam. By documenting species composition and habitat features across multiple sampling sites, it generates essential baseline information for ecological assessment of the river system. Seasonal surveys covering both dry and pre-monsoon periods highlight patterns of variation in fish abundance, which can be useful for identifying critical spawning or feeding grounds. The results also have direct relevance for local fisheries, as they

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underline the ecological services provided by the river to communities that depend on it for livelihood. Beyond biodiversity documentation, the study enhances understanding of riverine habitat heterogeneity and its role in sustaining aquatic life.

Future Prospects

Further research on the Ganol River can focus on long-term ecological monitoring to trace shifts in fish diversity caused by environmental changes and human activities. Advanced methods such as genetic barcoding and population-level studies can be introduced to resolve taxonomic ambiguities and uncover hidden species diversity. Habitat modeling and hydrological assessments could also provide insight into the potential impacts of climate change on river ecosystems. On a broader scale, integrating ecological research with socio-economic studies may help in designing community-based conservation initiatives and sustainable fisheries management plans. The outcomes of such research can serve as valuable guidelines for conservation authorities, policymakers, and cross-border collaborations aimed at protecting aquatic biodiversity in this ecologically sensitive region.

Conclusion

The present study highlights the rich and diverse ichthyofauna of the Ganol River, particularly along the ecologically sensitive border stretches of Assam–Meghalaya and Assam–Bangladesh.

The detection of one unidentified species possibly a new or unrecorded species is a significant observation. The ichthyofauna of the border regions of Northeast India remains understudied, and discoveries of new species have been reported in recent years. This underscores the need for further taxonomic, morphological, and genetic analysis

Regarding conservation status, most recorded species fall under the Least Concern (LC) category according to the IUCN Red List. However, the presence of species listed as Near Threatened (NT) and Vulnerable (VU) (IUCN, 2023) emphasizes the need for active monitoring. Anthropogenic pressures such as overfishing, sand mining, agricultural runoff, and habitat fragmentation—especially in border regions—may gradually impact the fish diversity, as observed in other studies (Goswami et al., 2012; Nath & Dey, 2021).

In conclusion, the Ganol River supports a biologically rich and ecologically significant ichthyofaunal population. The findings serve as valuable baseline data for future biodiversity assessments, conservation strategies, and taxonomic research in this less-explored transboundary river system.

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Chapter-25: Algae as a Source of Natural Colorants in Modern Cosmetics

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Introduction

The cosmetics industry is now embracing the use of natural ingredients. This is the result of response to consumer demand for sustainability, safety, and eco-friendly products. The natural ingredients include natural pigments derived from plants, algae, and microorganisms. They are getting noticed as alternatives to synthetic colorants. As these are often associated with toxicity and environmental concerns (Negi, 2025).

However historically, cosmetics were tinted with minerals like ochre, plant extracts, and insect-based dyes such as cochineal. Synthetic dyes only became famous in the 20th century. But increase in allergies and ecological toxicity made people come back to natural pigments (Chen *et al.,* 2023). Driven by clean beauty and vegan formulations (Negi, 2025) the business related to the natural ingredients infused cosmetics show a rise in demand. In specific the algal pigments have emerged as versatile bioactive compounds with bright colours and functional benefits.This article highlights algal pigment and its broad applicability in modern cosmetics (Chen *et al.,* 2023).

HISTORICAL PERSPECTIVES IN COSMETICS:

Microorganisms and fungi have historically contributed pigments to cosmetic practices. Fungal pigments, such as carotenoids and polyketides, have been used as natural dyes. Mostly for textiles and occasionally in cosmetics, like lipsticks (Lagashetti *et al.,* 2019). Although fungal pigments presented challenges like stability and safety, their historical role highlights the human desire for natural colorants.

Algae has been the important source as food, medicine, and raw materials for the coastal people for many years. The human desire to embrace colour has led the old civilization people to use the color from natural resources available more at that time. They used these colours for decorative purposes and also painted the human body. This early tradition set the stage for algae to emerge as a safer, more sustainable alternative in the modern cosmetic industry.

ECO-BIOLOGICAL ROLE OF ALGAE IN COLORANT PRODUCTION:

Due to their rapid growth, minimal resource requirements, and high pigment yields. Algae represents an environmentally sustainable source of natural colorants. Microalgae such as Spirulina and Chlorella produce a range of valuable compounds. This includes phycobiliproteins and carotenoids. These pigments are used in both nutraceuticals and cosmetics (Ramos *et al.,* 2025).

Algae utilize pigments to capture sunlight, which is a process that produces oxygen. This is a basic part of aquatic ecosystems. Furthermore, the cultivation of algae contributes to carbon capture. This reduces environmental burden compared to synthetic dye production. Algae

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also recycle industrial CO_2 emissions. This provides a circular economy model where pigment production is linked to carbon sequestration efforts.

They help in processing the nutrients and provide them for the aquatic ecosystems . The algae which are isolated from the waste water treatment produces the pigments containing biomasses. This led to the both benefits which include the purification and the product preparation. Unlike terrestrial crops, algae do not require fertile soil,so it is easy to grow. They can be cultivated in photobioreactors or open ponds. This makes large-scale pigment production feasible (Ramos *et al.,* 2025). So these products are not seasonal.

ALGAL PIGMENTS:

Algal pigments can be broadly classified into carotenoids, phycobiliproteins, and other accessory pigments like fucoxanthin. Carotenoids like beta-carotene and astaxanthin provide orange-red hues . This acts as antioxidants. This offers skin protection and anti-aging properties (Chini Zittelli *et al*., 2023). Phycobiliproteins, particularly phycocyanin from Spirulina, give deep blue shades. This colour is highly valued in cosmetics and food applications (Aizpuru & González-Sánchez, 2024). Fucoxanthin, a brown carotenoid from marine algae. This pigment is known for its skin-lightening and photoprotective effects (Dini, 2023).

- **Astaxanthin:** It is derived from *Haematococcus pluvialis*. It is 6000 times stronger than vitamin C in antioxidant capacity. This makes it useful in anti-aging creams (Chini Zittelli *et al., 2*023).
- **Lutein & Zeaxanthin:** These carotenoids protect against skin against blue-light damage. This is useful for consumers exposed to digital screens. These pigments are low in algae by dry weight on average (~0.1 %). But if it is grown and cultivated under favorable conditions then it can be in higher amounts (e.g. Dunaliella salina). Lipophilic carotenoids (e.g. β-carotene, lutein, fucoxanthin) could be incorporated into oil phases of cosmetics.
- **Fucoxanthin:** This brown-orange pigment is a natural-looking colour in skin-tint formulations. Clinical trials reveal fucoxanthin improves skin elasticity. And it can also be used in reducing hyperpigmentation(darkening) of the skin. These xanthophyll pigments have high market value because of its bioactivities like anti-inflammatory and helps to reduce body obesity. It could also offer niche “cosmeceutical” claims (e.g. for body / anti-cellulite products).
- **Chlorophylls**:Chlorophyll a, b, c, d, f and derivatives (pheophytin, chlorophyllide etc) have limitations like poor water solubility and are unstable to light, acid , base. But it works as an antioxidant, anti-inflammatory inflammatory, lowering the lipids. So these colours are mostly used in food industries.

Many algal pigment’s stability degrades under light, heat and shift in the pH. Cosmetic formulations must protect them by using techniques like encapsulation, antioxidant synergy.

These must also test the algal pigments for its compatibility of pigments with other cosmetic ingredients like emulsifiers, pH agents and surfactants. Algal pigments are expensive when it comes to extraction especially for the highly pure algal pigments. This high cost disturbs the scalability and limits its usage in mainstream cosmetics. As these are used in cosmetics, the

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regulation testing is very vital to avoid the irritation, allergic reactions and phototoxicity of the skin of the consumers.

Adoption of strategic approaches is much needed when it comes to bulk production and businesses. Instead of using natural forms the industries can use derivatives like chlorophyllide , metal-substituted chlorophyll to improve the stability of the pigments. To avoid the deterioration of the pigment quality techniques like microencapsulation, nanocarriers, and liposomes can be used. In order to increase the durability the industries can combine it with UV filter, antioxidants co-ingredients. The business can use niche cosmetics rather than marketing in a broad spectrum.

APPLICATIONS OF ALGAL PIGMENTS IN MODERN COSMETICS:

The algal pigments in cosmetics function in multiple domains. For instance, in skincare, antioxidants such as astaxanthin reduces oxidative stress (Bogdan *et al.,* 2025). Phycocyanin and carotenoids serve as natural substitutes for synthetic colours in lipsticks, eyeliners, and blush formulations (Kiki, 2023). Additionally, nutricosmetics oral supplements targeting skin health have included Spirulina-derived pigments for both color and bioactive benefits (Dini, 2023). These pigments are also used in making nail polishes.

There were rising concerns of health issues which are related to the contact of the skin with harmful chemicals such as titanium dioxide (white) , iron oxides (red, yellow, and brown) and chromium oxides (green). These pigments are not only harmless but also provide various benefits like biodegradable, non-toxic, and renewable. They can be even produced through energy-efficient processes that use very low quantities of harmful chemicals. It is not only used for topical formulations,but also as liposomal carriers. This improves penetration and stability.Beauty brands in Japan and Europe have pioneered “blue cosmetics” using Spirulina phycocyanin as a branding element. By highlighting natural and ocean-inspired themes. In nutricosmetics, algal powders are marketed for “beauty from within,” combining colorant and nutraceutical value.

ADVANTAGES OF ALGAL COLORANTS OVER SYNTHETIC DYES:

Algal pigments are chosen to reduce and to get rid of its negative effects on human health as well as the environment like aquatic ecosystems. To be specific these synthetic dyes like Coal tar, Carbon black, Titanium dioxide and many more have toxic,mutagenic and carcinogenic properties. These are used in hair dyes and sunscreen. As discussed earlier it also disrupts the environment, specifically marine. This imbalance affects diversity, growth and existence of different species which necessitates a treatment of liquid effluents from washing textiles before releasing them to the external environment.

Algal colorants is advantageous over synthetic colorants in following ways,

- As the name suggests these pigments are natural and eco-friendly alternatives to synthetic dyes. This makes them highly desirable in food, cosmetics, pharmaceutical and other industries.
- Synthetic dyes release toxic by-products during production and usage. But pigments from algae such as chlorophylls, carotenoids, and phycobiliproteins are biodegradable, renewable, and safer for human use.
- The algal pigments also provide added health benefits, which includes antioxidant, anti-inflammatory, and photoprotective properties. Whereas synthetic dyes don't have

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any such things. This dual role as both colorant and functional bioactive compound enhances their appeal in modern "clean label" and sustainable formulations.

- In cosmetics, algal pigments not only provide beautiful colors ranging from green to red and blue but also deliver skin-protective effects. These include reducing oxidative stress and slowing premature aging.
- Their natural origin aligns with the growing consumer demand for plant- and marine-based ingredients in beauty products. Also it aligns with the new ideology of the consumers like being vegan.
- Additionally, algae cultivation requires fewer resources compared to chemical synthesis, supporting sustainability goals.

These advantages make algal colorants an efficient replacement for synthetic dyes in industries seeking safe, multifunctional, and environmentally responsible solutions.

COMMERCIALISATION AND MARKET TRENDS:

The algal pigments market is segmented by type, form, source, and application. Driven by its antioxidant benefits and its usage in food, beverages, cosmetics, and animal feed by 2025, the beta-carotene segment is projected to hold the largest share (22.3%). While phycocyanin is expected to record the fastest growth due to its high demand in pharmaceuticals and clean-label products. The powder form segment will dominate because of its comfortability of handling, longer shelf life, and reduced degradation risks. Among sources, microalgae will lead the market, supported by rising health awareness, preference for natural food colors, and growth in the nutraceutical industry. In terms of application, the nutraceuticals segment will account for the largest share (38.2%), reflecting consumer demand for natural, health-promoting ingredients. Geographically, Europe is set to dominate with 32.1% of the global market share in 2025, valued at USD 141.7 million, driven by strict regulations on synthetic colors, strong wellness trends, and high demand for natural pigments.

EXTRACTION AND FORMULATION CHALLENGES:

Algal pigments face technical challenges in extraction, stabilization, and formulation. As discussed these cultivation of algae via open ponds are prone to other air borne contaminants. This contamination affects the algal pigments and its quality. Resource dependency is one of the significant things we need to care about. These algae are grown under a particular temperature and water requirement if it is changed or fluctuated then again this disrupts the quality of the pigments. For example, phycobiliproteins are sensitive to heat and light. This limits their long-term stability in cosmetic formulations (Aizpuru & González-Sánchez, 2024).

To enhance pigment stability and delivery, novel biotechnological approaches are explored. This includes genetic engineering and advanced encapsulation techniques. (Chini Zittelli *et al.,* 2023). Other techniques include High-pressure homogenization, ultrasound-assisted extraction, and green solvents (like supercritical CO_2). They are studied to improve pigment yield while keeping the process eco-friendly (Aizpuru & González-Sánchez, 2024). Another challenge is regulatory approval. Though phycocyanin is approved as a natural food colorant (E18), its use in cosmetics requires additional safety testing in some regions.

There should be a balance with the environment while producing these pigments via algae. This is followed in order to secure the ecosystem by avoiding over usage of marine algae for

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these pigments by companies. So every source is checked for sustainability. The economic challenges come with the combination costs of the cultivation, extraction and purification. These steps cost more to prepare a single cosmetic product. This affects the business by not allowing them to compete with the companies who use synthetic chemical colors and produce the same product for a low price.

PROSPECTIVE INNOVATIONS:

The future of algal pigments in cosmetics is strongly related to progress in biotechnology. Nowadays consumers prefer clean-label products, and eco-friendly production methods. This has pushed companies to make organic based cosmetic products. Research is progressively concentrating on expanding microalgal production, by improving pigment extraction methods, and increasing cost-effectiveness. There is increasing interest in multifunctional pigments that merge color with skincare advantages. This includes the antioxidant, anti-inflammatory, and UV-protective properties (Negi, 2025).

Synthetic biology has the capacity to create algae that can be engineered to produce high quantities of specific pigments like astaxanthin or lutein on an industrial scale. So that it will be feasible on a business basis. Delivery systems utilizing nanotechnology, such as pigment nanoparticles encapsulated in alginate, are being developed to enhance shelf-life and biological activity (Bogdan *et al.,* 2025). This again helps the company to yield profit and to gain . The demand from consumers for cosmetics with compelling sustainability is expected to propel algae pigments into mainstream markets.

The other fields in which the algae can be used other than cosmetics are as follows:

- **Clothing dyes:** As discussed earlier the algae contains pigments like chlorophyll, carotenoids and phycocyanin. These can also be used in dying both natural and synthetic fires.
- **Food colorants**: These principles have already been used. In the form of adding colors to the foods. But in future we can anticipate few changes which can be done according to food safety guidelines and the technical to produce high yield for pigments from algae
- **Biopaints:** This can also be used in the biopaints as it offers more pigments. This goes well with the sustainability projects. The company who loves to make projects by following sustainable goals can adopt these ideas in their business.
- **Furniture's raw materials:** Powdered microalgae are mixed with natural resins to create unique, sustainable materials for furniture and other design applications.

CONCLUSION:

Algae have become a potential source of natural pigments in modern cosmetics. Their variety of pigments offer not only safe and excellent substitutes for synthetic dyes but also provide functional advantages that align with modern wellness and sustainability trends. Through continuous technology advancements, pigments produced from algae influence the future of sustainable, bioactive cosmetic products.Although fungi and microbial pigments influenced initial cosmetic practices, algae now provide a scientifically evaluated, eco-friendly, and prospective approach in cosmetics.The combination of vibrant colors, health advantages, and eco-friendliness makes algae pigments not just substitutes but also pioneers in the cosmetic pigment industry.

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Chapter-26: Automated Detection of Forest Encroachment: Emerging Techniques and Comparative Analysis

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Abstract

Forests are an important block in the ecological framework. Protecting and safeguarding the forests are very important for maintaining the ecological balance. However, forests are susceptible to encroachment due to increased human activity and rapid urbanization. Monitoring and managing forest encroachment is crucial for safeguarding ecosystem integrity and biodiversity. This study presents a brief review of the different approaches used to monitor forest cover and the different methodologies used to detect forest encroachment. The paper also presents a comparison of the different methodologies used for detecting forest encroachment and also presents a generalised framework to automatically detect forest encroachment.

Keywords: *Automated Detection, Forest Encroachment.*

1. Introduction

Forest encroachment poses a persistent threat to global biodiversity, ecosystem services, and sustainable resource management. Growing populations and land-use pressures have resulted in the gradual and often undetected expansion of settlements, agriculture, and infrastructure into forested areas. Early detection and accurate mapping of such encroachments are essential to mitigate forest degradation and to develop effective forest management policies.

Forests play a critical role in maintaining environmental balance by sequestering carbon, providing habitats for diverse flora and fauna, and regulating water cycles. Encroachment often leads to irreversible ecological loss, increased greenhouse gas emissions, and diminishment of ecosystem services. Monitoring these changes is vital for enforcing conservation measures, planning restoration efforts, and ensuring the sustainability of forest resources.

The advancements in geospatial technologies, particularly remote sensing and GIS, have revolutionized forest monitoring. Remote sensing enables data acquisition over large, inaccessible, and dynamic landscapes, providing periodic, high-resolution imagery for temporal analysis. The use of different sensors—including optical, radar, and LiDAR—enables detailed mapping of canopy structure, land cover types, and human-induced changes, supporting multi-faceted detection approaches

2. Literature Review:

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There are several advanced methods for automated encroachment detection, drawing from geospatial, remote sensing, and AI technologies. Each has distinct technical strengths, and most modern solutions combine these approaches for accuracy and scalability. In this section, we attempt to investigate and analyse the different methodologies used for detecting forest encroachment.

Uddin et al. (2015) employed Geographic Object-Based Image Analysis (GEOBIA) techniques on QuickBird and IKONOS satellite images to detect, map, and assess changes in tree cover and forest condition, including deforestation due to encroachment, in a remote watershed in Nepal. The study applies region-growing and multiresolution segmentation methods for tree crown detection and land cover change analysis and demonstrates the effectiveness of object-based techniques for monitoring forest encroachment and degradation with fine spatial detail.

Weishampel et al. (2012) uses small-footprint airborne LiDAR to identify areas of canopy disturbance and illegal deforestation in the Caracol Archaeological Reserve along the Belize-Guatemala border. By comparing canopy height measures from LiDAR with deforestation patterns derived from Landsat images, the authors demonstrate that LiDAR reveals a significantly larger extent and depth of forest encroachment and canopy degradation than traditional optical sensors. The study highlights the added value of high-resolution LiDAR for locating and quantifying forest encroachment with greater accuracy.

Soorya Narayan Satheesh (2025) proposed a novel AI-based method leveraging very high-resolution satellite imagery to automatically identify and monitor forestland encroachments in India. The AI-driven approach aims to increase land available for afforestation, support real-time monitoring, and help India meet climate change commitments by improving CO2 sequestration prospects. The feasibility assessment concludes that current AI tools are practical and effective for automated encroachment detection, making proactive intervention possible.

Another notable publication is by Desclée et al. (2006), which proposes a statistical object-based change detection method to identify forest land cover changes using high spatial resolution satellite images. They proposed a robust approach effective in mapping various forms of forest encroachment and degradation. Multidate segmentation was used to delineate objects that are similar spatially, spectrally, and temporally across a sequence of satellite images. Each object is characterized by the statistical difference in reflectance values over time, with changed areas identified through a chi-square hypothesis test applied to these statistics. Objects showing abnormal (outlier) temporal changes are iteratively trimmed and labelled as changed using automated statistical procedures.

Kumar et al. (2014) applied high-resolution WorldView-II satellite data combined with cadastral vector data to digitize and update protected forest boundaries at the cadastral level. The research integrates cadastral data, GPS surveys, and satellite imagery using ArcGIS to produce highly accurate cadastral forest maps. These maps support transparency in forestland administration, precise boundary delineation, and monitoring of encroachments. A critical focus is on overlaying cadastral forest boundary vectors on ortho-rectified satellite images for spatial analysis and encroachment detection

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with sub-meter accuracy. The methodology offers a geospatial infrastructure for forest management and policy-making based on cadastral GIS layering techniques.

Purbahapsari et al. (2022) proposed an innovative GeoAI system that integrates satellite image data processed by machine learning to perform early detection and monitoring of forest and land fires. The GeoAI approach improves accuracy compared to traditional hotspot methods by using deep learning models trained on satellite image time series for burnt area recognition. The system overlays fire detection with forest area and concession boundaries, providing a comprehensive integrated platform that supports law enforcement, forest management, and public service effectiveness.

3. OBJECTIVES OF THE STUDY

Based on the literature review, the following objectives were formulated:

4. To address the benefits and limitations of the different methods used for automated forest encroachment detection.
5. To examine the general methodology used for automated forest encroachment detection.
6. To propose a generalized framework for automated forest encroachment detection.

7. COMPARATIVE ANALYSIS OF THE DIFFERENT METHODS USED IN AUTOMATED FOREST ENCROACHMENT DETECTION

Various methodologies have been used for detecting forest encroachment. Some of the most notable methods used for Automated Encroachment Detection are:

- **High-Resolution Satellite Imagery & Object-Based Analysis:** Satellite images, sometimes combined with drone surveys, are processed using Object-Based Image Analysis (OBIA), allowing for the detection of land use changes and unauthorized constructions at fine spatial resolutions.
- **LiDAR Technology:** LiDAR provides detailed three-dimensional mapping of landscapes. When combined with GIS, even subtle elevation changes and new structures that might indicate encroachment can be detected, especially in complex terrain.
- **AI and Deep Learning Algorithms:** Machine learning classifiers, particularly convolutional neural networks (CNNs), support vector machines (SVMs), and random forest algorithms, are trained to identify patterns and anomalies in spatial and temporal data. These efficiently spot changes not easily visible to human analysts, and enable near-real-time monitoring.
- **Change Detection Analysis:** Automated comparison of historical and current geographic datasets (satellite or LiDAR) highlights new constructions or land use changes, flagging potential encroachment areas.

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- **Cadastral Audits and GIS Data Layering:** Systematic review and comparison of digital cadastral records, zoning data, and property maps using GIS tools can expose boundary violations and unapproved land use when coupled with field surveys.
- **Geospatial AI Platforms:** Comprehensive solutions such as ArcGIS-powered GeoAI and LEDS (Land Encroachment Detection System) use multi-sensor data fusion, AI-powered change detection, and real-time alerting to support efficient land management at scale.

Table 1: Comparison of the different methods used in Automated Forest Encroachment Detection.

Method	Strengths	Limitations
Satellite & OBIA	Wide area coverage, fine detail	May miss changes under canopy/buildings
LiDAR	3D accuracy, detects elevation changes	Costly, less frequent data updates
AI/ML (CNN/SVM/RF)	High accuracy, adaptable to new patterns	Needs quality labeled data
Change Detection	Effective for temporal monitoring	Relies on time-series historical data
Cadastral & GIS	Legal/reporting integration, spatial analysis	Requires up-to-date records
GeoAI/Integrated Platforms	Scalable, real-time, multi-sensor fusion	Initial setup/integration complexity

8. METHODOLOGICAL FRAMEWORK

Based on the literature review and analysis of the different models, the standard workflow for forest encroachment detection includes:

• **Data Collection:** Acquisition of multi-temporal, high-resolution satellite imagery (e.g., Landsat, Sentinel) along with ancillary spatial data (e.g., DEMs, thematic maps).

• **Preprocessing:** Radiometric and geometric corrections, followed by image enhancement to improve feature discrimination.

• **Training Data Preparation:** Collection of field data and reference samples, classifying areas as forest, non-forest, and encroached zones for algorithm training.

• **Classification and Analysis:** Application of machine learning classifiers to segment imagery and detect encroachment. Knowledge-driven and data-driven approaches are employed, often validated using ground truth data and accuracy assessments.

• **Mapping and Monitoring:** Visualizing and quantifying spatial trends of encroachment, generating actionable outputs for stakeholders and policymakers.

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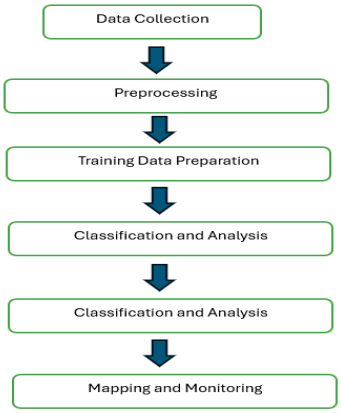

Figure 1: Overall Framework for Encroachment Detection.

9. Conclusion

Automated encroachment detection is increasingly important for urban planning, forest conservation, infrastructure protection, and dispute resolution, driven by technological innovation and growing demand for effective land management. The convergence of remote sensing, machine learning, and geospatial analysis offers powerful tools for early detection, accurate mapping, and adaptive management of forest encroachment. As technology advances and more data become accessible, these integrated approaches will play an increasingly pivotal role in safeguarding forests and supporting evidence-based policy interventions.

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Chapter-27: Role of Artificial Intelligence in Modern Hr Practices: A Theoretical Perspective

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Abstract

Artificial Intelligence (AI) is driving transformative change across diverse sectors, with significant implications for the field of human resources (HR). A notable example of AI's advancement is Sophia, the humanoid robot who addressed the United Nations on sustainable development, symbolizing the increasing integration of AI into global discourse. In the HR domain, AI is emerging as a powerful tool that operates across multiple levels from basic recruitment systems to advanced AI-powered platforms enhancing the accuracy, efficiency, and speed of talent acquisition processes. These tools, functioning autonomously or in collaboration with human professionals, are enabling HR teams to make data-driven decisions and gain predictive insights into a candidate's potential success within an organization. This study aims to explore the integration of AI in HR practices, particularly in recruitment and talent management, while assessing the associated benefits and challenges. The research is based on a qualitative methodology that includes the review of secondary sources such as academic articles, industry case studies, and expert opinions. The findings reveal that AI significantly improves hiring efficiency by automating routine tasks like resume screening and interview scheduling, while also enabling more accurate candidate matching and promoting unbiased recruitment when algorithms are properly designed. However, the study also highlights on-going concerns regarding data privacy, algorithmic transparency, and the potential displacement of HR roles. The implications suggest that organizations must invest in digital literacy and ethical AI frameworks to maximize the benefits while mitigating risks. In conclusion, AI represents a transformative shift in HR, not just in operational terms, but in redefining the strategic role of HR professionals. When adopted responsibly, AI can support more inclusive, efficient, and forward-thinking human resource practices, paving the way for a more adaptive and data-informed future of work.

Keywords: *Artificial Intelligence, Human Resources, Sustainable development, HR practices, Recruitment.*

1. Introduction

Artificial intelligence (AI) involves the emulation of human intelligence within machines, enabling them to mimic human actions and behaviours. Human resource management (HRM) is the practice of overseeing personnel, workplace culture, and maintaining a conducive work environment. The HR department primarily focuses on recruitment, hiring, training, and

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employee development initiatives. The integration of artificial intelligence in HR processes offers numerous advantages, streamlining operations, reducing costs, and saving time and resources. In the contemporary landscape, the application of artificial intelligence has gained traction across diverse sectors, including finance (banking), telecommunications, education, and corporations. Corporations, in particular, are increasingly adopting AI in their HR departments to enhance overall performance. By leveraging AI, HR tasks become more efficient, straightforward, and seamless. However, the implementation of AI is not without challenges. Integrating AI requires a well-prepared strategy, and its successful adoption demands a skilled workforce capable of handling its intricacies. Utilizing artificial intelligence in HR necessitates a proficient understanding of technology and its applications. Without adequate tech literacy, concerns such as data privacy and security may arise, potentially having adverse effects on the HR department and incurring additional costs. Therefore, to ensure the successful utilization of AI in HR practices, organizations must prioritize recruiting personnel equipped with the necessary skills and expertise. In summary, artificial intelligence's integration into human resource management brings forth efficiency and productivity benefits. However, it requires careful planning, a skilled workforce, and a comprehensive understanding of technology to reap its rewards while mitigating potential challenges.

2. Review of Literature

Scott W. O'Connor (2020): In his article "Artificial Intelligence in Human Resource Management, emphasized that artificial intelligence will maintain its constructive influence on the realm of human resources management in the forthcoming years. Furthermore, HR practitioners need to proactively acknowledge the potential challenges that lie ahead. To equip themselves for the future landscape of human resource management, professionals must proactively engage in understanding current trends within the field. Simultaneously, they should establish a robust groundwork of HR expertise, which can serve as a basis for their continuous growth and adaptation as the profession continues to evolve.

Prasanna Vatsa and Kusuma Gullamjji (2019): In the paper titled "To Study the Impact of Artificial Intelligence on Human Resource Management", it is clearly stated that the integration of HR practices with AI based applicants definitely have a stronger impact in enhancing the organizational performance. The study depicts that AI is everywhere in HR, be in recruitment, training, on boarding, performance analysis, retention and so on, but many of the organizations are still lagging in integrating AI to its HR – practices because of its cost associated in integration.

Jennifer Johansson and Senja Herranen (2019): In the paper titled "The Application of Artificial Intelligence in Human Resource Management", it is mentioned that the area of AI in recruitment is new and there are not many organizations that has implemented AI in all parts of the recruitment process. It also mentions that the main benefits of AI are seen as the speeded quality and elimination of routine tasks, while major challenge is seen as the companies' overall readiness towards the new technologies. Albert Christopher (2019): In his article names as "Use of Artificial Intelligence in Human Resource Management, the author says that AI – based applications raise employee productivity. It has the ability to analyze, predict, diagnose and become more capable resource while focusing on employee need and outcomes. However, there are challenges like privacy, talent gap, maintenance,

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integration capabilities or limited proven applications. AI systems must be managed carefully by finding reliable learning data sets, using the right implementation approach, seeking clarity, eliminating bias and considering unintentional consequences.

Barbara van pay (2018): In this article how AI is reinventing HR it was clearly stated that all the organizations mostly looking for AI solutions for their business and they are scared of letting a non-human entity handle the procedures of business. By using the AI in organization it can reduce the time consumed for filling and hiring the candidates who applied for the job, through screening multiple candidates, gathers data they rank the candidates by considering other information like experience ,skill set etc., to find right person. After finding the perfect fit for the role next main part is interviewing, now days AI interviewing software such as hike vue, mya are used mostly. AI technology takes care from sourcing to interview which drastically reduces the recruitment timeline and help to hire right candidates with ability to perform in specific roles and make placements much easier and at faster rate.

The importance of AI in HR management is multifaceted. AI can automate tasks such as resume screening, candidate sourcing, and initial interviews, saving time and resources for HR professionals (Chowdhury et al., 2023). It can personalize onboarding experiences, providing new hires with relevant information and resources tailored to their specific roles and needs. Additionally, AI can analyze employee data to identify performance trends, provide feedback, and identify areas for development. The research objectives of this study are to: 1. examine the current state of AI adoption in HR functions in Bangladesh; 2. identify the key challenges and opportunities associated with AI implementation in HR in Bangladesh; 3. evaluate the impact of AI on HR processes and outcomes in Bangladeshi organizations; 4. explore the ethical considerations and potential biases associated with AI in HR; and 5. provide recommendations for organizations and policymakers in Bangladesh to effectively leverage AI in HR.

To achieve these objectives, the research will address the following research questions: 1. What are the current applications of AI in HR functions in Bangladesh? 2. What are the key challenges and opportunities associated with AI adoption in HR in Bangladesh? 3. How does AI impact HR processes such as recruitment, onboarding, performance management, and talent management in Bangladesh? 4. What are the ethical considerations and potential biases associated with AI in HR in Bangladesh? 5. What are the recommendations for organizations and policymakers in Bangladesh to effectively leverage AI in HR?

3. The Role of Artificial Intelligence in Modern HR Practices

AI-driven tools are revolutionizing recruitment by automating candidate sourcing, screening, and assessment. For instance, companies like LinkedIn and HireVue use AI to analyze resumes and identify the best candidates based on job requirements. AI-powered chatbots, such as those used by IBM's Watson Recruitment, engage with candidates, answer their queries, and schedule interviews, saving time and effort for HR professionals.Moreover, AI reduces unconscious bias in hiring by basing assessment solely on objective criteria. For example, Unilever uses AI to test candidates through online games and video interviews. The system analyzes facial expressions, tone, and choice of words to predict whether a candidate would be suitable for a job, thus providing a just and inclusive process of hiring. This has ensured that diversity and efficiency have been realized in Unilever's hiring process.

Training and Development

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AI enhances employee training by offering personalized learning experiences. Platforms like Coursera and Degreed utilize AI to recommend tailored courses based on individual career goals and skill gaps. IBM's AI tool, Watson, provides real-time feedback and suggests resources to employees during their training sessions, ensuring they gain relevant skills efficiently.

Moreover, AI-based virtual reality (VR) and augmented reality (AR) simulations are increasingly being used for experiential learning. For instance, Walmart uses VR scenarios to train employees in customer service and handling difficult situations. This experiential learning approach helps the employees feel confident and perform better.

Ethical, Legal, and Regulatory Framework for AI in Recruitment

Artificial intelligence is transforming recruitment by making it smoother and increasing data-driven decision-making. However, as organizations increase the adoption of AI in hiring, it is imperative to keep in mind the ethical, legal, and regulatory considerations so that the adoption of AI is fair and responsible.

Ethical Considerations

AI in recruitment must focus on being transparent, accountable, and fair. Transparency refers to making the role of AI in decision-making clear to the candidates and ensuring that algorithms are understandable. Explainable AI (XAI) frameworks are critical to dealing with the "black-box" problem, whereby decisions seem to be made without an insight into how or why they were reached. Human oversight is necessary in validating AI-driven outcomes, including mitigating risks from possible errors.

Legal Frameworks

Governments globally are formulating laws related to AI in recruitment activities. In Europe, the General Data Protection Regulation mandates data transparency and protects candidate privacy, and the California Consumer Privacy Act in the United States offers similar protections. The Equal Employment Opportunity guidelines are equally important to ensure fair hiring practices. For example, regulations like the EU AI Act focus on categorizing AI systems by their risk levels and hold individuals liable for high-risk applications, such as recruitment. These laws ensure AI adoption aligns with legal standards and fosters trust among stakeholders.

4. Opportunities

Efficiency and Automation: AI can automate repetitive and time-consuming HR tasks, such as resume screening, data entry, and administrative duties. This allows HR professionals to focus on strategic initiatives and more value-added activities.

Data-Driven Decision Making: AI can process vast amounts of HR data to provide insights and trends, enabling informed and data-driven decision-making for better talent management strategies.

Enhanced Recruitment: AI-powered tools can identify suitable candidates faster, reduce bias in the selection process, and enhance the quality of hires through improved matching of skills and job requirements.

Personalization: AI can offer personalized employee experiences, from tailored on boarding plans to individualized training and development recommendations.

Predictive Analytics: AI can forecast workforce trends, such as attrition rates and skill gaps, allowing HR to proactively address challenges and plan for the future.

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Employee Engagement: AI can monitor employee sentiment and engagement, identifying potential issues early on and enabling interventions to improve job satisfaction and productivity.
Learning and Development: AI-powered platforms can recommend relevant training courses and materials based on employees' skills and career aspirations, fostering continuous learning.
HR Process Improvement: AI can optimize HR processes like performance appraisals, ensuring fairness, consistency, and transparency in evaluations.
Employee Assistance: AI-driven chat bots can provide instant answers to employee queries about policies, benefits, and procedures, enhancing user experience.

5. Challenges

Bias and Fairness: If not carefully designed and monitored, AI algorithms can perpetuate existing biases present in historical data, leading to unfair outcomes in areas like recruitment and promotions.
Data Privacy: The use of AI involves collecting and analysing sensitive employee data, raising concerns about data security and compliance with privacy regulations.
Employee Resistance: The introduction of AI tools can be met with resistance from employees who fear job displacement or mistrust AI-based decisions.
Skills Gap: The implementation of AI requires HR professionals to acquire new technical skills and a deep understanding of AI's limitations and potentials.
Loss of Human Touch: While AI can automate many tasks, it might compromise the personalized and empathetic interactions that HR professionals provide.
Transparency and Accountability: AI decisions can sometimes lack transparency, making it challenging to understand how decisions are made and potentially raising ethical concerns.
Integration Complexity: Integrating AI into existing HR systems and processes can be complex and require investments in technology and training.
Change Management: Implementing AI-driven changes in HR requires effective change management strategies to ensure smooth adoption and minimal disruption.

6. Findings and Discussions

The research findings are based on interviews conducted with HR professionals, AI experts, and policymakers in Bangladesh, as well as case studies of organizations that have implemented AI in their HR functions. The key findings are summarized below:
Limited AI adoption: While there is growing interest in AI in Bangladesh, its adoption in HR is still limited. Many organizations are exploring AI applications, but few have fully implemented AI-powered solutions.
Recruitment and selection: AI is being used primarily for resume screening and candidate sourcing. However, there is a growing trend towards using AI for initial interviews and assessments.
Performance management: AI is being used to analyze employee data and identify performance trends, but its use for providing feedback and coaching is still limited.
Talent management: AI is being explored for identifying high-potential employees and creating personalized development plans.
Challenges and opportunities: The key challenges to AI adoption in HR include lack of AI expertise, data privacy concerns, resistance to change, and ethical considerations. However,

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there are also significant opportunities for improved efficiency, cost-effectiveness, and employee experience.

Ethical concerns: Privacy concerns, bias and discrimination, and job displacement are major ethical considerations associated with AI in HR.

The findings from this research suggest that while AI offers significant potential for enhancing HR practices in Bangladesh, its adoption is still in its early stages. The limited adoption can be attributed to factors such as lack of AI expertise, data privacy concerns, and resistance to change. The use of AI in HR is primarily focused on recruitment and selection, with limited applications in performance management and talent management. This indicates a need for organizations to explore the full potential of AI in these areas (Griffin et al., 2009). Ethical considerations are a major concern in the use of AI in HR. Organizations must address issues such as data privacy, bias, and job displacement to ensure that AI is used ethically and responsibly. The findings from this research are consistent with existing literature on AI in HR. Studies have shown that AI can be used to automate HR tasks, improve decision-making, and enhance employee experience. However, the challenges and opportunities associated with AI adoption in developing countries like Bangladesh may differ from those in developed countries.

7. Future Study and Practical Implications

The Collaboration of Human and Machine

The future trend of the AI for HRM is still the collaboration of human and machine with the existence of confliction. The McKinsey Global Institute believes that “more than 30% of activities in 60% of occupations can be replaced by artificial intelligence”(Chui & Francisco, 2017). According to a research report from the University of Oxford, in the next 10 to 20 years, half of the 702 jobs in the United States will disappear under the influence of IT, and nearly 47% of US employees will be employed. Based on these data, how to elevate the competitive intelligence of human resource managers and deploy the human resources efficiently may be very difficult to handle with. How to collaborate the human and machine with using the developing technologies is also an important question. The large-scale rise in unemployment rate also will cause opposition and resistance.

In detail, in each dimension of human resource management, there are worthy researching questions to be answered. For example, the process design for the matching between job seekers and providers based on HR model and AI. The intelligent performance evaluation system combined with the AI algorithms and performance evaluation standards (Dom, 2018).

Data Driven Human Resource Management Analytics and Information System

To maintain the competitive advantages, enterprises can make strategic plan for the AI transforming by gradually building the internal data analytical system and improving information system. This will provide foundation for embedding with AI system. For each dimension of the HRM, the new AI technology can be attempted. Recruiting and Training can be the staring points as shown by cases analysis. The machine learning techniques for the employees’ performance prediction can also be applied for practice and research. The analytics of AI can also be applied for understanding organizational behaviors with data input.

Real Application Process, Advantages, and Risks AI and HR combination has been undenied trend in the HR revolutions. The current mature application is for recruiting, using chatbot

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and machine learning. Machine learning and augment learning algorithms are being developed to provide smart solutions for human resource management (Jill, 2018). However, most enterprises now are still not ready for AI application in HR. This process is not only technology diffusion, but also a merge with strategy, organizational behaviors, enterprise culture and management process in the enterprise. So how to design and implement the AI technology into HR practice gradually is still worth exploring. Except for the advantages of AI brings to HR, there are also risks may exist, such as data exposure and inadvertent misuse (Josh 2018). How to avoid such risks is also an interesting topic.

8. Conclusion

In conclusion, the integration of Artificial Intelligence (AI) into Human Resource Management (HRM) presents a transformative shift with significant potential benefits and challenges. AI's capacity to emulate human intelligence through algorithms and machine learning tools offers HR professionals the ability to streamline operations, enhance decision-making, and optimize processes across various HR functions. However, this advancement comes with responsibilities that need to be addressed strategically. While AI in HR has the potential to bring efficiency, data-driven insights, and improved employee experiences, careful implementation and ongoing vigilance are paramount. The implications of bias in algorithms, data privacy concerns, employee resistance to change, and the potential loss of the human touch must be thoughtfully managed. Moreover, the integration of AI demands a re-evaluation of skill sets among HR professionals, ensuring they possess the necessary technological know-how to harness AI effectively while maintaining the ethical and human-centered dimensions of HRM. As Scott W. O'Connor highlighted, AI's role in HR is expected to continue its positive trajectory, shaping the future of HRM. HR practitioners must equip themselves with a deep understanding of the current trends, while also laying a strong foundation of HR knowledge. This will allow them to navigate the evolving landscape, harness the capabilities of AI, and align its applications with organizational goals and values. Ultimately, the successful implementation of AI in HR will hinge on striking the right balance between technological advancements and human expertise. It is through this balance that organizations can harness AI's power to enhance HR operations, fostering a more productive, inclusive, and engaging work environment for employees, while also ensuring fairness, transparency, and compliance in HR practices.

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Chapter-28: A Comparative Analysis of Educational Loan Schemes

Subtitle: A Case Study of Public vs. Private Sector Banks: State Bank of India and HDFC Bank

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Abstract

This study, "A Comparative Analysis of Educational Loan Schemes: Public vs. Private Sector Banks," examines the educational loan offerings from public and private banks, with a specific focus on the State Bank of India (SBI) and HDFC Bank. Rising education costs have driven students to seek financial support, making it essential to evaluate loan options based on terms, interest rates, repayment conditions, and customer satisfaction.

The analysis highlights distinct characteristics of public and private sector banks in terms of loan schemes. Public banks, such as SBI, often provide loans with government-backed benefits, lower interest rates, and longer repayment tenures, making them accessible to a broad spectrum of students. These banks typically offer favorable terms, especially for economically disadvantaged students and female students, with interest rate concessions and subsidies available under schemes like the Central Scheme of Interest Subsidy (CSIS). On the other hand, HDFC, as a private bank, offers competitive rates, flexible loan amounts, and faster processing, although often at a higher cost and with stricter eligibility and collateral requirements.

Methodologically, this study utilizes primary data collected via surveys from students at Dibrugarh University and secondary data on loan schemes. Analysis shows that the majority of students (81%) favor public sector banks for their lower interest rates and manageable terms. However, common challenges, such as lengthy processing times and complex documentation, were reported across both types of banks. For private banks, the appeal lies in their efficient service, but higher costs and stringent terms can be limiting.

The findings aim to guide students in making informed financial decisions, recommending that banks simplify documentation, enhance transparency, and shorten processing times to improve accessibility. The study's limitations include its focus on only two banks and a regional scope within Assam, suggesting further research across other institutions and regions to generalize results better.

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2. Introduction

We know that access to quality education is a fundamental right and an essential element for personal and societal development. However, the escalating cost of education has made it increasingly difficult for many individuals to afford higher education without financial assistance. Educational loans have emerged as a viable solution, offering students the necessary financial support to pursue their academic dreams. This study aims to conduct a comparative analysis of educational loan schemes provided by public and private sector banks, with a focus on understanding the differences in terms and conditions, interest rates, repayment options, and overall customer satisfaction.

This comparative study will delve into the specific features of educational loan schemes from selected public and private sector banks, analyzing their benefits and drawbacks. By examining customer experiences and satisfaction levels, this study aims to provide valuable insights for students and their families in making informed decisions about financing their education.

3. Background

Educational loans have become indispensable in the financial plof students aspiring for higher education. Public sector banks, driven by government policies, often offer loans with lower interest rates and more favorable repayment terms to support educational advancement. Private sector banks, while also catering to the needs of students, operate with a profit motive that can lead to differences in loan terms and customer service experiences. Analyzing these differences is essential for understanding how each sector impacts students' financial burdens and opportunity

4. Significance of the Study

The significance of this study lies in its potential to inform students and their families about the nuances of educational loan schemes offered by public and private banks. As education costs continue to rise, making an informed choice about educational loans becomes increasingly important. By highlighting the strengths and weaknesses of each sector, thisstudy aims to empower students to select the most suitable loan option for their needs, thus facilitating better financial planning and stress-free education journeys.

Moreover, it sheds light on the financial barriers and procedural hurdles faced by students in higher education, particularly in regions like Assam. Understanding these challenges can reveal the specific issues—such as complex loan procedures, high-interest rates, or inadequate support from financial institutions—that impact students' access to and satisfaction with educational loans. By examining these factors, the study can inform policymakers, banks, and university administrators about areas for improvement to make educational financing more accessible, efficient, and student-friendly.

6. Literature review

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Role of Public Sector Banks in Educational Lending

Public sector banks, such as the State Bank of India (SBI), are significant players in educational financing, often guided by government policies. They are known for providing loans with government-backed benefits, lower interest rates, and more favourable, longer repayment tenures. These features make education more accessible to a wide range of students, including those from economically weaker sections.

Government Schemes and Concessions

Public banks frequently offer special concessions to support specific student demographics. This includes interest rate reductions for female students and subsidies for economically disadvantaged students under government initiatives like the *Central Scheme of Interest Subsidy (CSIS)*. These schemes provide interest subsidies during the moratorium period, significantly reducing the financial burden on students.

Role of Private Sector Banks in Educational Lending

Private sector banks, like HDFC, operate with a profit motive, which influences their loan terms and customer service. They compete by offering faster loan processing and flexible loan amounts. However, these benefits often come at the cost of higher interest rates and stricter eligibility and collateral requirements.

Student Preference and Rationale

Analysis shows that a significant majority of students (81%) prefer public sector banks for educational loans. The primary reasons for this preference are the lower interest rates and more manageable repayment terms offered by public banks compared to their private counterparts.

Common Procedural Challenges for Students

Despite the availability of loans, students encounter significant procedural hurdles across both public and private banks. Common challenges reported include complex documentation and paperwork and long processing times, which can be significant barriers for applicants. These issues impact students' ability to access educational financing efficiently.

Significance of a Comparative Analysis

Given the differences between public and private lenders, a comparative analysis is crucial to help students make informed financial decisions. Understanding the strengths and weaknesses of each sector empowers students to select the most suitable loan for their needs, facilitating better financial planning and reducing stress during their education journey. The study specifically aims to fill this knowledge gap, with a focus on students in regions like Assam.

7. HYPOTHESIS FORMATION

The hypothesis for this comparative study is that public sector banks offer more favorable educational loan schemes in terms of interest rates and repayment flexibility compared to private sector banks, which might offer quicker processing times and more competitive service but at higher costs and stricter terms.

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H_0: There is no difference between public and privatesector banks in terms of educational loan.

H_1 or **H_a**: There is difference between public and private sector banks providing educational loan.

8. METHODOLOGY OF THE STUDY

Secondary data collection

To analyses the education loan schemes provided State bank of India and HDFC bank various information regarding interest rate, repayment process, amount of loan etc. are collected from their official websites.

Primary data collection

Primary data is information gathered directly from the students who have taken education loan for the purpose of research. It is gathered in order to solve the problem at hand. As a result, primary data is data obtained directly by the researcher. In the instance of our study, primary data is collected using:

- Online questionnaire sent through WhatsApp.

Sample design: Sampling is the process of selecting a subset of individuals or items from a larger population for the purpose of conducting research or drawing conclusions about that population.

Population: A population can be defined as the totality of all items and attributes studied in the research. However, acquiring all of this data is time-consuming and expensive. As a result, we use samples to draw conclusions about the population. Students of Dibrugarh University who have taken education loan are being studied to understand the challenges faced by students while availing educational loan and their satisfaction level.

Sampling Technique: Purposive sampling technique is used to draw the sample because the number of students who have taken education loans is very small and they are not spread proportionately across different centers and departments. Moreover, purposive sampling can be cost-effective and time-efficient compared to probability sampling methods, as it minimizes the need for extensive sampling frames and random selection procedures.

Sampling Unit: Students of Dibrugarh university who have taken education loan

Educational loan schemes on public sector bank

OVERVIEW OF PUBLIC SECTOR BANKS

Indian public sector banks play a crucial role in providing educational loan schemes to support students pursuing higher education, both in India and abroad. These schemes

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typically cover a wide range of expenses, including tuition fees, books, accommodation, and travel, making education more accessible for students from diverse socio-economic backgrounds. Most banks offer loans under schemes like the **Central Scheme of Interest Subsidy (CSIS)**, which provides interest subsidies for economically weaker sections during the moratorium period (course duration plus a year). Popular banks like State Bank of India (SBI), Punjab National Bank (PNB), and Bank of Baroda offer education loans with flexible repayment tenures, ranging from 5 to 15 years, and competitive interest rates, typically ranging from 7% to 10%, depending on the loan amount and student profile. The loans are generally collateral-free for smaller amounts (up to INR 7.5 lakhs) under the Indian Banks' Association (IBA) model education loan scheme, with higher amounts requiring collateral. Indian public sector banks also provide certain relaxations, such as interest rate concessions for female students and students pursuing studies in premier institutions like IITs and IIMs. Additionally, many banks allow co-borrowing by parents or guardians and offer repayment flexibility, including EMI (Equated Monthly Installments) after a grace period, making these loans a vital resource for funding education.

For this research, the **State Bank of India (SBI)** has been chosen to study its various educational loan schemes. The primary reason for selecting SBI is its stature as the largest public sector bank in India, with an extensive customer base and widespread reach. Given its extensive network and long-standing presence in the Indian banking landscape, SBI offers a diverse range of educational loan products tailored to various academic pursuits.

TYPES OF EDUCATIONAL LOANS OFFERED BY SBI

STUDENT LOAN:

This is a general loan scheme for students pursuing studies in India or abroad in approved courses at recognized institutions.

Processing Charges

- Loans up to Rs. 20 lacs: NIL
- Loans above Rs. 20 lacs: Rs. 10,000 (plus taxes)

Security

- Up to Rs. 7.5 Lacs: Only Parent/ Guardian as co-borrower.

No Collateral Security or third-party guarantee

- Above Rs. 7.5 Lacs: Parent/ Guardian as co-borrower and tangible collateral security

Margin

- Up to Rs 4 Lacs - Nil
- Above Rs 4 Lacs - 5% for studies in India, 15% for studies in abroad

Repayment will commence one year after completion of the course.

Loan to be repaid in 15 years after the commencement of repayment.

In case second loan is availed for higher studies later, to repay the combined loan amount in 15 years after completion of second course.

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Loan Amount

- Studies in India Medical Courses: Upto Rs 30 lacs
- Other Courses: Upto Rs 10 lacs

Studies abroad

- Upto Rs 7.50 lacs

Interest rate

Effective rate: 11.15%

Concession: 0.50% concession in interest for girl students

Type: floating

Category of institutions	Maximum Loan Limit	
	No Security, only Parent/ Guardian as co-borrower	With tangible collateral of full value and Parent/ Guardian as co-borrower
List AA	Rs. 50 lacs	No upper limit
List A	Rs. 40 lacs	No upper limit
List B	Rs. 30 lacs	No upper limit
List C	Rs. 7.5 lacs	Rs. 30 lacs

Takeover of Education Loans

This product is designed for individuals who already have an existing education loan from Type: floating

another bank or financial institution and want to transfer (takeover) their loan to SBI, usually to benefit from better terms or interest rates.

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Eligibility:

Loan to be a fresh (first-time) takeover
The student-borrower should be a major at the time of switchover
The loan should have been fully disbursed at the time of the takeover

Quantum of Finance

Quantum of Finance Minimum: Rs. 10 Lakhs

Quantum of Finance Maximum: Rs. 1.5 Crores

Interest rate

Effective rate: 11.15%
Concession: 0.50% concession in interest for girl students

Shaurya Education Loan

The Shaurya Education Loan Scheme by SBI provides financial assistance to meritorious wards of Defense and Indian Coast Guard personnel for pursuing higher education in India or abroad. The loan is available only if the parent (co-borrower) holds a Defense Salary Package or Indian Coast Guard Salary Package account with SBI, which must continue throughout the loan tenure. It covers full-time graduation, post-graduation, professional, or diploma courses at recognized institutions, with a maximum loan limit of ₹40 lakhs for studies in India and up to ₹1.50 crores for studies abroad. No margin is required for loans up to ₹4 lakhs, while a 5% margin applies above this limit. Processing fees are waived for loans up to ₹20 lakhs, with ₹10,000 plus taxes charged beyond that. The effective interest rate is 11.15% (11.75% for unsecured loans), with an additional 0.50% concession for girl students

Overview Of Hdfc Bank

HDFC Bank (Housing Development Finance Corporation) is one of India's leading private sector banks, known for offering a wide range of banking and financial services. It was established in 1994 and is headquartered in Mumbai, India. Here's an elucidation of the term and its significance: Foundation & Growth: HDFC Bank was incorporated in August 1994, with its first corporate office in Mumbai. It is part of the HDFC Group, originally founded to provide housing finance inIndia.

PRODUCTS & SERVICES:

HDFC Bank offers a broad range of services, including:

1) **Retail Banking:** Savings and current accounts, fixed deposits, credit

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cards, home loans, auto loans, personal loans, and more.

2) **Wholesale Banking**: Financial services for corporates and businesses, including trade finance, cash management, and loans.
3) **Treasury Services:** Foreign exchange, derivatives, and capital market services.
4) **Digital Banking**: Mobile apps, net banking, and digital payment solutions have been areas of innovation for HDFC Bank.

COMPETITIVE INTEREST RATES:

HDFC Bank offers educational loans at relatively competitive interest rates which helps reduce the financial burden on students and

parents. The interest rates can vary based on the course, institute, and repayment terms, but they are generally aligned with the market standards or better.

FLEXIBLE LOAN AMOUNTS:

The bank provides loans for a wide range of amounts, covering bothdomestic and international education. Whether it's for undergraduate, postgraduate, or professional courses, HDFC offers loans tailored to the needs of the student.

LONG REPAYMENT TENURE:

HDFC Bank offers flexible repayment tenures, which can be extended upto 15 years in some cases. This gives students sufficient time to repay their loans after completing their studies and findingemployment.

TAX BENEFITS:

Students or parents repaying HDFC educational loans can avail of tax benefits under Section 80E of the Income Tax Act, where the interestpaid on the loan is deductible from the taxable income.

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QUICK LOAN PROCESSING:

HDFC Bank is known for its efficient loan processing system. Students can get quick approvals for their educational loans, especially for courses at reputed institutions. This fast processing helps students meet tight admission deadlines.

TYPES OF EDUCATIONAL LOANS PROVIDED BY HDFC BANK

HDFC BANK EDUCATION LOAN FOR INDIAN EDUCATION:

This loan is designed for students pursuing higher education within India. It covers a wide range of courses, including undergraduate, postgraduate, and diploma courses in recognized Indian institutions. Indian nationals who have secured admission to arecognized Indian educational institution. Students can apply for courses in fields like engineering, medicine, management, arts, and more.

HDFC BANK EDUCATION LOAN FOR FOREIGN EDUCATION:

This loan is aimed at students planning to pursue higher education abroad, covering various expenses related to international studies. Indian students who have secured admission to recognized foreign universities. Students applying for undergraduate, postgraduate, or professional courses. Typically, up to ₹20 lakhs ormore, depending on the course and country.

HDFC BANK LOAN FOR SKILL DEVELOPMENT COURSES:

HDFC Bank provides loans for vocational, technical, or skill development courses. This loan is useful for students who want to enhance specific skills through short-term or certification programs.

Indian nationals who have secured admission to certified skill development or technical programs. Typically, up to ₹1.5 lakhs,depending on the course.

HDFC EDUCATION LOAN FOR MEDICAL COURSES:

Specialized educational loans are available for students pursuing medical studies, including MBBS, BDS, nursing, and postgraduate medical courses. Students admitted to recognizedmedical institutions in India or abroad. Higher loan amounts are offered due to the expensive nature of medical courses, often goingabove ₹10-20 lakhs.

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INTEREST RATES AND REPAYMENT TERM OF HDFC EDUCATION LOAN

The interest rates for HDFC Bank's education loans typically fall in the range of 9% to 15% per annum. However, the exact rate depends on various factors like the loan amount, type of course, institution, and whether the loan is secured by collateral.

Type of Interest:

Floating Interest Rate: Most education loans come with floating interest rates that change with the base rate set by the Reserve Bankof India (RBI) or HDFC Bank's Marginal Cost of Lending Rate (MCLR).

Fixed Interest Rate: In some cases, a fixed interest rate might be offered, especially for short-term loans or special schemes.

Special Concessions:

HDFC Bank sometimes offers lower interest rates or concessions for students admitted to premier institutions like IITs, IIMs, or globally reputed universities.

Female students may get a 0.50% concession on the applicable int

COMPARATIVE ANALYSISOF EDUCATIONAL LOAN SCHEMES

Feature	SBI Education Loan	HDFC Bank Education Loan
Loan Amount	Up to ₹1.5 Crore, depending on course and institution type; except for some of the selected premier institutions there is no upper limit.	Typically up to ₹20 Lacs for Indian education, higher amounts available for foreign studies and specialized programs like medical studies
Interest Rate	Floating, generally ranges from 8.05% to 11.75%	Floating rate ranging from 9% to 15%, varies with loan type, amount, and collateral
Interest Concession	0.50% concession for female students	0.50% concession for female students, additional concessions for premier institutions like IITs and IIMs
Processing Fees	Up to ₹20 Lacs: NIL; Above ₹20 Lacs: ₹10,000 + taxes	Based on loan type and amount; generally higher for foreign education schemes

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Collateral Requirement	Loans up to ₹7.5 Lacs require only a co-borrower; loans above ₹7.5 Lacs need tangible collateral Exception: for some selected premier institutions loans up to ₹50 lacs no tangible collateral is required.	Loans above ₹7.5 Lacs typically require collateral (e.g., property, fixed deposits, or third-party guarantor)
Repayment Tenure	Maximum of 15 years for most schemes	5 to 15 years, depending on loan amount, course type, and presence of collateral
Repayment Start (Moratorium)	Course duration plus 12 months post-completion or 6 months upon securing a job, whichever is earlier	Course duration plus 6-12 months, with an option to start paying simple interest during the moratorium
Margin Requirement	5%-15%, depending on loan amount and location of studies (5% for domestic, 15% for foreign studies)	Generally required for larger loans but may be waived for smaller loans
Loan Coverage	Tuition, examination fees, hostel expenses, and travel expenses (for international courses); also covers laptop and equipment costs if required by the institution	Tuition, books, equipment, and travel expenses for international courses, also includes hostel expenses for certain loans
Other Benefits	Option to take a second loan for higher studies, with a combined repayment tenure of 15 years	Flexibility to pay partial interest during the course to reduce future EMI burden

DATA ANALYSIS AND INTERPRETATION

Plot data and interpretation:

Course	Frequency	Percentage
Graduation	20	95.2
Post graduation	1	4.8

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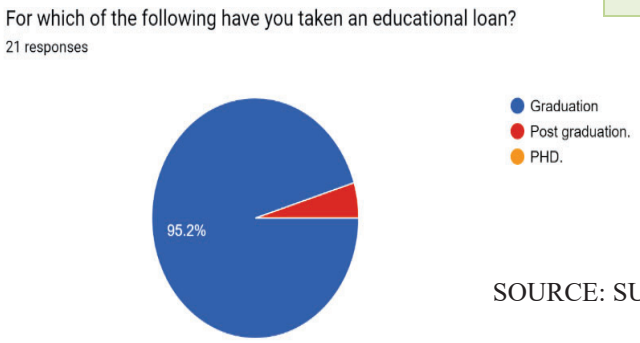
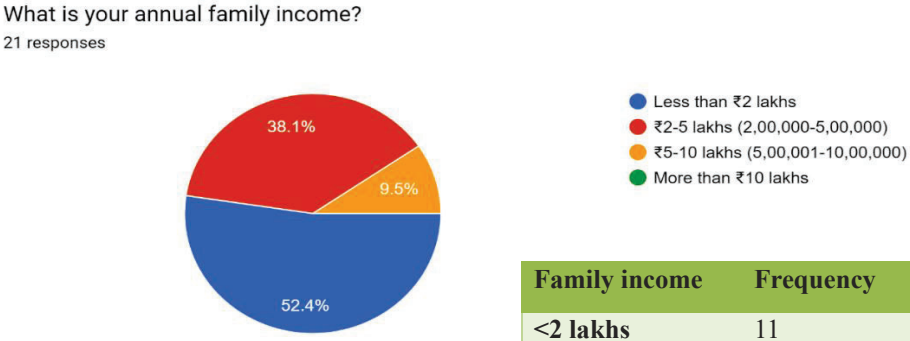
PHD	0	0



SOURCE: SURVEY

Interpretation:
95.2% of the total respondents took education loan for graduation, 4.8% of the total respondents took education loan for post-graduation while number of respondents who took education loan for PHD programme is zero.



Family income	Frequency	Percentage
<2 lakhs	11	52.4
2-5 lakhs	8	38.1
5-10 lakhs	2	9.5
>10 lakhs	0	0

SOURCE: SURVEY

Interpretation:
The family income of 52.4% of the respondents is less than two lakhs, the family income of 38.1% of the respondents is between two lakhs to ten lakhs, the family income of 9.5% of the respondents is between five to ten lakhs and there are respondents whose family income is more than ten lakhs.

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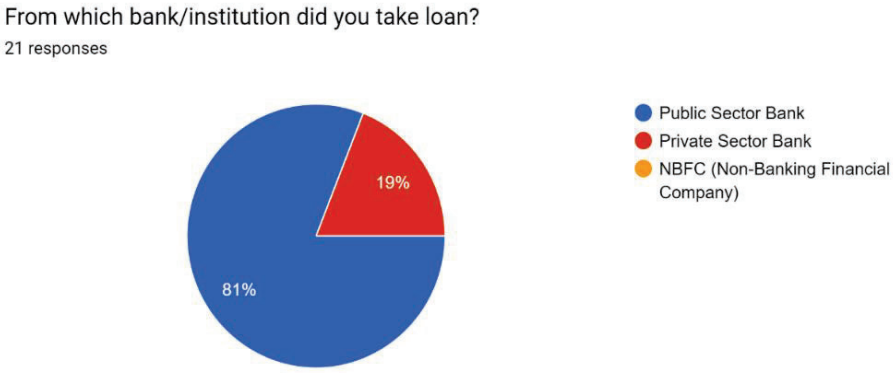
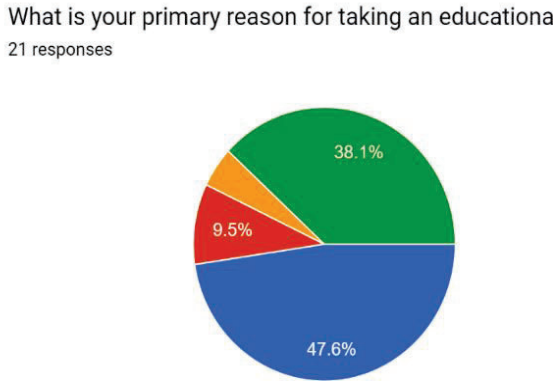


Institution	Frequency	Percentage
Public sector bank	17	81
Private sector bank	4	19
NBFC	0	0

Interpretation:
t of the total respondents almost four-fifth (81%) chose public sector banks for taking education loans
ł one-fifth (19%) of the respondents chose private sector banks for taking education loans.



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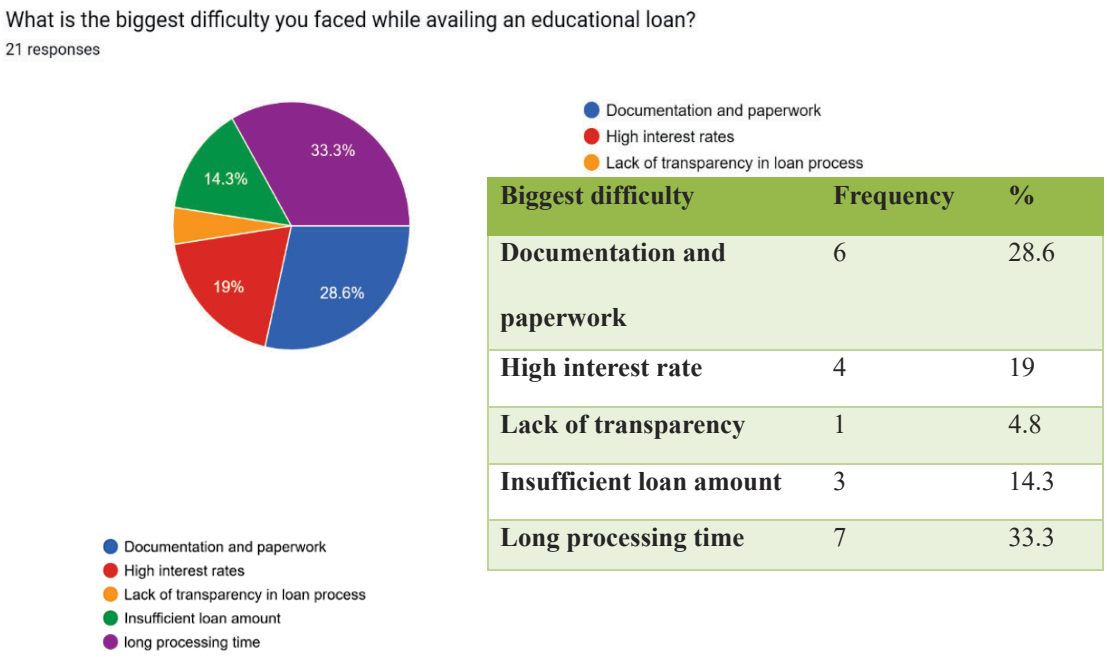
Reason	Frequency	Percentage
Tuition fees	10	47.6
Living expenses	2	9.5
Books and supplies	1	4.8
For all of the above	8	38.1

SOURCE: SURVEY

Interpretation:

Almost half of the respondents (47.6%) took education loan for only tuition fees, 9.5% and 4.8% of the respondents took education loan for living expenses and for books and supplies respectively, while 38.1% of the respondents took education for all of these reasons i.e. for tuition fees, living expenses and books and supplies.



Biggest difficulty	Frequency	%
Documentation and paperwork	6	28.6
High interest rate	4	19
Lack of transparency	1	4.8
Insufficient loan amount	3	14.3
Long processing time	7	33.3

SOURCE: SURVEY

Interpretation:

From the table it is clear that more than 50% of the respondents face difficulties regarding “documentation and paperwork” and “long processing time”; where 28.6% is for the former and 33.3% for the latter. Along with this high interest rate is the problem for 19% of the respondents.

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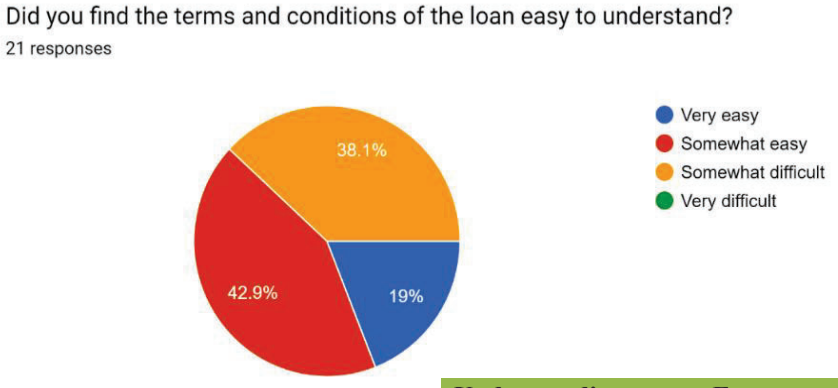
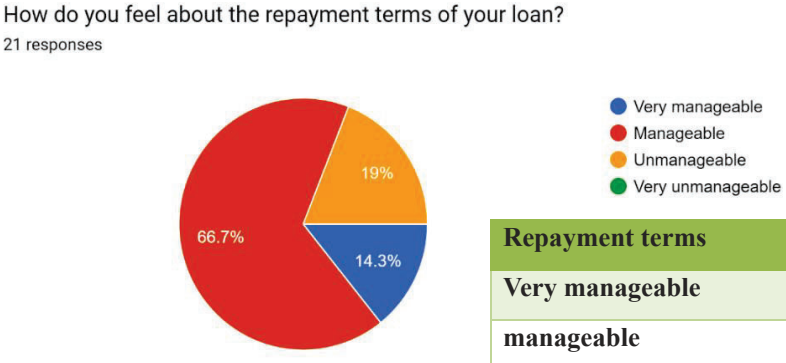


Understanding Terms& condition	Frequency	Percentage
Very easy	4	19
Somewhat easy	9	42.9
Somewhat difficult	8	38.1
Very difficult	0	0

SOURCE: SURVEY

Interpretation:

It can be said that the majority of the respondents found the terms & conditions easy to understand as 19% of the respondents voted for "very easy" and 42.9% of the respondents voted for "somewhat easy"; while 38.1% of the respondents found the terms & conditions "somewhat difficult" to understand.



SOURCE: SURVEY

Repayment terms	frequency	percentage
Very manageable	3	14.3
manageable	14	66.7
Unmanageable	4	19
Very unmanageable	0	0

Interpretation:

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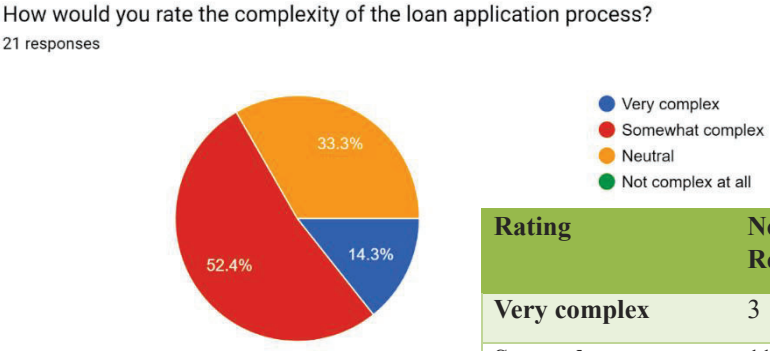
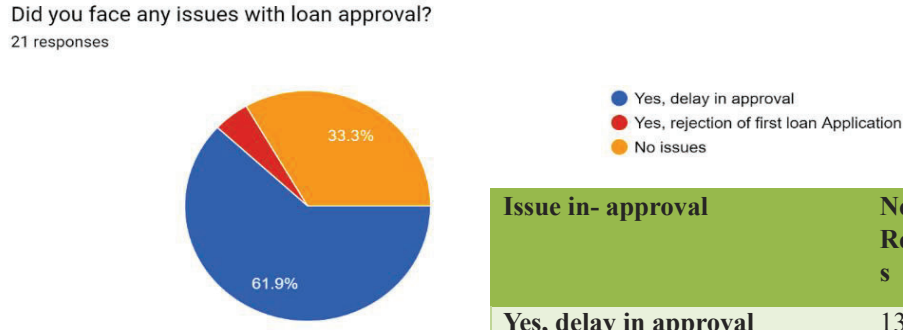
It is clear from the table that majority of the respondents showing positive attitude towards the repayment term as 14.3% and 66.7% of the respondents found the repayment term "very manageable" and "manageable" respectively, while only 19% of the respondents found the repayment term "unmanageable".



Rating	No. of Responses	Percentage
Very complex	3	14.3%
Somewhat complex	11	52.4%
Neutral	7	33.3%
Not complex at all	0	0%

SOURCE: SURVEY

Interpretation:
From the table it is clear that more than 50% of the respondents faces difficulties regarding "documentation and paperwork" and "long processing time"; where 28.6% is for the former and 33.3% for the later. Along with this high interest rate is the problem for 19% of the respondents.



Issue in- approval	No of Responses	percentage
Yes, delay in approval	13	61.9%
Yes, rejection of first loan application	1	4.8%
No issues	7	33.3%

SOURCE: SURVEY

Interpretation:
Out of the total respondents, more than

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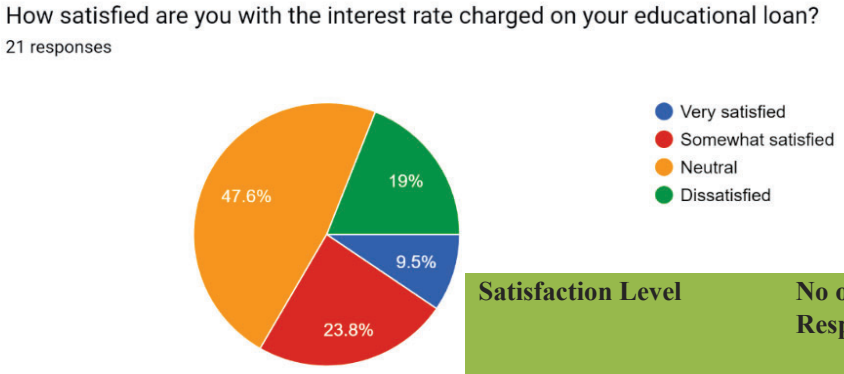
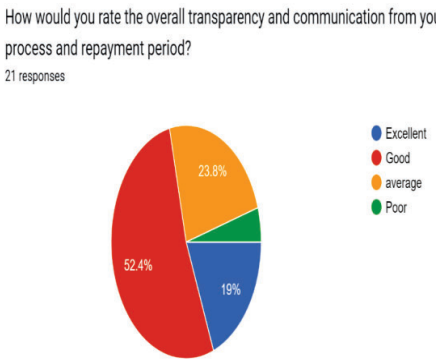
three-fifths (61.9%) of the respondents faced a delay in loan application and only one-third (33.3%) of the respondents faced no issues with loan approval.



Satisfaction Level	No of Responses	Percen--tage
Very Satisfied	2	9.5%
Somewhat satisfied	5	23.8%
Neutral	10	47.6%
Dissatisfied	4	19%

SOURCE: SURVEY

Interpretation:
One-third of the respondents are satisfied with the interest rate charged on their educational loan and almost one-fifth of the respondents are dissatisfied with the interest rate, while almost half of the respondents are neither satisfied nor dissatisfied with the interest rate.



Rating	No of Responses	Percentage
Excellent	4	19%
Good	11	52.4%
Average	5	23.8%
Poor	1	4.8%

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Interpretation:

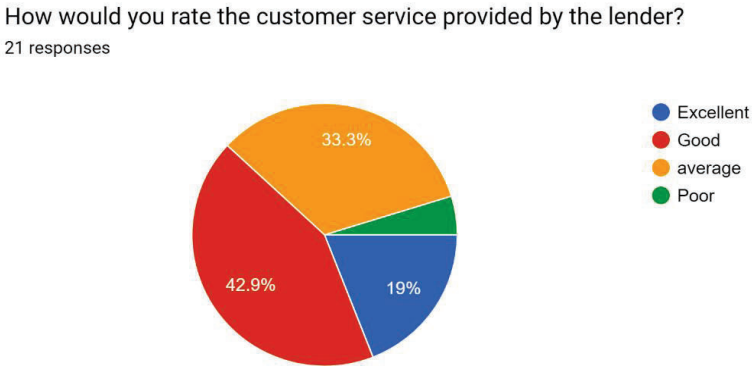
rom the above table, it is clear that almost all of the re
ansparency and communication from the lender excep
ıe overall transparency and communication poor.

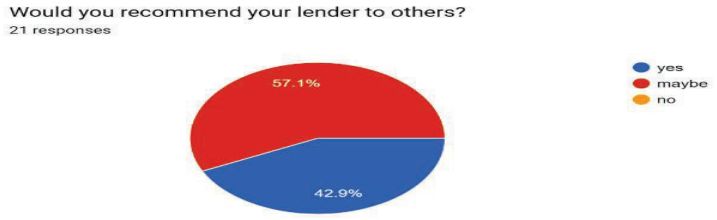
SOURCE: SURVEY

Interpretation:

Customer service	No of Responses	Percentage
Excellent	4	19
Good	9	42.9
average	7	33.3
poor	1	4.8

Out of the total respondents 19% of the respondents found the customer service provided by the lender excellent, 42.9% of the respondents found the customer service provided by the lender good, one third of the respondents found the customer service provided by the lender good and only 4.8% of the respondents found the customer service poor.





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COMPARISON BETWEEN STATE BANK OF INDIA AND HDFC BANK WITH RESPECT TO CUSTOMER EXPERIENCE AND SATISFACTION LEVEL

Response	Percentage	Number of Responses
Yes	9	42.9%
Maybe	12	57.1%
No	0	0.0%

BASIS	STATE BANK OF INDIA	HDFC BANK
Terms and condition	58.8% of the respondents found the terms and conditions easy to understand.	75% of the respondents found the terms and conditions easy to understand.
Repayment terms	76.4% of the respondents found the repayment terms manageable.	75% of the respondents found the repayment terms manageable.
Satisfaction with interest rate	23.52% of the respondents are satisfied with the interest charged.	50% of the respondents are satisfied with the interest charged.
Transparency and communication	64.7% of the respondents are satisfied with the transparency level and communication from their lenders.	75% of the respondents are satisfied with the transparency level and communication from their lenders.
Issue during loan approval	64.7% of the respondents faced issues during loan approval.	75% of the respondents faced issues during loan approval.

Hypothesis testing

Based on the hypotheses stated in the study on educational loans provided by public and private sector banks, here's a breakdown of the hypotheses and the findings supporting them:

Hypothesis	Description	Findings & Suggested Acceptance
H0	There is no difference between public and private sector banks in terms of educational loans.	**Reject H0**: Based on the study's findings, there is a significant preference for public sector banks (81% of students), primarily due to lower interest rates, manageable repayment terms, and government-backed benefits. This suggests a notable difference in loan offerings between public and private banks.
H1 or Ha	There is a difference between public and	**Accept H1**: The study reveals that public banks, such as SBI, offer more favourable terms (like

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	private sector banks in providing educational loans.	lower interest rates and extended repayment periods), whereas private banks, such as HDFC, provide quicker processing but often at higher costs. This observed distinction supports the acceptance of H1.

Thus, the findings suggest that H1 (there is a difference between public and private sector banks in educational loan offerings) should be accepted based on the observed contrasts in customer preferences, interest rates, and loan terms between the banks studied.

FINDINGS OF THE STUDY

- **Preference for Public Sector Banks**: The majority of students at Dibrugarh University prefer public sector banks over private ones for educational loans, with around 81% choosing this option due to factors like favorable terms and lower interest rates.
- **Challenges in Loan Application**: Students face significant challenges in the loan application process, primarily due to long processing times (33.3%) and extensive documentation requirements (28.6%).
- **Understanding of Terms and Conditions**: While 61.9% of students find the loan terms either "very manageable" or "manageable," some (38.1%) struggle with understanding these terms, indicating a potential gap in transparency or guidance during the loan process.
- **Repayment Terms Satisfaction**: Most respondents feel that the repayment terms are feasible, with 66.7% finding them manageable. However, some students (19%) express concerns about the manageability of repayment.
- **Approval Delays and Complexity**: Over half of the respondents report delays in loan approval, which may deter students from pursuing loans with banks. Additionally, around two-thirds find the loan application process complex, which could indicate an area for improvement in user support and information availability.

SUGGESTIONS

- **Reducing Loan Processing Times**: Given that long processing times are a major challenge for students, banks should consider optimizing their application and approval processes. Implementing digital solutions and reducing redundant documentation could speed up approvals and enhance customer satisfaction.
- **Simplify Documentation Requirements**: Extensive paperwork is another barrier faced by students. Banks could streamline the required documents by consolidating forms, adopting digital signatures, and allowing online submissions to simplify the process.

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- **Enhance Transparency and Communication**: To address difficulties in understanding loan terms, banks should offer clearer explanations and regular updates.

LIMITATIONS OF THE STUDY

- Only two banks (State Bank of India and HDFC) are compared. This limited selection might not fully capture the diversity in educational loan schemes offered by other public and private sector banks.
- Geographic Limitation: The study is conducted within a single geographic area (Assam), which may limit the applicability of findings in regions with different economic conditions or banking policies.
- Evolving Financial Policies: Loan schemes, interest rates, and government subsidies can change frequently. The findings of this study may quickly become outdated if banks adjust their policies in response to market changes or regulatory shifts.
- The data collected through the questionnaire may be subject to self-reporting bias, where respondents may provide inaccurate or socially desirable responses.

CONCLUSION

In conclusion, this study provides a comparative analysis of educational loan schemes offered by public and private sector banks, focusing on the State Bank of India (SBI) and HDFC Bank. The findings reveal that public banks, particularly SBI, are favoured by students for their lower interest rates, flexible repayment terms, and government-backed benefits, making them accessible to a broader range of students. In contrast, HDFC Bank, as a private institution, appeals to those who prioritize faster processing times and flexible loan amounts, despite higher interest rates and stricter eligibility criteria.

Challenges identified include long processing times and extensive documentation requirements, which discourage some students from applying for loans. Additionally, while a majority find repayment terms manageable, a segment of students struggle with understanding loan conditions, suggesting a need for clearer guidance from banks.

Recommendations include streamlining the loan application process, simplifying documentation, and enhancing transparency in communication. Although limited to two banks and a specific geographic area, this study sheds light on the essential differences in educational loan schemes, offering valuable insights for students navigating financial options for higher education. Further research across a broader range of banks and regions is suggested to generalize these findings.

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Chapter- 29: Employment Opportunities through Tourism in Goalpara District of Assam: Prospects and Challenges

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Abstract

With technological advancement in all sectors including communication, tourism is spreading tremendously in the world as a whole. Tourism is not merely a travel for fun rather it also linked with several economic activities that can lead to various employment opportunities. Thus, we can use tourism as a tool for reducing unemployment. This paper will explore how tourism can contribute in unemployment reduction and also explores different tourist attraction points in Goalpara district that can be used for future growth of tourism and help the natives to get good employment opportunities.

Keywords- Tourism, employment opportunity, Goalpara, unemployment, rural tourism.

Introduction

Tourism is travel for enjoying time and engage in activities that give pleasure to human mind. The commercial activities and organisations related to providing and supporting such travels is called tourism industry.

Being a labour abundant country India has been facing unemployment since independence. Government of India have also launched different schemes to promote employment opportunities. Similar to India, Assam is also facing unemployment as an obstacle in the path of development. Government of Assam currently giving importance on developing skills of youth by different schemes so that they can earn money even if they don't get a government job. In this unemployment scenario Tourism being a labour-intensive industry can help to generate employment opportunities and help to reduce unemployment in Assam and as well as in India.

Objective

1. To analyse the various employment opportunities in the tourism industry.
2. To analyse different types of tourism in Goalpara District.
3. To study the prospects and challenges of Tourism in Goalpara Assam

Methodology

This study is descriptive in nature and based on secondary data. This study includes research articles in magazines, periodicals, websites, published books etc and data from Ministry of Tourism, Government of India.

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Review of Relevant Literatures

Pawar (2013) in his research paper "The Possibilities and Strategies for Development of Tourism with Special Reference to Dharwad Gadag and Haveri District" found that tourism provides income and diversification to local communities. Most of the income generated from outside visitors stay within the local economy.

Singha (2013) in his article "Ecotourism for Sustainable Development: A Case Study of Goalpara District in Assam" able to draw an overall view that Goalpara district has immense potentiality for such low impact and sustainable development-oriented tourism.

Katoch (2016) in his paper "The Impacts of Rural Tourism on Local Community Development: A Study of Himachal Pradesh India" observed that large numbers of tourists are coming to Himachal Pradesh for tourism activity. This can be justified by the increase in the figure of the tourists in the statistics on a yearly basis till date.

Das (2017) in his article "The Prospects and Problems of Tourism in Assam" found that the development of tourism industry Assam largely depends upon the formulation of a proper tourism development policy and people's co-operation and consciousness. The High-Powered Shukla Commission has recommended for establishing a North-East Tourist Development Corporation to develop tourism in the region.

Kalita (2024) made a study on "Tourism Entrepreneurship and Its Role in Socio Economic Development of Western Assam". Major findings are the tourism entrepreneurship of Assam is not only a source of visual entertainment but also a significant driver of economic growth. This entrepreneurism plays an important role in creating employment opportunities for both the skill and unskilled workers.

Baishya (2024) studied about "Employment Generation in Context of Eco-Tourism in Assam". Tourism industry in India generates several employment opportunities that positively contribute global economies. Both in rural and urban areas, this industry creates multiple job opportunities across different skill levels.

Tourism & Employment generation

Being a labour-intensive industry, tourism can help to control and reduce unemployment. Tourism can generate huge employment opportunities directly and indirectly. In direct process it generates employment in the form of hotel management teams, travel agencies, cab or rental taxies or two-wheel vehicles, souvenir dealers, local products shopping outlets, vegetable sellers, restaurant staff, tour guide, museums management teams, jobs in protected areas such as national parks, palaces, religious sites, resorts, photographer, jobs in farm houses like cook, gardener and others etc. apart from direct process it also generates employment outside the tourism industry. Tourism indirectly generate employment in the form of activities like restaurant supplies, food delivery, construction companies that builds necessary infrastructure for tourism like road, bridges etc, marketing agencies, accounting services, farming etc. so development of tourism is directly linked with increasing demand in

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other sectors like agriculture, construction etc which will again generate employment in those sectors.

Tourism and Employment: India

The tourism industry is regarded as the foundation for related industries such as hospitality, civil aviation, travel and transportation, hotels, resorts, and home accommodations, street sellers, spice stores, travel companies, etc. Both the federal and state governments make significant investments each year to support the growth of the tourism industry. One of the key factors influencing growth, job creation, rising national and personal income, improving the balance of payments position and foreign exchange revenues, raising people's standard of living and consumption, etc., is the improved tourism industry.

Year	Share in Employment (in %)	Employment (million)
2009-2010	10.17	64.5
2010-2011	10.78	65.6
2011-2012	11.49	66.7
2012-2013	12.36	66.9
2013-2014	11.37	67.21
2014-2015	12.25	69.75
2015-2016	12.38	72.26
2016-2017	12.2	75.34
2017-2018	14.78	72.69
2018-2019	14.87	75.87
2019-2020	13.5	69.44
2020-2021	12.91	68.07
2021-2022	12.66	70.04
2022-2023	12.57	76.17

Source: Ministry of Tourism

The table shows the share in employment in percentage and the actual number of people employed in million through tourism in India from 2009-10 to 2022-23. According to the data, between 10 and 15 percent of India's jobs were continuously generated by tourism. Both the percentage share and employment figures climbed steadily between 2009 and 2016 i.e., from 10.17% to 12.38% which was a result of both direct and indirect growth of jobs due to tourism. Tourism continues to be an important contributor to the employment in India. In 2017–18 and 2018–19, the employment share increased significantly to 14.87%. However, there is a decline starting in 2019–20. The COVID-19 pandemic, which caused serious travel disturbances, lockdowns, and employment losses in hotels, airlines, transportation and other tourism-dependent sectors. The years 2021–2022 and 2022–2023 show signs of the post-pandemic recovery, with employment rising once again to 76.17 million and share in employment started to increase in 2022–2023 but the percentage share of employment through tourism did not entirely return to pre-pandemic levels.

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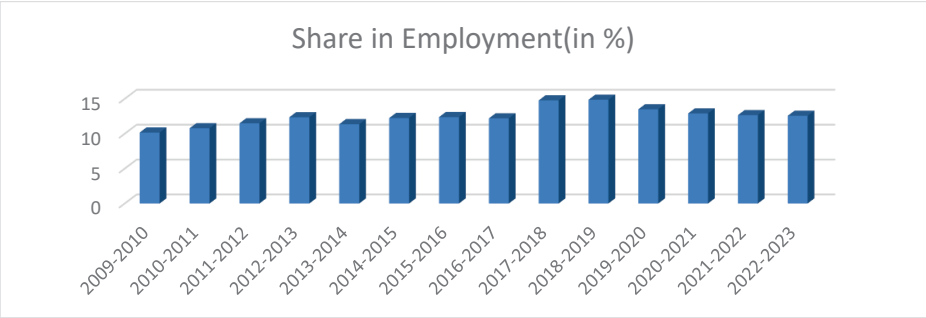

Tourism and Assam

Assam is a region in northeastern India that is rich in both natural beauty and cultural legacy. Assam, one of the states that make up the northeast, is a true representation of the region's natural beauty and grace and has long been acknowledged as a major tourism destination. Both the other states in the North Eastern Region and other regions of the country are easily accessible from Lower Assam, also known as Western Assam. Assam is now well-known throughout the world thanks to its tourism industry, and its wildlife tourism is particularly alluring on a worldwide scale. Credit for this tourism belongs to places like Kaziranga National Park, Rajib Gandhi National Park, Manash National Park, and Rimona National Park, among others.

Tourism in Goalpara

Goalpara is situated in the west part of Assam in the south bank of mighty Brahmaputra. Natural beauty, cultural heritage, religious significance and historical importance make Goalpara a unique district for tourist attraction. Its unique blend of natural sites, archaeological sites, scenic hills with ancient temples, large tribal cultural heritage of Rabha, Bodo, Garo, Hajong and others. All these make Goalpara a potential hub for Tourism in Assam.

The places of Goalpara that attract tourist can be explained as follows –

1. **Nature Tourism:**

Nature-based tourism is mostly associated with natural settings that draw tourists for the purpose of directly experiencing nature. Goalpara has a variety of natural areas that can draw tourist.

- **Nisangram:** It is situated 7 miles from the Dudhnoi subdivision and is among the most scenic spots in Goalpara District. Tourists are drawn to Nisangram mostly by its beautiful scenery, eco-friendly practices, and cleanliness.
- **Urpad Beel:** One of the biggest lakes in lower Assam is Urpad Beel, which is located in the Goalpara district of Agia. It is well-known for aquatic plants like water lilies and birds like kingfishers, and it draws photographers and environment lovers.

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- **Nalonga Waterfall:** One of Goalpara's tourist attractions is the Nalonga Waterfall in Agia. This waterfall is ideal for short trips or a peaceful natural break because it falls over a rock ridge and is surrounded by dense forest.
- **Kumri Beel:** Located in the Goalpara district, Kumri Beel is a naturally occurring lake that draws a lot of tourists, photographers, and environment enthusiasts. The beel is surrounded by 5 villages (about 200 families) of fishers who earn their daily bread from the aquatic resources of the beel.
- **Ajagar Wildlife Sanctuary:** It is another nature-based tourist place located in Badahapur, Goalpara. It focuses on forest area conservation and rich diversity of flora and fauna.

2. **Religious Tourism:** People who travel alone or in groups for religious reasons, like rituals, worship, or the pursuit of peace, are engaging in this sort of tourism. In Assam, Goalpara is a popular destination for religious tourists.

- **Sri Surya Pahar:** Sri Surya, a well-known archaeological site in Assam, is situated roughly 12 kilometers southeast of Goalpara town. It is connected to the worship of Surya, the Sun God. There are many ancient Sculptures, Shivalingas, Buddhist Stupas, Jain Carvings, Modern Sun Temple which attracts tourists.
- **Tukreswari Temple:** This ancient Hindu temple, which is devoted to Sati, is situated in Assam's Goalpara district. This temple's primary draw is its distinctive fusion of historical significance, spiritual value, and a large monkey population.
- **Paglartek Shiva Mandir:** This ancient temple is situated in the Goalpara district's Barbhita village. Tourist can observe the neighbouring Brahmaputra River and explore its cultural legacy.
- **Sri Chaitanya Gaudiya Math:** It is another cultural hub aligned to the Sri Krishna Chaitanya culture, located in Goalpara. It hosts many events and festivals relating to Sri Krishna which attracts many devotees.
- **Nandeswar Devalaya:** On top of Nandeswar Hill, close to the Dudhnoi River, Nandeswar Devalaya is one of the oldest Shiva temples.

3. **Rural Tourism:** In rural tourism, people showcase rural life, handloom, art and craft, raw culture at rural locations and villages in the natural environment. Being naturally beautiful and good connection with their root, most of the villages in Goalpara have the potential to enter in rural tourism. Villages by providing a rural set up for relaxation with all their native resources and by including activities like fishing, farming etc can attract people mostly from cities who want to enjoy few days staying away from city chaos. In Goalpara, a village called Rangsapara which is quite popular as cleanest village of Assam has already showed a real example of rural tourism.
4. **Cultural Tourism:**

Goalpara not just has natural beauty but also it has rich cultural heritage that can attract tourist. It represents unique blend of indigenous traditions, diverse ethnic groups, festivals, cuisine, art, dance, music and spiritual practices. Goalpara is home to tribes like Rabha, Bodo, Hajong, Garo, Koch-Rajbanshi and many other. Each of these communities has own language, dress, dance, music, festival, cuisine, handloom style etc. thus we can say that there

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is great potential for cultural tourism in Goalpara district of Assam. Festivals like Dodan mela, Baikho, Baishagu etc can attract tourist as well.

Challenges

Future planning and implementation in Goalpara, Assam must be done at both the ordinary and management levels. But even if Goalpara's tourism industry needs a lot of work, there are a few issues that must be resolved first. Some of the difficulties are listed below:

1. **Lack of Infrastructure and Transportation:** Like other states of Assam, in Goalpara also, a major problem is the absence of infrastructure and transportation. The majority of the rural areas are still not well connected to the cities for seamless interactions. This causes a disconnect between the potential for tourism in rural areas and the number of travellers who want to go there.
2. **Absence of sufficient trained tourist guid:** This is a big challenge when it comes to tourism in Goalpara, Tourists are often found in a state of confusion without the proper guidance from tourism stakeholders.
3. **Lack of awareness:** Another problem with tourism is that visitors and local communities don't know enough about it.
4. **Lack of decent accommodation facility:** It is another challenge which need to be addressed. Even though we don't anticipate five-star hotels be found in rural locations, there must be enough good hotels or lodging options for visitors to stay.
5. **Weather change:** Climate change is considered a major concern in the travel industry. Because floods, heavy rains, and rising temperatures harm tourism assets and reduce visitor numbers,

Conclusion

Though we have found several challenges but there is strong possibility of Goalpara being a tourism hub in near future due to its natural abundance and archaeological sites. Goalpara is blessed for religion tourism, having ancient sites like Surya pahad, with proper planning and action Goalpara can transform it into a proper tourist place with enough hotels and guides that can attract tourist more. Again, there is a strong possibility of rural tourism and adventure tourism in Goalpara due to its geographical characteristics. Since this district also share boundary with Meghalaya, it also has hills where they can introduce adventure activities like hiking, rock climbing, camping, mountain biking, zip-lining etc. So with help of both public and private stakeholders Goalpara can emerge as a tourist attraction point and can provide various employment opportunities which will eventually lead to unemployment reduction in the state as a whole.

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Chapter-30: Internet Gaming Disorder (IGD) and Social Disconnectedness

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Abstract

Gaming addiction, commonly known as Internet Gaming Disorder (IGD), is a behavioral addiction marked by intense and uncontrollable involvement in video games (overtheinternet), resulting in considerable disruption to daily functioning. Moderate gaming can offer stress relief, enjoyment, and even enhance visual-spatial skills and motor abilities (Granic et al., 2014), as well as improve mental health outcomes (Kowal et al., 2021). Nevertheless, contemporary trends indicate that the emphasis in online gaming has shifted from simple amusement to a potential risk factor (John et al., 2019). Excessive participation in online gaming can negatively affect physical well-being (musculoskeletal pain (e.g., wrist discomfort), mental well-being, and social well-being) and difficulties in interpersonal relationships (Lui et al., 2011; Jeong & Kim, 2011) and feelings of loneliness (Kamal & Wok, 2020; Li, 2023). One of its most profound consequences is social disconnection, loneliness, reduced real-world social interactions, impaired social skills, and strained relationships where individuals prioritize gaming over real-world relationships and social interactions resulting in reduced social activity (Yemima & Purnama, 2024), heightened social anxiety and feelings of loneliness (Niazi et al., 2024), social isolation (Fattah & Othman, 2022) leading to withdrawal from social interactions, strained relationships, and weakened family bonds (Chitra et al., 2023).

Keywords: ***Gaming, Internet Gaming Addiction, Social Isolation***

1. Introduction

Internet Gaming Addiction

As defined by the WHO (World Health Organization, 2020), Gaming disorder classified in the ICD-11 (International Classification of Diseases-11th) is “a pattern of gaming behavior ('digital-gaming' or 'video-gaming') marked by inadequate control over gaming, a growing priority assigned to gaming over other activities to the degree that gaming supersedes other interests and daily responsibilities, and the continuation or intensification of gaming even when negative consequences occur. For gaming disorder to be diagnosed, the behavioral pattern must be serious enough to lead to considerable challenges in personal, familial, social, educational, vocational, or other significant areas of functioning, and it typically has to be apparent for a minimum of 12 months”. Likewise, Mestre-Bach et al. (2023) defined Internet Gaming Disorder as “a continuous and repeated engagement in internet gaming, even in the face of physical or psychological harm”.

In recent years, with the easy accessibility of internet services and the popularity of internet gaming, the number of individuals with internet gaming disorder has increased manifold. In 2021, India reported a notable surge in online gamers, with approximately 390 million, an 8 increase from the prior year, and projections indicating it will surpass 450 million by 2023.

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Of these gamers, around 95 million participated in paid online gaming. Also, the global estimated occurrence of Internet gaming disorder among adolescents has been reported as nearly 8.8% (Gao et al., 2022).

While moderate gaming can offer stress relief, enjoyment, and even enhance visual-spatial skills and motor abilities (Granic et al., 2014). Similarly, certain online gaming applications have demonstrated success in improving mental health outcomes (Kowal et al., 2021) and fostering social connectedness (Bashir et al., 2024). However, current trends suggest that the focus of online gaming has transitioned from mere entertainment to a possible risk factor (John et al., 2019). Also, excessive participation in online gaming has been reported to have deleterious effects on physical health (musculoskeletal pain (e.g., wrist discomfort), mental health, and social health (difficulties in interpersonal relationships) (Lui et al., 2011; Jeong & Kim, 2011). In multiple studies, individuals with gaming addiction exhibit various physical symptoms like dry eye symptoms and pain (Byeon et al., 2022), chest pain, frequent headaches, and poor sleep quality (Ohayon & Roberts, 2021), that contribute to poor social functioning, mental distress, depression (Sitorus et al., 2020; Zabrina, 2023) along with increased psychological stress (Katz et al., 2015). It has also been noted that gamers frequently exhibit emotional and cognitive anomalies, resulting in withdrawal symptoms and declining life satisfaction (Zhang, 2023), psychotic tendencies, sleep disruptions, and difficulties in social adaptation, suggesting a harmful effect on overall mental health (De Pasquale et al., 2020).In a study, Morabito et al. (2021) discovered that people with Internet Gaming Disorder may use excessive gaming to cope with stress and escape from daily troubles, resulting in unhealthy eating habits, social disconnection, withdrawal symptoms, and mood alterations. Moreover, personality factors such as self-control, sensation seeking (Mehroof & Griffiths, 2010), conscientiousness, neuroticism, extraversion, and openness to experience have been observed to serve a significant role in influencing addictive internet gaming (Cole & Hooley, 2013).

2. Internet Gaming Addiction and Social Disconnectedness

According to Lee et al. (2001), social connectedness is defined as “the subjective feelings of belongingness or closeness with others or various social groups, which can be used in intimate relationships such as those with family, friends, and peers, or broader connections to strangers and societal groups”.

With advancements in Internet technology, the concept of social connectedness has evolved; it now encompasses not only face-to-face interactions but also connections formed through

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online networks (Morris et al., 2014; Chen & Schulz, 2016). People who experience high levels of social connectedness tend to feel a strong bond with others, view them as friendly and accessible, and engage actively in social activities, integrating well into social groups (Lee & Robbins, 1995). Conversely, insufficient social connections can result in a range of adverse effects, such as behavioral or health challenges, resulting in depression and anxiety, increased aggression, and intensified feelings of isolation, along with physical symptoms (Rose et al., 2019). In the premises of internet gaming, those struggling with gaming addiction frequently experience symptoms of loneliness (Kamal & Wok, 2020; Li, 2023), social anxiety (Niazi et al., 2024), fatigue, and poor self-esteem (Archana et al., 2019).

Numerous studies have indicated that gaming addiction (IGA) is increasingly recognized as a contributor to social disconnectedness, mainly among adolescents and the young adult population. Findings suggest that disproportionate gaming leads to fewer social interactions and heightened feelings of isolation, as individuals often choose virtual interactions over real-life relationships, and social disengagement is associated with reduced social activity (Yemima & Purnama, 2024). Spending excessive time on social media platforms (over 4 hours daily) can adversely affect health, despite its connection to networked social interactions (Wheatley & Buglass, 2019). Additionally, heavy immersion in virtual gaming environments may lead to a decrease in genuine social connections (Faust & Prochaska, 2018), a restricted social circle, illustrating a reciprocal association between heightened Internet usage and a constricted social environment (Ohayon & Roberts, 2021). Another investigation focusing on PUBG gamers found that gaming addiction correlates with social isolation, indicating that excessive gaming can undermine significant social relationships (Nawaz et al., 2020). The evidence suggests that online gaming addiction considerably detracts from an individual's social skills, leading to social disconnection. Increased gaming frequency is associated with reduced capabilities in communication, relationship cultivation, and conflict resolution, ultimately impacting real-world interactions. Also, online gaming poses a serious problem to a person's capacity to interact with the outside world through efficient communication, forming connections with others, settling routine disputes, and diminishing interpersonal communication outcomes, poor social interaction, decreased social engagement (Tras,2019), social isolation (Fattah & Othman, 2022), social withdrawal, weakened family bonds which in turn exacerbates psychiatric illness like depression and anxiety (Chitra et al., 2023).

As indicated by the research, it can be deduced that excessive gaming on the Internet adversely affects a person's mental, social, and physical health. However, when used in

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moderation, online gaming can reduce stress, boost visual-spatial skills and motor functions, and even enhance mental well-being. In sum, it ultimately depends on the individual how he/she utilize the gaming platforms, so that maximum benefits can be drawn from it.

Suggested Practical Strategies To Tackle Internet Gaming Addiction (IGA):

a) **Monitor and Limit Gaming Duration**
   - Set a timer to restrict your daily gaming (for example, 1-2 hours). Gradually decrease this by 15-30 minutes each week.
   - Allocate specific times for gaming (like 7-8 PM) to prevent impulsive gaming marathons.

b) **Substitute Gaming with Other Activities**
   - Choose a new interest (such as reading, jogging, or painting) to occupy your gaming hours. Dedicate 30 minutes each day to this new endeavor.
   - Participate in community clubs or groups (for instance, hiking or a book club) to foster social interactions.

c) **Alter Your Surroundings**
   - Place gaming devices in less accessible locations (such as a closet).
   - Implement parental control applications, like Screen Time (iOS) or Family Link (Android), to enforce daily limitations.

d) **Address Triggers and Anxiety**
   - Engage in 5-10 minutes of mindfulness or deep breathing exercises each day to mitigate cravings.
   - Tackle stress or boredom through physical activity (such as 20-minute walks) or journaling.

e) **Create a Support Network**
   - Share your goal with a friend or family member for accountability and check in with them weekly.

f) **Turn Real-Life Goals into a Game**
   - Establish small, attainable goals (for instance, complete one task each day) to mimic the rewards found in gaming.

g) **Seek Professional Assistance if Necessary**
   - Reach out to a therapist for Cognitive Behavioral Therapy (CBT) if gaming feels unmanageable.
   - Search for local or online counselors who specialize in behavioral addictions.

h) **Track Your Growth**

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- Keep a record of gaming hours compared to other productive activities each day (using a notebook or app).
- Celebrate achievements (for example, a week with reduced gaming) with a reward like a movie.

3. Chapter Highlights

- Moderate gaming can offer stress relief, enjoyment, and even enhance visual-spatial skills and motor abilities. Similarly, certain online gaming applications have demonstrated success in improving mental health outcomes.
- Excessive participation in online gaming can negatively affect physical well-being, mental well-being, and social well-being.
- Numerous studies have indicated that internet gaming addiction (IGA) is increasingly recognized as a contributor to social disconnectedness, mainly among adolescents and the young adult population. Findings suggest that disproportionate gaming leads to fewer social interactions and heightened feelings of isolation, as individuals often choose virtual interactions over real-life relationships. Social disengagement is associated with reduced social activity, poor social interaction, decreased social engagement, and social isolation.
- Practical strategies to tackle internet gaming addiction (IGA): (1) Monitor and Limit Gaming Duration (2) Substitute Gaming with Other Activities (3) Alter Your Surroundings (4) Address Triggers and Anxiety (5) Create a Support Network (6) Turn Real-Life Goals into a Game (7) Seek Professional Assistance if Necessary and (8) Track Your Growth.

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Chapter-31: Plagiarism and Academic Ethics: Challenges and Solutions in Research

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Abstract

Plagiarism has become one of the most significant issues in educational and research circles across the globe. Plagiarism is the act of presenting another person's ideas, words or intellectual outputs as one's own without giving due credit. Such an unethical approach degrades the authenticity of academic work, taints the reputation of individuals and institutions alike, and undermines the very pillar of trust and originality in education and research. Scholarly ethics, which include honesty, transparency and accountability, are directly opposed to plagiarism. This paper critically discusses the meaning, forms, causes, and effects of plagiarism and the role of scholarly ethics in research. It further discusses preventive approaches such as awareness campaigns, detection software, adequate training in referencing and citation and the influence of institutional policies. The research points out that academic integrity are both an individual obligation and a requirement for systemic change. The debate underscores that although plagiarism is powered by reasons like pressure to publish, ignorance and easy digital access to information, it can be readily checked by ethical research culture, strict enforcement of guidelines, and the promotion of originality. The article concludes by stating that academic ethics should be the guiding philosophy for research, promising innovation, equity, and trust in knowledge generation.

Keywords: Academic Ethics, Plagiarism, Research Integrity, Academic Misconduct, Higher Education

Introduction:

In the modern academic environment, knowledge production and sharing are at the heart of human advancement. Research drives scientific progress, cultural enrichment, and academic excellence. Alas, this lofty endeavour is often riddled with severe challenges that undermine its integrity and authenticity. Plagiarism has risen among them as one of the most formidable dangers. Plagiarism can be generally understood as the unauthorized and unethical borrowing of someone's intellectual property, either in the form of words, ideas or creative work without due credit (Pecorari, 2015). With the speedy development of digital technologies, increased online resources and greater competition within academia, plagiarism has become more widespread and more difficult to manage. Parallel to that, academic ethics has come to the forefront of research practice debates. Academic ethics are the moral codes and professional ethics that direct students, instructors and researchers in creating authentic and reliable work.

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Academic ethics uphold honesty, justice and accountability in academic practice (Resnik,2020). When the ethical rules are disregarded, research loses its authenticity and institutions suffer reputational damage.

This paper has a critical attempt at probing plagiarism and academic ethics through defining the meaning, causes, effects and measures of prevention of plagiarism. It brings to fore the need to adopt ethical practices in academics and presents practical steps for ensuring originality and authenticity in research.

Objectives of the study:

The primary objective of the paper is to define plagiarism, explore its ethical implications and assess its impact on academic integrity. Additionally, the researchers identify the causes and consequences of plagiarism and propose strategies to reduce its occurrence in academic settings.

Methodology:

This study utilizes a descriptive and analytical approach, examining articles, thesis, books and policy documents from reputable sources. It synthesizes ideas and guidelines to address plagiarism prevention and promote academic integrity.

ANALYSIS AND INTERPRETATION:

Plagiarism: Definition and Types:

Plagiarism was derived from the Latin term plagiarius, which means "kidnapper," and it's when one uses somebody else's work or ideas without acknowledging them. This could mean copying words, making use of someone's ideas, or even recycling your own past work without indicating that. Fishman (2016) writes that plagiarism isn't merely about word copying, it's not acknowledging the original individual, which defeats creativity, learning and trust. It is essential to know the kinds of plagiarism because most students and novice researchers unintentionally plagiarize as they don't know how to cite.

Direct Plagiarism: Direct plagiarism refers to when one copies another individual's word-for-word sentences without quotation marks or credit. It is as if stealing an individual's work and passing it off as one's own. Carroll (2007) states that this kind is easy to identify using tools such as plagiarism checkers.

Mosaic Plagiarism: Mosaic plagiarism occurs when a person blends another individual's words or thoughts with their own without crediting them. It's more difficult to recognize since it combines unique and copied content, yet it remains incorrect. According to Pecorari (2013), this usually occurs when individuals do not understand how to paraphrase or omit citations intentionally.

Paraphrasing Plagiarism: Paraphrasing plagiarism occurs when one repeats another author's work in his or her own words but fails to acknowledge the original author. Even if the words are different, the ideas are not their own, hence still plagiarism. Howard (1995) indicates that students tend to do this when they are not aware of how to cite paraphrased work.

Self-Plagiarism: Self-plagiarism is where one repeats their past work without informing anybody that it is not new. This can deceive teachers or readers to believe it's new work. Roig (2006) describes that this violates the guidelines of honesty and originality in school or workplace.

Accidental Plagiarism: Accidental plagiarism occurs when someone does not know citation guidelines or is in error, such as not citing a source. It remains plagiarism, despite not being

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intentional. According to Martin (1994), this occurs frequently with new researchers who have not yet mastered proper citation.

Cyber Plagiarism: Cyber plagiarism is reproducing material from the internet, such as websites or electronic files, without acknowledging the source. It's prevalent because it's easy to reproduce online material. Scanlon (2007) states that the internet has made this kind of plagiarism a serious issue for maintaining academic integrity.

Causes of Plagiarism:

Plagiarism occurs due to various reasons such as school pressures, unfamiliarity with rules or individual challenges. Such factors cause individuals to plagiarize others' work without mentioning credit. Below, every reason is broken down simply to illustrate why plagiarism occurs and how it impacts honesty in schoolwork.

Pressure to Publish: In scholarship, there is a phrase that goes, "publish or perish," meaning scholars have to write numerous papers to be able to advance their careers. Such pressure can cause them to concentrate more on writing numerous papers rather than developing new ideas, sometimes resulting in plagiarism from other people's work. Fanelli (2018) states that such competition may force individuals to plagiarize in order to maintain pace.

Lack of Awareness: Most students, particularly new ones, do not know how to credit properly. They may copy another person's work unintentionally because they have not yet been taught the rules of citation. Martin (1994) raises the issue that novice researchers tend to plagiarize unintentionally because nobody has informed them on how to cite properly.

Digital Access: The internet provides the facility of finding information very easily, and this results in a "copy-paste" behavior. Individuals can easily borrow words or ideas from websites without any acknowledgment, especially when under pressure. Scanlon (2007) states that online content feels cost-free to use, hence more cyber plagiarism.

Poor Time Management: When students are under close timelines, they may be too busy to do their research or write their own material. This may lead them to copy from others as an easy means of completing. Carroll (2007) describes that students who do not plan well may plagiarize in order to meet deadlines despite it being incorrect.

Language Barriers: Individuals who do not use English as their native language can struggle to produce academic writing. To stay away from errors, they could simply copy and paste without referencing. Pecorari (2013) indicates that international students tend to plagiarize due to a difficulty of writing in English.

Weak Academic Integrity Policies: Certain schools lack explicit or strict policies regarding plagiarism, which makes it appear acceptable to plagiarize. In the absence of firm guidelines, scholars and students may not fear plagiarizing. Carroll (2007) states that there must be explicit rules in order to prevent plagiarism and maintain school assignments authentic.

Consequences of Plagiarism:

Plagiarism has severe impacts that extend beyond just penalizing the individual who copies. It hurts students, schools, society and even the mental wellness of individuals involved. Recognizing these impacts reveals why honesty is so crucial in academic work.

For Students and Researchers: When students or scholars plagiarize, they are slapped with severe sanctions such as failing assignments, loss of degrees, or expulsion from school. It can also damage their image, making it more difficult to acquire jobs or to promote in their

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careers. Park (2003) outlines that plagiarism can leave a permanent stain on an individual's scholarly and professional life, since trust is difficult to restore once it has been lost.

For Institutions: Universities and colleges lose out when plagiarism occurs because it causes them to be perceived as less reliable. When cases of plagiarism become known, schools risk losing their good reputation, declining in ratings and losing students' trust, parents' and financiers'. Carroll (2007) adds that institutions with common cases of plagiarism fail to sustain their image of quality education.

For Society: Research plagiarism slows down the pace of progress since it disseminates false or not-so-original ideas, wasting time and resources. When researchers plagiarize rather than develop new knowledge, it ends up producing misinformation that influences society's confidence in science and innovation. Pecorari (2013) points out that plagiarized research erodes the trustworthiness of research which society relies on for progress.

Psychological Impact: Individuals who are caught plagiarizing usually feel stressed, embarrassed, and lose faith in themselves. The feeling of being untruthful and fear of being caught consume them emotionally. Martin (1994) identifies that plagiarism's psychological implications make it more difficult for individuals to have confidence in what they do and in their ability to proceed with their studies.

Scholarly Ethics in Research:

Scholarly ethics are principles of right and wrong that frame the way research and learning is supposed to be done. These principles concentrate on respecting other individuals' ideas, being transparent in conducting research, and being truthful about findings. Resnik (2020) states that scholarly ethics ensure research is equitable and credible, allowing all to count on the knowledge it produces. Following are the major principles of academic ethics presented in a straightforward manner.

Honesty: Honesty is telling the truth about your research, such as the facts you discover and the findings you present. Researchers should never invent data or modify their findings to make themselves look more appealing. Honesty creates trust and maintains research as reliable. Shamoo and Resnik (2015) assert that honesty is the basis for ethical research since it guarantees that the truth is communicated to others.

Trust: Trust is all about ensuring other researchers, students and the public are able to have faith in your research. If researchers are honest and open, they gain confidence in their outcomes. Trust is necessary for collaboration and for individuals to respect research. Steneck (2007) describes how trust in research is developed through consistency and honesty, allowing everyone to trust the work being conducted.

Fairness: Fairness is giving credit to all the people who assist with the research, such as co-authors or individuals whose work you borrow. It's ensuring that no one's work gets overlooked or borrowed. Being fair makes research honest and is a demonstration of everyone's hard work. Israel and Hay (2006) observe that fairness in awarding credit avoids conflicts and aids ethical cooperation in research.

Respect: Respect is about appreciating the diversity of ideas, cultures, and viewpoints in research. Respect entails handling others' work and effort with delicacy regardless of the source. Respect assists in maintaining a conducive learning and discovery environment. Resnik (2020) highlights that respecting intellectual and cultural differences enhances the strength and equity of research.

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Responsibility: Responsibility is ensuring your research is original, accurate, and in accordance with ethical guidelines. Researchers should thoroughly vet their work and not plagiarize others' work without giving them credit. Responsibility guarantees research is reliable and useful. Macfarlane and Saito (2018) point out that responsible researchers are serious about their task to deliver work that helps others without hurting them.

Strategies to Prevent Plagiarism:

There are several strategies to prevent plagiarism in schools and research, ensuring that all do genuine work. These strategies teach students and researchers how to avoid copying and adhere to ethical guidelines. The following are brief descriptions of each strategy to prevent plagiarism.

Awareness and Training: Educating students on research ethics and proper citation by means of workshops, classes, or orientation sessions can assist in making them aware of how to evade plagiarism. These sessions demonstrate how to properly credit others' work. Devlin and Gray (2007) note that an early education of students in ethical writing decreases unintentional plagiarism.

Strict Institutional Policies: Universities and schools must have concise rules against plagiarism, including specific punishments such as failing grades or suspension. Firm policies leave no doubt that copying isn't permitted. Carroll (2007) points out that firm, thoroughly explained rules prevent plagiarism by demonstrating it's serious.

Use of Plagiarism Detection Tools: Software such as Turnitin, Urkund, and iThenticate can scan for plagiarized content by cross-referencing them against other materials. The software assists instructors and scholars to identify plagiarism with ease. Pecorari (2013) describes that detection software makes students provide authentic work, aware that it will be screened.

Promotion of Originality: Empowering students to think critically and write their own thoughts enables them to produce unique work. By paying attention to their own ideas, they depend less on borrowing. Howard (1995) recommends that the process of teaching analytical skills minimizes the necessity to use someone else's work.

Mentoring: Instructors and mentors may assist students in how to conduct ethical research and writing. Individual attention will show students the proper way to reference sources and not make errors. Martin (1994) emphasizes that mentoring is essential for novice researchers to appreciate academic honesty.

Support in Time Management: Allowing students sufficient time to finish assignments or giving flexible deadlines may lower the temptation to plagiarize. When students are not under pressure, they will tend to work on their own. Carroll (2007) also observes that increased support towards managing time prevents students from taking shortcuts such as copying.

Research Ethics Committees: Schools ought to establish ethics boards to oversee academic work and ensure that it adheres to ethical guidelines. The committees can advise researchers and implement honesty. According to Resnik (2020), ethics committees assist in upholding high standards of research by resolving plagiarism problems.

Discussion:

Plagiarism is not just about someone goofing up, it is about a larger problem related to how society and schools operate. Issues like too much pressure to perform, schools doing too little to assist, and the ease of getting online content to copy from make copying appealing. Some societies understand sharing ideas as standard, whereas Western educational institutions are

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concerned with having your own ideas, which makes it difficult to determine what constitutes plagiarism (Sutherland & Smith, 2008). This is whether different cultures should have different rules about plagiarism. But wherever you are, copying damages new ideas and creativity, so it is everywhere an issue. Also, plagiarism checkers can detect copied work, but they can't distinguish between cheaters and people who accidentally cheated, so individuals still must judge what is fair. The aim is to educate all individuals to be truthful and make schools less stressful and more innovative. Good guidance and clear rules can make it easier for honesty to become important.

Conclusion:

Plagiarism is an enormous issue that damages the integrity of schoolwork and scholarship. Plagiarism destroys trust, halts originality and makes schools less credible. Too much stress, lack of knowledge about rules and readily available information online lead to plagiarism, yet individuals and schools have to join forces in doing the right thing. Scholarly ethics, such as being honest, fair and responsible lead us to conduct reliable research. To prevent plagiarism, we must educate individuals with the rules, enforce strict policies, utilize tools that detect copying and advise students well. Above all, research has to be for learning and generating new ideas rather than trying to publish immediately. By incorporating honesty as an important aspect of education, we are able to ascertain that knowledge is actual, reliable and beneficial to all in the future.

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Chapter-32: Management of SDG-3 related Concepts in Class III Environmental Studies Textbook of Assam

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Abstract

This study examines the representation of SDG-3 (Good Health and Well-Being) concepts in the Class III Environmental Studies textbook of Assam, with a focus on preventive health practices, including handwashing, vaccination, and safe drinking water. Using a content analysis method, all ten units of the textbook were analyzed to identify which health-related concepts are present, partially covered, or missing.

The findings reveal that the textbook provides partial coverage of SDG-3 concepts. Units such as Let Us Go to the Garden and Taking Care of the Body introduce nutrition, medicinal plants, exercise, and physical health, while Our Family and Proper Use of Leisure Time address emotional well-being, cooperation, and mental health. Safe drinking water is emphasized in Units 4, 5, and 8, highlighting water sources, pollution prevention, and cleanliness. However, essential preventive health practices, such as handwashing and vaccination, are completely absent across all units. Several units, including About the Sky and Our Village, do not contain any health-related content, reflecting uneven coverage of SDG-3 concepts.

The study concludes that while the textbook encourages general health awareness, environmental hygiene, and emotional well-being, it fails to provide comprehensive guidance on preventive measures critical for child health. Integrating basic practices such as handwashing, vaccination, and first aid education would strengthen the textbook's alignment with SDG-3 and promote a more holistic understanding of health and well-being among young learners. This analysis underscores the need for curriculum enhancement to ensure that primary education equips students with foundational knowledge for both physical and psychosocial health.

Keywords: *SDG-3, Good Health and Well-Being, Environmental Studies, Class III, Preventive Health, Textbook Analysis, Assam.*

Introduction

At 21st century people are busy in innovation, technological practices, making money for searching peace and happiness. Many times, we forget our health and wellbeing due to many reasons. **WHO** describes health as a state of total wellbeing of physical, mental and social aspect; the concept of health is not limited to absence of disease or infirmity. Health is the primary factor of human live and acquiring good health is the fundamental right of every individual. At present, world communities are talking about Sustainable Development Goals; the global commitment tend to ensure safe future by practicing 17 goals. Out of 17 goals the 3rd goal popularly known as SDG-3 is all about "Good health and well-being." For achieving

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this goal by 2030 world communities need to be take some strategies; researches show that awareness through education can be an effective one for accomplish this goal.

***Sustainability and Sustainable Development Goals*:** Sustainability refers fulfilling the present needs without hampering the ability of future generations to fulfil their needs **(United Nations Brundtland Commission, 1987).** Sustainability is a continuous process not the end product. Sustainability simply means sustain the capacity of ecological systems so that our future generation need not to compromise for use. Sustainability is requirement of our present generation to effectively manage available resources so that it must ensure quality life style of both present and future generation **(Asheim, 1994)**. There are three pillars of sustainability i.e. Economic, Social and Environmental which were introduced by the World Summit on Social Development of United Nations held in 2005 (**United Nations General Assembly, 2005**).

The concept of sustainable Development highlights the need to improve our lifestyle without hampering the well-being of future generation **(Lasekan, et al., 2023)**. In general view Sustainable Development includes three interrelated and complimentary approaches i.e. Economic, Environmental and Social development **(Ciegis, et al.,2009)**. The concept of Sustainable Development aims to make balanced among environmental, economic and social components **(Jabareen, 2006)**. These developments must not see as constrains of future generation. Sustainable development is a global commitment to ensure quality human life, living with carrying the capacity of supporting ecosystems (**The International Union for Conservation of Nature**).

Sustainable Development Goals (SDGs): Sustainable Development Goals (SGDs) are the global initiatives to ensure sustainable future for all. The foundation of SDGs laid on **United Nations Conference on Sustainable Development, 20-22 June 2012, Rio de Janeiro**. In the year 2015 all United Nations members took an agenda popularly known as "The 2030 Agenda for Sustainable Development" for ensuring sustainability. 17 SDGs are the heart of this agenda **(Department of Economic and Social Affairs, UN)**. UN member countries intend to achieve these 17 goals by 2030. The 17 SDGs are present below.

Figure:2 Sustainable Development Goals

The government of India also shown positive response towards global initiative 17 SDGs and sign the declaration 2030 agenda on September 2015. In the current report of Sustainable Development Goals Index, India's rank is 109 with overall 63.99 score (**SDG Transformation Centre: Rankings, 2024**).

***Education for Sustainable Development (ESD)*:** Education for Sustainable Development is the recent and emerging concept of education. ESD is the reaction towards challenges facing by our planate. ESD is the deliberate practice for empowering individuals with knowledge,

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skills, values, attitudes and behaviours which is beneficial to our environment, economy, and society. The main vision of ESD is to create a sustainable future through responsible choices **(UNESCO).** Education is the key component of achieving Sustainable Development Goals (SDGs); it breaks poverty, reduce inequalities and gender discrimination, empower all people to healthy and sustainable lives **(United Nations)**. ESD refers incorporating sustainable development issues into teaching and learning process, the suitable topics for inclusion are poverty eradication, peace, justice, human rights, gender equality, ensuring good health, environmental protection, rural and urban development, natural resource management and other SDGs related concepts **(UNECE, ESD strategy)**.

SDG-3 in Environmental Textbook*:** Textbooks are the key components for cultivating knowledge, skills, competencies among learners. ESD is the strategy for achieving SDGs and emphasizes on developing competencies through education. UNESCO provide a guidebook named "Textbook for sustainable development -A guide to embedding***." UNESCO emphasizes on ESD-led curriculum so that world communities achieve SDGs.

In present study, the investigators select the class-III Environment studies textbook i.e. **We and Our Environment; Part I** developed by ***State Council of Educational Research and Training,*** approved by ***Government of Assam*** and published by the ***Assam State Textbook Production and Publication Corporation Limited***, Guwahati on behalf of Govt. of Assam, India. In Assam class-III students study the Environment studies textbook as a core discipline. The textbook tends to develop very basic concepts regarding our lives such as, our surroundings, birds, animals, trees, family components, school components, water body, communication etc. The textbook intends to prepare responsible citizen of the country as well as of globe.

***Review of related literature*: Jeremy, et al. (2017)** argue that social science textbook worldwide plays vital role in transforming various components concerning SDGs. Knowledge, skills can be acquired through social science textbook for achieving 2030 agenda of SDGs. **Nguyen, (2019)** suggest that curricular developer should give emphasis on Education for Sustainable Development related themes while preparing curriculum basically of geography subject. He argues that many times textbook developer give emphasis on one dimension of SDG but it need to be multi-dimensional. **Haque's (2013)** investigate about inclusion of ESD in national curriculum of Bangladesh at primary level. He found that the updated national curriculum and textbook for 1-5 grades sufficiently represent ESD related concepts across various subjects not only on science. **Annamalai, et al. (2025)** found in their study that out of 17 SDGs only some SDGs (SDG7, SDG9, SDG11, SDG13, SDG14, and SDG15) dominated in Malaysian High School English Textbooks. **Ahmad Qabian. et al. (2025)** Conducted a study on "Mapping the representation of four SDGs in international elementary science curriculum and textbooks." They found that the science curriculum framework represents skills and applications for SDG 4 across all four grades. There was a moderate representation of knowledge and understanding and skills and applications for SDG 15, while SDG 6 and SDG 8 were represented minimally or not at all at times. **Muhammad J. et al. (2024)** study explore that Justice, equality, cultural diversity, and ethics have been sufficiently represented throughout the textbook with fewer explanations and discussions on issues that deal with the environment, climate change, responsible economic growth, and institutional frameworks. **Md. Moazzam (2019**) argue that Sustainable development closely

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interrelated with environmental education and has become an important part of education at all levels. We should be responsible for its conservation and protection. Development should be sustainable. Education for Sustainable Development (ESD) is an integral part of quality education as well as an important mean for sustainable development. **Sajjan Choudhuri (2019)** argued that there are a little number of literatures regarding sustainable development initiatives in India and many of the SDGs were remain unexplored by the researchers. Also, concluded by identifying the SDGs of gender equality, reduction in inequality, peace and justice, and responsible consumption and production as the most important research areas for future research of sustainable development initiatives in India.

***Research gap*:** Researchers investigates various research works of concern field. The review indicates that there are very little amount of research works exist in the field of management of SDG-3 related concepts in the textbooks; there are many scopes for further researches in the field of management of SDG-3 in school textbooks. It is seen that there are some researches have done on management of SDGs in Social Science, Science, Mathematics, English language etc. textbooks in other countries. In India a smaller number of studies are done in the concern field.

Existing studies indicates few SDGs such as SDG-4, SDG-6, SDG-8, SDG-15 are potentially reflected on the textbooks and have huge scopes of many studies in the concern field. Investigators found that there is no any proper investigation in understanding the management of SDG-3 related concepts on Environmental Studies textbooks in India. At the current status, there is no research in Assam, India on "management of SDG-3 related concepts in Environment Studies textbook of class-III" SCERT, Assam Textbook

***Significance of the study*:** Education is the process of modifying learners' behaviours in a desired manner. Textbooks are the means of these modifications. Textbooks are the key components of imparting knowledge, skills, competencies among school going learners. In the present study investigators select class-III environmental studies textbook because, the young children (8-9 years old) are the curious one and they are in the initial phase of education, in Indian society this age is called the age of imposing good manners, habits, thinkings, moral sense etc. within our young mind. Most importantly it is the time of rapid brain development and memory capacity. Researchers assumes that this is the right period of imparting, imposing knowledge, skills, competencies needed for good health and well-being.

In school education the textbooks are prepared by prominent authors, experts and educationalist. In Assam, elementary education is run on joined practices of SCERT, Department of Elementary Education, Assam, Directorate of Elementary Education, Assam, State Education Board, Sarva Shiksha Abhiyan. Textbooks are prepared according to the guidelines of National Curriculum Framework for School Education-2023(NCERT) now (Prior NCFSE-2023 National Curriculum Framework 2005 provides the guidelines for textbooks preparation). SCERT and Department of Elementary Education, Assam prepares various textbooks such as, Assamese, English, Hindi and other local languages, Mathematics, Environmental Studies, Social Science etc. Environmental studies are the core subjects from class-I to class-V in Assam. Which incorporates basic concepts regarding our social system, educational institutions, health and hygiene, civic sense, morality, humanitarian values etc. As we know SDGs has different aspects, in the present study the investigators tend to know

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up to what extent the SDG-3 related concepts are represented in Environmental Studies textbook of Claas-III of Assam.

Researches expected that, this study will give insight to educators, policymakers, government and common masses the current status, gap of SDGs in Environmental Studies textbook of class-III of Assam. This study helps further researchers to use it as reference. This study can be beneficial and provide information about SDGs based textbooks as learning materials for class-III students in Assam, India.

***Research questions*:** The researchers formulate the following two research questions-

1. Which SDG-3 concepts are present or absent in the Class III Environment Studies textbook of Assam?
2. How are preventive health practices (e.g., handwashing, vaccinations, safe drinking water) represented?

***Objectives of the study*:** Followings are the objectives of the study-

1. To identify the SDG-3 related concepts that are included or missing in the Class III Environmental Studies textbook of Assam.
2. To analyze the representation of preventive health practices such as handwashing, vaccinations, and safe drinking water in the content of Class III Environmental Studies textbook of Assam textbook.

***Methods and materials*:** Research is systematic study about any phenomenon. Rocco (2011), argue that Research is careful and very systematic investigation of searching new fact or information of any branch of knowledge. It is a scientific process which has some systematic methodologies. For this study, researcher employed qualitative content analysis approach. This approach is frequently used in qualitative research to determine the presence of certain words, themes, or concepts within some qualitative data. To conduct present study, investigators choose qualitative design because investigator tend to describe the research result in the form of words which can lead absolute result in this type of study. Investigators used content analysis which analyze the document (school textbook) rather than student's behavior. The Environmental Studies textbook named "We and Our Environment part-I" developed by *State Council of Educational Research and Training (SCERT),* approved by *Government of Assam* and published by the *Assam State Textbook Production and Publication Corporation Limited*, Guwahati on behalf of Govt. of Assam, India was selected using purposive sampling technique and data were analyzed and interpreted through qualitative content analysis.

***Data analysis*:** In this study, for data analysis, core textbook of class-III named "We and Our Environment part-I" developed by *State Council of Educational Research and Training,* approved by *Government of Assam* and published by the *Assam State Textbook Production and Publication Corporation Limited*, Guwahati on behalf of Govt. of Assam, India has been systematically examined.

Data analysis related to objective No. 1: *To identify the SDG-3 related concepts that are included or missing in the Class III Environmental Studies textbook of Assam.*

Unit 1: Let us go to the Garden: This unit introduces students to various kinds of plants, trees, and herbs through a conversation between the teacher and learners. Both the teacher and students visit a garden, observe the surroundings, and discuss what they see. If students are unable to identify the plants, the teacher helps them. The unit highlights vegetables like

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mustard, spinach, coriander, and mint, as well as fruits that contribute to a healthy life. Importantly, it raises awareness about medicinal plants such as neem, aloe vera, tulsi, and curry leaf tree, emphasizing their benefits and uses. Overall, the unit nurtures young minds with knowledge about plants and the importance of a green environment.
SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Nutrition (fruits, vegetables); Medicinal plants (Neem, Tulsi, Aloe vera, Curry leaves)	Hygiene, sanitation, vaccination, first aid, physical activity, emotional well-being	The focus is on plant-based health benefits but overlooks the broader scope of SDG-3.

Unit 2: Animals Around Us: This unit presents different kinds of animals around us, describing their body structures and ways of living. It begins with aquatic animals like fish, explaining their body structure and respiratory system, and continues with amphibians, terrestrial animals, and many domestic and wild animals such as snakes, lizards, and crocodiles. The unit also introduces birds such as crows, common wagtails, vultures, eagles, ostriches, and penguins, highlighting their habitats and characteristics. Finally, through home assignments, the unit helps students understand the importance of domestic animals in daily life, particularly as food sources.
SDG-3 Analysis Table:

SDG-3 Concepts Present	**SDG-3 Concepts Missing**	**Remarks**
Food sources from domestic animals (milk, eggs, meat)	Hygiene, disease prevention, zoonotic awareness, safe handling of animals	Emphasis is on animal classification and life, with less focus on health connections.

Unit 3: Our Family: This unit focuses on family life, introducing students to different types of families and the importance of family relationships. It emphasizes values such as respect for elders, love and kindness toward younger members, helping those in need, and cooperation among family members. The unit also highlights inclusivity, showing how families interact positively with specially-abled children. Cultural aspects of Assamese tradition are included, such as traditional dishes, bell-metal utensils, and the wearing of Mekhela Chadar. Storytelling, songs, and lullabies by grandparents are used to convey family values and cooperative behavior.
SDG-3 Analysis Table:

SDG-3 Concepts Present	**SDG-3 Concepts Missing**	**Remarks**
Emotional well-being (love, kindness, cooperation, inclusivity toward specially-abled)	Hygiene, nutrition, health practices, preventive health, first aid	Offers a strong psychosocial aspect and promotes harmony and inclusivity.

Unit 4: Taking Care of the Body: This unit emphasizes the importance of health for humans. It covers the necessity of proper foods, fruits, exercises, and playing games or sports. Students learn about different components of food, including carbohydrates, proteins,

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and vitamins, along with their sources. The unit encourages a balanced diet and pure drinking water for sound physical health and highlights the connection between body and mind. It concludes with suggestions on road safety and strategies for waste management.

SDG-3 Analysis Table**:**

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Balanced diet (carbohydrates, proteins, vitamins); Exercise; Games/sports; Pure drinking water; Link between body and mind; Road safety; Waste management	Vaccination, medicinal plants, first aid, harmful habits	Strongest unit for SDG-3 as it covers nutrition, physical health, safety, and environmental health.

Unit 5: Water in Our Daily Life: This unit focuses on the importance of sustaining usable water and water bodies for future generations. It describes human and animal dependence on water and mentions plants like lotus and lily. The unit explains various sources of water such as rain, ponds, canals, lakes, rivers, streams, seas, and oceans. It raises awareness about water pollution, suggests strategies to avoid wasting water, and emphasizes proper use of water in daily life, including managing one-time use water.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Safe water use; Water conservation; Pollution prevention; Proper utilization of water	Hygiene, sanitation practices, health effects of contaminated water	Provides an environmental health perspective with partial connection to SDG-3.

Unit 6: Our Vehicles: This unit introduces learners to various vehicles, including trains, buses, motor cars, autorickshaws, aeroplanes, boats, ferries, bicycles, and bullock carts, explaining their uses in daily life.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Road safety (implied through transport knowledge)	Physical health, pollution and respiratory effects, accidents, first aid	Limited direct connection to health.

Unit 7: About the Sky: This unit begins with a poem emphasizing the aesthetic views of the sky at different times of the day. It introduces the eight planets, the solar system, the Earth's natural satellite (the Moon), and other members of the solar system. The unit also includes historical events, such as the Moon landing by Neil Armstrong, Edwin Aldrin, and Michael Collins, and mentions planetariums in Guwahati, Jorhat, and Kokrajhar.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
None directly related	All SDG-3 concepts	Purely science and astronomy based.

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SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
	absent	

Unit 8: Our School: This unit describes a model and ideal school where teachers and students maintain cordial relationships, with cooperation from villagers. It emphasizes good sanitation, drinking water facilities, playgrounds, gardens, and wide, scientific classrooms. The unit also introduces measurement tools like thermometers, barometers, and weighing scales, explaining their daily uses.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Sanitation and clean drinking water; Playground (physical activity); Teacher-student cordial relations (mental well-being)	Nutrition, vaccination, first aid, harmful habits	Offers partial coverage of SDG-3, focusing on infrastructure and well-being.

Unit 9: Proper Use of Leisure Time: This unit emphasizes creating a happy mind and a fit, healthy body, and encourages harmony among friends through playing games. It suggests strategies for proper leisure activities, such as reading, helping at home, writing letters, planting and caring for flowers, participating in quizzes, and watching or listening to appropriate media. The unit also warns about the harmful effects of excessive mobile phone and TV use on health.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
Physical health (games, sports); Mental health (happy mind, harmony among friends); Harmful effects of excess mobile or TV use	Nutrition, hygiene, first aid, vaccination	Highlights important psychosocial health aspects and balances physical and emotional well-being.

Unit 10: Our Village: This unit introduces learners to the living styles of towns and villages, explaining the structure of cities, towns, and villages. It describes local governance bodies such as the Gaon Panchayat, town committees, municipalities, and municipal corporations, along with their heads.

SDG-3 Analysis Table:

SDG-3 Concepts Present	SDG-3 Concepts Missing	Remarks
None directly related	All SDG-3 concepts absent	Focuses on civic administration rather than health.

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Data analysis related to objective No.2: *To analyze the representation of preventive health practices such as handwashing, vaccinations, and safe drinking water in the content of Class III Environmental Studies textbook of Assam textbook.*

Units	Handwashing	Vaccination	Safe Drinking Water	Remarks
Unit 1: Let us go to the Garden	Absent	Absent	Absent	Hygiene indirectly implied, but no explicit guidance.
Unit 2: Animals Around Us	Absent	Absent	Absent	No preventive health instructions.
Unit 3: Our Family	Absent	Absent	Absent	Focus on emotional well-being; preventive health absent.
Unit 4: Taking Care of the Body	Absent	Absent	Present	Clean drinking water mentioned; handwashing and vaccination missing.
Unit 5: Water in Our Daily Life	Absent	Absent	Present	Safe water sources and pollution awareness highlighted; no direct link to disease prevention.
Unit 6: Our Vehicles	Absent	Absent	Absent	No coverage of preventive health.
Unit 7: About the Sky	Absent	Absent	Absent	Science-focused unit; preventive health absent.
Unit 8: Our School	Absent	Absent	Present	Clean drinking water in school mentioned; handwashing and vaccination missing.
Unit 9: Proper Use of Leisure Time	Absent	Absent	Absent	Focus on mental and physical well-being; hygiene practices not covered.
Unit 10: Our Village	Absent	Absent	Absent	Focus on civic administration; preventive health absent.

Discussion and findings: The analysis of the Class III Environmental Studies textbook of Assam revealed that SDG-3 (Good Health and Well-Being) concepts are unevenly represented across units:

- Nutrition and medicinal plants are addressed in Unit 1 through the discussion of vegetables, fruits, and herbs like neem, tulsi, and aloe vera.
- Emotional well-being and social health are highlighted in Units 3 and 9, focusing on family bonding, cooperation, kindness, and proper leisure activities.
- Physical health, exercise, and balanced diet are well-covered in Unit 4, which also addresses water, waste management, and road safety.

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- Safe drinking water is included in Units 4, 5, and 8, while handwashing and vaccination are absent across all units.
- Some units, such as About the Sky (Unit 7) and Our Village (Unit 10), have no direct health content.

Overall, the textbook provides partial coverage of SDG-3, focusing more on nutrition, physical activity, and emotional well-being, while preventive health practices and other crucial components remain underrepresented. The analysis of the Class III Environmental Studies textbook of Assam also reveals that preventive health practices are inadequately represented. While safe drinking water is partially addressed in Units 4, 5, and 8, critical practices such as handwashing and vaccination are completely absent. This indicates a significant gap in early health education, as children are not provided with foundational knowledge about simple yet essential preventive measures.

Conclusions: The Class III EVS textbook of Assam successfully introduces children to several aspects of health, including nutrition, physical activity, and emotional well-being. However, critical preventive health practices such as handwashing and vaccination are absent, and some units completely omit health content. To fully align with SDG-3, the textbook requires enhancement in hygiene, preventive health, and disease awareness, ensuring that young learners acquire a balanced understanding of health and well-being.

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Chapter-33: An exploration of the major causes of stress among students and the role of parents and teachers in its management

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Abstract

Academic stress is a prevalent issue affecting students and teachers, with significant implications for mental health and performance. This study explores the causes of academic stress, emphasizing the roles of students, educators, and parents. For students, academic stress stems from high expectations, competitive environments, and overwhelming workloads, often exacerbated by societal pressure to excel. Teachers face stress due to excessive workloads, unrealistic administrative demands, and the pressure to ensure student success, which impacts their well-being and teaching quality.

Parents, while well-meaning, can inadvertently contribute to this stress by imposing high expectations or neglecting to provide adequate emotional support. The lack of effective communication between parents, students, and educators often worsens the situation. Additionally, the rise of digital education and social media amplifies stress through constant connectivity, comparison, and distractions.

The paper highlights the critical role of parents in mitigating academic stress. By fostering open communication, setting realistic expectations, and emphasizing holistic development over mere academic success, parents can create a supportive environment. Encouraging time management, healthy habits, and resilience among students further alleviates stress. Teachers, supported by professional development and institutional policies, can also adopt stress-reducing strategies such as differentiated instruction and mindfulness practices.

The findings underscore the importance of a collaborative approach involving parents, teachers, and institutions to address academic stress, promoting a balanced and supportive educational ecosystem.

1. Introduction:

Stress among students has become a significant concern in today's demanding educational landscape, where academic pressures, social dynamics, and personal goals intersect. This stress can arise from various factors, including heavy assignments, competitive environments, and the pursuit of higher education. In this context, both parents and teachers play vital roles

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in alleviating these pressures and promoting a healthier balance in students' lives. Parents are essential in providing emotional support and fostering open communication. By creating a nurturing home environment that emphasizes mental well-being, parents can help students feel comfortable sharing their worries. It's important for them to recognize signs of stress and engage in meaningful conversations about academic challenges and personal aspirations, reinforcing that self-worth is not solely based on academic achievements. Encouragement, rather than imposing unrealistic expectations, can empower students to manage their time wisely and seek assistance when needed.

Teachers also have a crucial responsibility in addressing student stress. An empathetic and understanding approach can create a supportive classroom atmosphere conducive to learning. By implementing strategies such as flexible deadlines, group projects, and mindfulness activities, teachers can help alleviate academic pressure. Additionally, incorporating social-emotional learning into the curriculum equips students with vital skills for managing stress and building resilience. Teachers can serve as mentors, guiding students through their academic paths while emphasizing the importance of balancing work and personal time.

Collaboration between parents and teachers is essential; maintaining open communication channels allows for a cohesive approach to supporting students. Regular meetings, workshops, and feedback can help parents and educators align their strategies, ensuring that students receive consistent messages about mental health and well-being. In this collaborative framework, students can learn to prioritize self-care, acknowledge their limits, and understand that seeking help is a sign of strength. By establishing a supportive network at home and school, the negative effects of stress can be reduced, enabling students to excel both academically and emotionally.

Ultimately, it's crucial to shift the focus from merely achieving academic success to also include well-being, ensuring students are prepared not only for exams but also for a balanced and fulfilling life. This comprehensive perspective is vital for building resilience in the face of challenges and fostering a healthier educational environment for future generations.

2. Objectives of the Study-

- Identify primary factors contributing to student stress.
- Examine the role of parents in managing student stress.
- Examine the role of teachers in managing student stress.
- Investigate the role of parent-teacher communication in student support.
- Develop effective strategies for parents and teachers to support students.

3. Methodology-

For the present study, qualitative research based on literature study involves a systematic analysis of existing texts to explore themes, concepts, and patterns within a particular field. This methodology allows researchers to gain insights from various sources, such as books, journal articles, and reports, enabling a deeper understanding of a topic without direct data

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collection. By critically reviewing and synthesizing literature, researchers can identify gaps in knowledge, contextualize findings, and generate new theoretical perspectives. This approach is particularly valuable in areas where empirical research may be limited, offering a comprehensive view of existing knowledge while informing future research directions.

4. Review of Related Literature-

1. Reddy et al. (2019) aimed to identify the major causes of stress among students, focusing on academic pressures, social dynamics, and family expectations. The study sought to understand how these stressors impact students' mental health and academic performance. The findings revealed that high academic workload, competition among peers, and parental expectations were significant contributors to student stress. Students reported feeling overwhelmed, leading to anxiety and reduced academic performance (Reddy et al., 2019).

2. Mason and Kim (2020) investigated the specific roles of parents and teachers in managing student stress. They aimed to evaluate effective communication strategies and support systems that can alleviate stress. The study found that students who experienced strong support from both parents and teachers reported lower stress levels. Open communication and active involvement from parents, combined with supportive teaching practices, were effective in helping students navigate academic pressures (Mason & Kim, 2020).

3. Cohen and Janicki (2021) explored the effects of social relationships on student stress. The researchers aimed to determine how peer dynamics and family support systems contribute to students' overall stress levels. The study highlighted that positive peer relationships and strong familial support significantly mitigate stress. Students who felt connected to their peers and received emotional support from parents demonstrated better coping strategies, resulting in lower anxiety levels (Cohen & Janicki, 2021).

4. Thompson et al. (2022) examined the impact of parental involvement on student stress management, focusing on communication and emotional support strategies. Their research showed that parental engagement, including regular check-ins about academic pressures, led to reduced stress. Students whose parents were involved in their education reported feeling more secure and less anxious, which improved their academic performance and emotional well-being (Thompson et al., 2022).

5. Smith and Jones (2023) investigated the role of teachers in creating supportive classroom environments to manage stress. The objective was to assess the effectiveness of specific teaching strategies aimed at reducing student anxiety. The findings indicated that teachers who implemented flexible teaching methods, such as differentiated instruction and stress-relief activities, significantly reduced student stress levels. Students felt more valued and less pressured, leading to a more positive learning environment (Smith & Jones, 2023).

5. Discussion and Findings-

1. PRIMARY FACTORS CAUSING STUDENT STRESS-

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- Academic Pressure: The increasing demands of academic performance are a significant source of stress for students. The pressure to achieve high grades, excel in standardized tests, and meet college admissions requirements can create an overwhelming burden. Many students feel compelled to maintain perfect GPAs and engage in advanced coursework, which often leads to excessive workloads. This relentless focus on academic excellence can result in anxiety, sleep disturbances, and burnout, ultimately affecting their overall well-being.

- Time Management Challenges: Students frequently struggle with balancing their academic responsibilities with extracurricular activities, part-time jobs, and social lives. Poor time management can exacerbate stress as students juggle multiple commitments. When they fail to allocate time effectively, they may experience last-minute cramming for exams or rushed completion of assignments. This chaotic schedule can lead to feelings of inadequacy and increased anxiety, making it difficult for students to feel in control of their lives.

- Social Pressure and Peer Relationships: Navigating social dynamics can be another significant stressor for students. Adolescents are particularly sensitive to peer opinions, and the fear of social rejection can lead to anxiety and low self-esteem. Additionally, competition among peers for popularity or social status can exacerbate feelings of inadequacy, making it challenging for students to establish and maintain healthy relationships.

- Family Expectations: Parental expectations can heavily influence a student's stress levels. Many students face pressure from their families to excel academically and pursue specific career paths. This expectation can lead to a fear of disappointing parents, which heightens stress and anxiety. When students feel they are not meeting these expectations, it can result in feelings of shame and inadequacy, further complicating their emotional landscape.

- Financial Concerns: The financial burden associated with education, including tuition, textbooks, and other fees, can significantly contribute to student stress. Many students worry about accumulating debt or the financial strain on their families. Concerns about affording college and potential job prospects can create anxiety, as students grapple with the reality of their future financial situations. This stress can distract them from their studies and lead to feelings of hopelessness.

- Transition and Life Changes: Life transitions, such as moving to a new school, entering college, or dealing with family changes (like divorce), can introduce significant stress. These changes often require students to adapt to new environments, expectations, and social circles. The uncertainty and anxiety that accompany these transitions can overwhelm students, affecting their academic performance and emotional health.

- Mental Health Issues: Pre-existing mental health conditions, such as anxiety disorders or depression, can exacerbate stress levels in students. Those already struggling with mental health challenges may find it increasingly difficult to cope with academic pressures and social expectations.

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• Technology and social media: Constant exposure to curated images of peers' successes can create unrealistic standards and feelings of inadequacy. Cyberbullying, online harassment, and the fear of missing out (FOMO) can lead to heightened anxiety and loneliness. Students may find it difficult to disconnect, leading to increased feelings of stress and overwhelm.

In summary, the primary factors contributing to student stress encompass a range of academic, social, familial, and personal challenges. Understanding these factors is essential for developing effective strategies to support students in managing their stress and fostering a healthier, more balanced educational experience. By addressing these issues, educators and parents can work together to create environments that promote resilience and well-being among students.

2. Role of Parents In Managing Stress Of Students-

Parents play a crucial role in managing student stress and anxiety, significantly impacting their children's emotional well-being and academic success. Here are some key aspects of this role, elaborated for a deeper understanding in the following discussion-

• Emotional Support: Providing a nurturing environment where children feel safe to express their emotions is essential. When parents actively listen and respond empathetically, it helps students feel validated and understood. This supportive dynamic reduces feelings of isolation and encourages open sharing of worries, allowing parents to guide their children through difficult moments.

• Open Communication: Fostering an environment of open dialogue about academic pressures and personal challenges is vital. Parents who encourage their children to talk about their experiences help build trust and make it easier for students to articulate their stressors. This collaborative approach allows families to explore potential solutions together, strengthening the parent-child bond.

• Setting Realistic Expectations: It's important for parents to communicate high yet achievable expectations. By emphasizing the value of effort, perseverance, and personal growth rather than solely focusing on outcomes, parents can alleviate the pressure that often accompanies academic performance. This mindset fosters a healthier attitude toward success and helps children develop resilience in the face of challenges.

• Encouraging Balance: Promoting a well-rounded lifestyle that includes leisure activities, hobbies, and quality family time is crucial for managing stress. Parents can help their children create a balanced schedule that prioritizes not only academic responsibilities but also opportunities for relaxation and fun. This holistic approach prevents burnout and nurtures overall well-being.

• Identifying Signs of Stress: Parents need to be vigilant and observant of behavioural changes that may indicate stress. Signs such as withdrawal from activities, changes in sleep patterns, or a decline in academic performance can signal underlying issues. Early

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recognition of these signs enables parents to intervene promptly and provide the necessary support, preventing more severe anxiety from developing.

- Promoting Coping Strategies: Teaching children effective coping mechanisms is a key aspect of stress management. Parents can introduce mindfulness practices, relaxation techniques, and problem-solving skills, empowering their children to handle stress more effectively. Engaging in activities like physical exercise, creative pursuits, or spending time in nature can also serve as valuable outlets for stress relief

- Collaborating with Schools: Building partnerships with teachers and school counselors enhances the support system for students. By staying informed about their children's academic environment and stressors, parents can work together with educators to address specific challenges. This collaboration fosters a more supportive school atmosphere and helps students feel cared for both at home and in school.

- Modelling Resilience: Parents who demonstrate resilience in their own lives can impart valuable lessons to their children. Sharing personal stories about overcoming obstacles and coping with stress can provide practical examples for students. This modelling encourages children to adopt a similar resilient mindset when faced with their own challenges.

- Seeking Professional Help: If stress and anxiety become overwhelming, parents should not hesitate to seek professional assistance. Mental health professionals, such as counselors or therapists, can provide specialized support tailored to the needs of both parents and children. This proactive approach ensures that students receive the guidance necessary to navigate their emotional struggles effectively.

By actively engaging in these strategies, parents can create a nurturing and supportive environment that significantly aids in managing student stress and anxiety, ultimately promoting healthier emotional development and academic success.

3. Role of Teachers in Managing Stress Of Students-

Teachers play a pivotal role in managing student stress, significantly impacting their emotional well-being and academic success. In today's fast-paced educational environment, where academic pressures and social dynamics can lead to heightened anxiety, teachers are uniquely positioned to create supportive and nurturing classroom atmospheres.

- Fostering a Positive Classroom Environment

Teachers play a crucial role in creating a safe and inclusive classroom where students feel comfortable expressing their thoughts and feelings. By promoting collaboration and open communication among peers, educators can cultivate a sense of belonging that reduces anxiety. A supportive environment allows students to engage more freely in learning activities, fostering resilience and reducing the fear of judgment.

- Implementing Effective Teaching Strategies

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Adopting differentiated instruction is essential for accommodating diverse learning styles and paces. By tailoring lessons to meet individual needs, teachers can prevent students from feeling overwhelmed by material that is either too challenging or too easy. Additionally, providing flexible deadlines and opportunities for revision can help alleviate academic pressure, allowing students to focus on mastering content rather than merely completing assignments.

- Integrating Mindfulness Practices

Incorporating mindfulness exercises into the curriculum can significantly benefit students' mental health. Activities such as deep breathing, guided meditation, or brief moments of reflection can help students manage stress and improve their focus. These practices not only reduce immediate anxiety but also equip students with tools they can use in various situations, fostering emotional regulation and well-being.

- Developing Coping Strategies

Teachers can empower students by teaching them effective coping mechanisms. Providing resources on time management, study skills, and stress reduction techniques equips students with practical tools to navigate academic challenges. Workshops or seminars that focus on these topics can further enhance students' abilities to manage stress, leading to improved academic performance and emotional health.

- Building Strong Relationships

Establishing strong, trusting relationships with students is vital in managing their stress levels. When teachers show genuine interest in their students' lives, both academically and personally, they can better identify signs of stress or anxiety. Regular check-ins and one-on-one conversations create an atmosphere of trust, making it easier for students to seek help when needed.

- Collaborating with Parents

Effective collaboration with parents enhances the support system for students. By keeping parents informed about classroom dynamics and individual progress, teachers can foster a more holistic approach to student well-being. Encouraging parental involvement in education ensures that students receive consistent messaging and support, both at home and in school.

- Modelling Healthy Behaviour

When educators practice self-care and manage their own stress, they set a positive example for students. Demonstrating healthy coping strategies encourages students to adopt similar behaviours, promoting a culture of well-being within the classroom.

- Providing Emotional Support

Being approachable and available for students who need guidance is a fundamental aspect of a teacher's role. Creating an atmosphere where students feel comfortable seeking help is

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essential for their emotional development. Teachers who actively listen and provide support can make a significant difference in how students cope with stress.

- Promoting a Balanced Curriculum

A balanced curriculum that includes both academic rigor and creative or recreational pursuits can help alleviate student stress. Recognizing and celebrating diverse talents beyond traditional academics encourages a more holistic educational experience. This approach allows students to explore their interests, reducing pressure and enhancing overall well-being.

By implementing these strategies, teachers can significantly contribute to managing student stress and fostering a supportive educational environment, ultimately promoting students' emotional resilience and academic success.

4. The Role of Parent-Teacher Communication in Student Support -

Effective communication between parents and teachers is essential for supporting student success and well-being. When parents and teachers maintain open lines of communication, they create a collaborative environment that allows them to share valuable insights about a child's academic performance, emotional health, and any challenges the child may face. By keeping parents informed about school activities, academic expectations, and potential stressors, teachers enable parents to offer better support at home, reinforcing the same messages their children receive in school. Regular updates through meetings, emails, or school platforms facilitate active parental involvement, allowing for timely interventions when issues arise.

1.Regular Updates

Teachers should send updates regularly. This can be through newsletters, emails, or apps. Keeping parents informed about class activities and their child’s progress is crucial.

2.Personalized Communication

Teachers should address specific student needs in their communication. This approach helps build a stronger connection with parents.

3.Parent Meetings

Teachers should schedule regular meetings. Both formal and informal meetings are important to discuss a student’s progress and ways to improve.

1. Initiate Contact

Parents should feel encouraged to contact teachers about their child's progress or any concerns. Initiating contact helps keep the lines of communication open.

2. Participate in School Activities

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Parents should be involved in school events and meetings. This involvement shows they care about their child's education and helps strengthen their relationship with teachers.

3. Provide Feedback

Parents can give feedback about their child's home life. This feedback helps teachers understand and support the student better.

In summary, effective communication between parents and teachers is key to a successful education. It improves the student's learning experience, helps parents feel confident, and gives teachers useful insights. As we use better communication methods, the chance to improve student success through strong parent-teacher relationships is significant.

6. EFFECTIVE STRATEGIES FOR PARENTS AND TEACHERS TO SUPPORT STUDENTS:

Practice self-care: This includes eating healthy food, getting enough sleep, exercising, and taking time to relax.

Manage your time: Plan your time and break tasks down into smaller, more manageable chunks. You can also write down your assignments and exams in a planner or on your phone.

Practice mindfulness: This can include deep breathing, meditation, or aromatherapy.

Take a break: Step away from the situation and focus on something you enjoy.

Practice positive self-talk: Learn to be supportive of yourself and cut yourself some slack.

Talk to someone: You can talk to a friend, tutor, or someone in your family about your stress.

Consider counseling: If stress is still getting to you, you can consider asking for help from counseling services

7. Conclusions

Stress is an inevitable part of life, but managing it effectively is crucial for maintaining both physical and mental well-being. Implementing stress management strategies such as mindfulness, exercise, time management, and healthy coping mechanisms can help reduce the negative impacts of stress. Regular physical activity not only improves overall health but also releases endorphins, which naturally reduce stress. Practicing mindfulness techniques, like meditation and deep breathing, allows individuals to stay present and manage their emotional responses more effectively. Time management skills, such as prioritizing tasks and setting realistic goals, help minimize the feeling of being overwhelmed.

Additionally, cultivating a support network of friends, family, or professionals can provide emotional relief and offer alternative perspectives during stressful times. Identifying stress triggers and learning how to address them, whether through relaxation or problem-solving, is also essential. Ultimately, recognizing that stress is a natural response and finding

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personalized strategies to manage it allows individuals to lead a more balanced and productive life. By adopting these strategies, people can not only cope with stress but also build resilience, improving their capacity to handle future challenges.

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Chapter-34: A Study on Marriage Among the Tiwa's of Sidhabari Village, Morigaon District, Assam

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Introduction

The Tiwas or the Lalungs are scheduled tribe of Assam belonged to the Indo-Mongoloid ethnic race. The Tiwa community has a mythological and historical origin and migration. Some of the scholars claimed that the Tiwa people are group of Tibeto-Burmese tribe. They came down through the course of the Brahmaputra and settled in different parts of Assam. They were later pushed to the present area of habitation by other tribes probably during the Kamata period. According to Sarma Thakur (1985) "The River Brahmaputra rescued or gave shelter to the Bohemian people, hence they were known as Lalungs. The Tiwas are divided basically into two sub-groups as Hill Tiwas and Plain Tiwas. Hill Tiwas lives in the westernmost areas of Karbi-Anglong as well as in the north eastern corner of Ri-Bhoi district of Meghalaya. They are divided into several clans recognized by specific names .In the plains, Tiwa concentrations are mainly found in the districts of Nagaon and Morigaon in Central Asaam. They are spread in Morigaon, the Revenue Circles of Nagaon, Kaliabar, Lanka, Raha, and Kampur in Nagaon district, and the South Tribal Belt of Sonapur. According to Sharma Thakur (1985: 66), originally, they had only twelve clans which are as followed: Amehong, Amfli, Chalang, Dafor, Damong, Kakhor, Radu, Lasa, Lorom, Macharang, Madur,Maloi, Sukai. These clans are further subdivided into various sub-clans. The mainstay of the Tiwa economy, both in the hills and plains, is agriculture.The Tiwas worship different gods and goddesses but their supreme deity is Lord Mahadeo or Fa Mahadeo. The most important festivals are the three Bisus, Sagra ,Misawa, and Jon Beel Mela etc. The three Bihus, Bohag Bihu, Magh Bihu and the Kati Bihu, which are the state festivals of Assam, are celebrated by the Tiwas as Bisu.

Marriage in every human society that we know is a complex cultural phenomenon which ensure that continuance of the family and other grouping based on kinship.Marriage has been defined as a "union between a man and a woman such that children born to the woman are recognized as legitimate offspring of both parents "(Notes and Queries in Anthropology,1951:110). Marriage is also defined as "a recognized relationship between male and female which is expected to result in the establishment of a domestic unit consisting of both parents and their children. Obviously everywhere this domestic unit is not the same". It is an established union for starting of a family and their children born out of the union are legitimate offspring.Thus marriage is a social contract for the satisfaction of physical, biological, economic, and spiritual needs of male and female leading to the formation of a family. The important functions of the marriage are procreation,social andeconomic function and fulfilment of sexual urge.

Objectives: To study the marriage system among the Tiwa tribe.

Methodology:

In order to fulfil the objective of the study data has been collected from the village Sidhabari of Morigaon district.The paper is based on both primary data and secondary source.The methods and techniques used in the data collection are interview , observation and case study.

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Findings:

Sidhabari village is located 5kms away from Nagaon Town which comes under the jurisdiction of Morigaon District.The total number of population of the village is 1140.Among this 564 are males and 576 are females.The total number of family in the village is 213.Agriculture is the main source of income. The people of the Sidhabari village describe their concept of marriage, as it has been universally described. They consider marriages as a universal bondage which binds two individuals of opposite sex and admits into a family life.

Marriage is also a set of cultural patterns to sanction parenthood and to provide a stable background for the care and rearing of children. Apart from this, they are more or less dependent upon cooperation and division of labour between the two sexes, and marriage an institution that help in these aspects permanently. Among them marriage is an elaborate process which involves many rituals and traditions and heavy expense so, many families prefer marriage by elopement due to unsound economic status but they have preserved many of traditional rituals.The concept of marriage among the Tiwas of Sidhabari village is monogamous in which one man marries one woman at a time. It is the most prevalent marriage. A man can have second wife after the death of his first wife. Widow and widower can marry for the next time if they want. There is no social stigma but their marriage does not involve any big ceremony. They strictly follow incest taboo and clan exogamy in which they can't marry within their clan members because they consider themselves as siblings. Great importance is attached to this rule and those who break it and marry within their own clan are considered to have committed a social sin.

Among them, marriage is usually accompanied by a ceremony, except in the case of elopement. However, there is much variation in the style of these ceremony mainly depending upon economic status of the party involved in the marriage. Among them we found *Borbiya*, *Poluai Ana Biya*, *Gobhia Rakha Biya*, *Juron Biya* – are the forms of marriage. In the village another form of marriage is found which they called as "*Burha Biya*". It is a kind of marriage which is prevalent mostly among them. This type of marriage is done after elopement. Without the performance of "*Burha Biya*" a married couple will not get social recognition. The villagers discourage divorce and as such divorce case is very rare. Bride price is prevalent but it is very nominal. Mainly they practiced patrilocal residence but in some cases matrilocal residence is also found where boy resides at his wife's house after marriage. As among the Tiwas of Sidhabari village we found that after the performance of *Paluai Ana Biya,* they perform *Burha Biya* which is said as same as *Bor Biya*. But in some cases, we found that they performed *Choklong biya* which is also called as *Athukora Biya*. Where one performs the marriage in front of the clan members. The married couple wear new dresses, and offer *tamul paan* (betel ana betel leaf) with an amount of Rs.50 in a *sarai* (dish with a stand) and took *ashirwaad* (blessings) in front of the samaj.

Among the Tiwas of Sidhabari village we find different types of marriage. They are *Borbiya, Paluai Ana Biya, Gobhia Rakha Biya, Juron Biya, Choklong Biya, Burha Biya.*

***Paluai Ana Biya*:**

Paluai Ana Biya by elopement is widely prevalent among the Tiwas of the Sidhabari village. Most of the families try to avoid the irksome procedure of a formal marriage although they have eagerness to solemnize formal marriages. The main reason to perform this kind of marriage is the less expenditure involved in the elopement marriage. Besides love at first sight, it is one of the major causes for solemnizing *Paluai Ana Biya*. In this case the boy and the girl decide, and are not sure whether their

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parents will agree to their marriage. So, the boy takes away his beloved to his residence at night with the help of his friends. Next day two or three relatives of the boy informs the girl's house and informs the girl's father about the matter. After seven days, they perform a ceremony called *Mitir Khuwa*. The married couple go to the bride's home with groom and other family members. On this day the groom's family have to take some things with them, the list of the things is given by the bride's family on that day in which the boy's relative informed the girl's father about the matter. The list of the things includes '*Zu*' one *jari*, t*amu*l 5 poon, pan 20 *guch*i, '*Lowpiya*' (vessel containing ricebeer), one basketful of *pitha* (rice cakes), *urahi pitha* (made of Bora chawl, Sali chawl). All these things are arranged in two baskets one side containing *pitha* and other side is the jar of *lowpani* and all these things are covered by one "*Uka seleng kapoor'* (white handwoven cloth) The *Bhar* is carried by the '*Bharwa'* who take the things to the bride's home. *'Bharwa'* is followed by the elderly members of the groom, some villagers and the bride and the groom.

The bride's family arranged a small feast. Some members of the village of the bride's father invited and after reaching the groom and bride along with the *bharwa*. Both the families are together. After that the groom's family gave things to the bride's family in front of all the members present there. The groom gives an amount of Rs.50-30 to the bride's family and after that the married couple take '*Ashirwaad*' (blessings) in front of the members present there. The elderly members give blessings to the bride and the groom. Both the parties enjoyed a small feast in which '*Zu*' plays an important part.After attending this ceremony the bride and the groom return to their house. Now in the groom's house, some kind of ritual is performed. Near the gate of the groom's house the mother of the groom will cut a *'Chorai kon*i' (hen's egg) and it should fall in the *'Kol paat'* (plaintain leaf) which is placed near the gate. The bride and the groom are welcomed by the groom's family and other family and relative members.

Juron Biya:

The Tiwa people of the Sidhabari village performed *Juron Biya*. *Juron biya* is not so much prevalent among them. It is another form of arranged marriage minus the details of a *Bor Biya*. Generally, persons of low economic status perform this type of marriage. The father or the guardian of the prospective groom meets the father of the guardian of the prospective bride and discuss about the marriage. When both the parties agree, a date is fixed for the Juron ceremony. On the appointed day the boy's party consisting of the elderly relatives goes to the girl's house with ornaments, dress and '*Bhars*' (which include *pitha, zu*, and *tamul paan*). The elderly people of the gir'ls village bless them for happy married life. After some entertainment the boy's party leaves the girl's house along with the bride which marks the end of the marriage.

***Bor Biya*:**

The well to do and educated Tiwas generally prefer this type of marriage which involves huge expenditure and long drawn formalities. Generally it continues for three days. Two days before the marriage the groom and the bride are ceremonially bathed in their respective houses by their relatives and *khe*l (clan) members. Water for this purpose is ceremonially collected from rivers or streams or well. On third day rituals of marriage ceremony are undertaken by both the parties. The *khel* members takes the initiative for this purpose. Other villagers are also invited including *Gaon Burha* (village headman*)* and elderly persons. Marriage ceremony is solemnized at the house of bride at night. During the day a big feast is arranged for the people in both the side. Rice beer (Zu), Fish, Meat, Vegetables are essential items in their marriage feast.In the evening the groom, along with his friends and the *Zela* (go between) proceeds to the girl's house. The groom and bride are dressed in their

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traditional attire. And their ceremony proceeds.After concluding marriage rituals the couple bow down in front of the elderly persons and they bless them with good wishes for their happy married life. And the groom and bride go back to groom's house and live there together. In Sidhabari village *Bor Biya* was not so much prevalent.

***Choklong Biya*:**

It is a typical form of marriage found among the Tiwas of Sidhabari village. It can be performed by a single couple or number of couples. It is done in a very simple and short method. On an auspicious day all the *khel* (clan) members, relatives and elderly villagers are invited. The girl and boy will ceremonially bath and dressed in their traditional attire. One place is made in front of the clan members and elderly villagers where the couple will sit. There will be 1 bunch betel nut and 10 *guchi* betel leaf. Rice beer is an essential item of this marriage. It is kept in a special type of vessel called "*modor down*". The girl and boy will bow in front of the people and they will bless them for happy conjugal life. Then, the girl will serve the rice beer from "*modor down"* to the villagers and they will have it. Betel nut and betel leaf are also distributed by 2 or 3 persons of clan members to other members. In this marriage there is no feast for the villagers. This marks the end of *Choklong biya*. *Chaklong biya* has one specific feature that it can be performed by a single couple or number of couples at a time . In that case also some formalities and procedures are involved and all the clan members and elderly members are invited and proceeds the *Choklong biya*.

***Gobhia Rakha*:**

Though the Tiwas of Sidhabari village follow patrilineal system but a very thin matrilineal system is traced which is reflected in the *Gobhia Rakha* type of system. Generally parents having a single daughter without any son prefer to have a *Gobhia.* Not much rituals are observed in this type of marriage. For the villagers the girls side arranged a small feast.Many cases are found of *Gobhia* in Sidhabari village.

***Burha Biya*:**

This is a very interesting concept which is found among the Tiwas of Sidhabari village. Marriages other than *Bor biya* like *Gobhia Rakha, Juron Biya, Paluai Ana* are incomplete without *Burha biya*. Generally, *Burha Biya* are solemnized after some years of marriage. It may be performed at any time after 2,3 or 5 years also depending on their situation. So, it is called *Burha biya* because it takes place later and their children also get to witness their parents marriage. *Burha biya i*s generally performed to get approved by the society and can enter any socio-religious function or ceremonies. The society will approve their relation.The ceremony will take place for two days as in *Bor Biya*. The groom and bride are ceremonially bathed by their relatives and *khel* (clan) members. They will get dressed in their traditional attire and the couple will sit in front of clan members and elderly villagers and ceremony starts and priest will chant *Duan(hymns)*. The couple will bow down in front of the clan members and they will bless them for happy conjugal life. A big feast is organized for members. And now the couples get approved by the society and can enter and socio-religious ceremonies or formalities. This ends the *Burha Biya*.

Conclusions: Marriage among the Tiwas is an elaborate process which is very expensive and takes 3 to 4 days. But due to poor economic condition they perform in a very simple and short way. The villagers mainly perform elopement marriage. They perform every rites and rituals connected with the marriage. They follow monogamy form of marriage and clan exogamy as they believe that clan members to be the siblings of the same parents. The acquiring of mates is done through elopement

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and mutual consent. The residence after marriage is patrilocal as decent is traced through father's side.But in the village few cases are found where the married couple use to live in the girls house after marriage. And in some cases like where there is only one daughter and no son then the family adopt their son in law as *Gobhia* and it becomes matrilocal residence. There is no bar for widow or widower to enter into marriage. Divorce is rare. Dowry is absent as bride price is present among the Tiwa tribe but it is very nominal.

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Chapter-35: Preserving the Colonial Heritage of Tezpur (Assam), through Digital and Participatory Approaches

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Abstract

Tezpur (Sonitpur district of Assam), bears the imprints of British colonial administration and military presence through a number of built heritage structures, including churches, colonial bungalows, administrative buildings, and war memorials. These heritage assets, however, remain under documented and face deterioration due to neglect, encroachment, and environmental pressures. This chapter explores the potential for digital heritage mapping and community-based documentation as tools to preserve and reinterpret colonial memory scapes in Tezpur. Drawing on international models like the African Built Heritage Project in Benin, the chapter proposes a framework that integrates LiDAR, GIS, and oral history methods with local stakeholder participation. It argues that such initiatives can both conserve heritage structures and open up critical conversations around colonial memory, identity, and the future of Assam's architectural landscape.

Introduction

Tezpur, a city on the banks of the Brahmaputra in Assam, is widely known for its mythological significance and role in shaping Assamese cultural identity. Yet beneath this celebrated image lies an overlooked colonial past, materially embedded in its landscape but largely absent from academic, policy, and public discourse. As a former British administrative and military hub with a cantonment, civil station, and tea estates, Tezpur retains a diverse colonial architectural legacy: churches, bungalows, cemeteries, jails, and public buildings, many now neglected, repurposed, or deteriorating. This chapter argues that these structures represent a neglected '*lieux de mémoire*' or sites of memory that demand preservation not as imperial relics but as spaces for critical engagement. Grounded in critical heritage studies, postcolonial memory theory, decolonizing praxis, and digital humanities, the proposed approach treats colonial heritage as a contested, dynamic domain shaped by history, material culture, and community identity.

Drawing on theorists like Laurajane Smith, Edward Said, and Paul Ricoeur, the chapter challenges the idea of heritage as neutral or universally agreed upon. In Tezpur, the colonial built environment's marginalization reflects broader tensions between honoring indigenous identity and confronting colonial legacies. These structures, occupying a liminal space between rejection and reverence, are palimpsests layered with histories of power, adaptation, and silence.

To ethically engage with these memory scapes, the chapter emphasizes decolonizing methodologies that centre local agency, vernacular knowledge, and relational ethics, as

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advocated by thinkers like Walter Mignolo and Linda Tuhiwai Smith. In Tezpur's context, this means involving residents, students, caretakers, and civil society in the documentation and interpretation of colonial sites, ensuring local perspectives shape how the past is remembered. Digital tools like GIS, LiDAR, photogrammetry, and 3D modelling offer new ways to document and share heritage. However, critical digital heritage scholars warn that such technologies are not neutral and must be applied reflexively to avoid reinforcing existing power structures. This chapter therefore proposes a community-driven, critically-informed digital heritage model that uses technology to democratize access, amplify silenced histories, and foster inclusive memory practices. Within this framework, a pilot initiative is proposed to digitally map and document select colonial sites in Tezpur using participatory methods. Inspired by global projects like the African Built Heritage initiative in Benin, the model brings together scholars, technologists, artists, students, and local communities to co-create a living archive. Beyond preservation, the aim is to generate intergenerational dialogue, support cultural resilience, and contribute to rethinking heritage in postcolonial cities not as static monuments, but as evolving, plural sites of memory and meaning.

Colonial Tezpur in Historical Context

The British colonial footprint in Tezpur was firmly established in the early 19th century, following the annexation of Assam (1826). As colonial administration expanded its reach into the Brahmaputra Valley, Tezpur rose in strategic importance, becoming the district headquarters of Sonitpur and serving as a critical node for civil, military, and plantation governance in Assam. This period saw the rapid growth of colonial infrastructure to accommodate the needs of British officers, military personnel, and European planters who had begun to dominate the region's tea economy. The town's urban fabric began to reflect the spatial and architectural logic of the colonial regime, with zones demarcated for administration, residence, and recreation, often segregated along racial and class lines (Sharma, 2012).

A number of colonial era structures constructed during this time continue to mark Tezpur's landscape, albeit in varying states of preservation. Among the most prominent is **St. John's Church**, built in 1864, which stands as one of the oldest surviving churches in Assam and reflects the spiritual and social lives of British residents. The **Tezpur District Library building**, originally constructed as a British club, exemplifies colonial leisure architecture and now serves a completely transformed civic function, offering a compelling example of adaptive reuse (Mitra, 2007). **Colonial bungalows**, located primarily along Circuit House Road and the vicinity of Chitralekha Udyan, once housed administrative officials and planters; many of these feature signature colonial architectural elements such as high-pitched roofs, timber framing, expansive verandas, and the use of indigenous materials tailored to Assam's humid, monsoonal climate.

Other significant remnants of the colonial period include **war memorials and cemeteries**, some of which commemorate British soldiers and European tea planters who died in the region, particularly during periods of conflict or disease outbreaks. The **Tezpur Jail**, another key structure, is an example of colonial penal architecture, reflecting both the disciplinary logic of empire and the infrastructure of surveillance and incarceration. Together, these sites form a cohesive yet fragmented memory scape that narrates the city's entanglement with colonial governance, architecture, and spatial planning.

Despite their historical value many colonial structures in Tezpur lack official documentation or legal protection, leaving them vulnerable to decay, alteration, and urban encroachment. Their unrecognized status complicates conservation and raises questions about memory and neglect in contemporary Assam. Understanding their significance is crucial to preserving Tezpur's evolving urban heritage.

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Significance of Colonial Heritage Sites

Colonial buildings in Tezpur, while deeply entangled with the legacies of imperial domination and control, carry layered and often contested meanings for local communities today. For some residents, these structures represent the foundations of modern infrastructure, governance, and urban planning in the city, marking the introduction of systematic administration, transportation networks, and civic amenities that shaped Tezpur's transformation into a district headquarters. For others, however, they serve as tangible reminders of a fraught colonial past characterized by the displacement of indigenous landowners, the marginalization of local voices, and the imposition of foreign rule. These contrasting perspectives highlight the complex emotional and historical valences embedded within the colonial built environment, which cannot be reduced to a single narrative of either celebration or rejection.

Despite such tensions, the colonial heritage sites in Tezpur present significant opportunities across multiple domains. From an educational standpoint, they offer invaluable resources for learning about historical architectural styles, urban development patterns, and the socio-political dynamics of the colonial era. Their preservation and interpretation can deepen public understanding of the city's layered past, fostering critical engagement with history. In terms of cultural tourism, these sites have the potential to attract both domestic and international visitors interested in heritage trails that reveal Assam's diverse historical trajectories. By integrating colonial sites into curated tours and interpretive programs, Tezpur can broaden its tourism appeal while encouraging respectful dialogue around its colonial legacy. Furthermore, these sites play a vital role in shaping urban identity, influencing how the city narrates its past to future generations and positioning itself within broader regional and national histories.

However, many of these heritage sites in Tezpur are currently in a state of deterioration and suffer from a lack of formal legal protection. Without urgent attention, the physical integrity and historical significance of these buildings are at risk of irreversible loss (Jokilehto, 2007). This situation underscores the pressing need to systematically document, analyse, and preserve Tezpur's colonial heritage. Leveraging technological tools such as digital mapping, 3D modelling, and archival digitization, combined with inclusive, community centred narratives, can offer innovative pathways for safeguarding this heritage. Such an approach ensures that preservation efforts are not merely about conserving bricks and mortar but about maintaining the multiplicity of meanings and memories that these colonial sites embody.

Methodological Framework

To effectively preserve and critically engage with Tezpur's colonial heritage, this chapter proposes an interdisciplinary methodological framework that integrates digital humanities, architectural conservation, and oral history. At the core of this approach is a combination of advanced technological tools and community centred narrative methods, aimed at creating a holistic record of both the physical structures and their social significance. The first set of techniques involves the use of LiDAR (Light Detection and Ranging) and drone-based photogrammetry, which enable precise, high-resolution three-dimensional mapping of heritage buildings. These technologies are particularly valuable for capturing the current condition of structures that are vulnerable to decay, urban encroachment, or environmental pressures. LiDAR and photogrammetry allow for the detection of fine architectural details that may be invisible to the naked eye, while also producing detailed digital models that can serve as virtual archives. Additionally, such models enable monitoring to track changes over time caused by factors such as climate variability or urban development.

Complementing these tools, Geographic Information Systems (GIS) platforms such as ArcGIS and QGIS need to be employed to spatially map the distribution of colonial era buildings across Tezpur

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(Conolly & Lake, 2006). GIS layers integrate a range of relevant data, including environmental information like flood zones and erosion risks, legal protection status of sites, land ownership patterns, and accessibility. Crucially, GIS also facilitates the incorporation of indigenous or pre-colonial landmarks, allowing for comparative spatial analyses that situate colonial heritage within a broader historical and cultural landscape. This geographic visualization supports more informed conservation planning by highlighting areas of vulnerability and contestation.

While technological methods form a crucial component of the framework, they must be paired with narrative based approaches to fully capture the meanings and memories attached to colonial heritage sites. Oral history and community memory work is therefore essential (Portelli, 1991; Perks & Thomson, 2015). This involves conducting interviews with local residents, caretakers, and elders who possess lived experience and knowledge about the colonial sites. Such testimonies often reveal rich layers of folklore, local myths such as stories about bungalows or British cemeteries and personal accounts of how these buildings were repurposed or reinterpreted following India's independence. By integrating these narratives, the project moves beyond static documentation toward creating a **memory scape**: a dynamic, living archive that records how the colonial built environment is remembered, contested, and continuously reshaped by communities (Cameron & Kenderdine, 2007; Crampton, 2009).

Together, these multi-method strategies combining digital precision with oral histories offer a robust and ethically grounded approach to preserving Tezpur's colonial heritage. This methodology not only documents the material fabric of the city's imperial past but also situates it within processes of cultural meaning-making and postcolonial identity formation.

Design of Digital Heritage Preservation in Tezpur

Drawing inspiration from international efforts such as the African Built Heritage Project in Benin, this chapter **proposes** a pilot initiative on "Mapping Colonial Tezpur." The project **may envision** a locally grounded yet technologically advanced model for identifying, preserving, and reinterpreting Tezpur's colonial-era built environment. It **could aim** not only to document heritage sites but also to foster community participation, educational outreach, and policy advocacy.

The overarching fourfold objectives of the initiative **may be**: to identify, document, and digitally preserve at least 10 (ten) significant colonial era structures across the city; second, to create a publicly accessible, web-based GIS platform that integrates interactive maps, 3D models, photographs, and oral narratives; third, to actively engage local institutions including schools, NGOs, and heritage clubs in participatory mapping, storytelling, and awareness-building activities; and fourth, to promote heritage education and ethical tourism through curated digital tours and printed interpretive materials.

The proposed project **could unfold** across five interconnected phases. Phase I **might involve** preliminary historical research, field surveys, and archival mapping to identify and verify heritage sites. This **may include** both ground-level surveys and drone-based reconnaissance to assess the current conditions of structures. Phase II **would likely focus** on the digital documentation of these sites using LiDAR scanning, photogrammetry, and geospatial data integration. High-resolution imagery, architectural detailing, and geo-tagged site data **could be** collected and organized into a central digital archive. In Phase III, the project **might turn** toward oral histories and community memory. Through interviews, workshops, and storytelling sessions conducted with residents, schoolchildren, and caretakers, this phase **may seek** to recover local narratives, myths, and everyday memories tied to the colonial-era buildings. These narratives **could be** essential for embedding the material structures within their social and emotional landscapes. Phase IV **may centre** on the creation of a public-

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facing platform an interactive online dashboard that hosts a navigable GIS map, 3D building models, archival photographs, and audio-visual oral history clips. This platform **could serve** both as an educational tool and a living archive, accessible to students, researchers, tourists, and policymakers alike. Finally, Phase V **might focus** on outreach and policy engagement. Project findings **may be** compiled into a short policy brief highlighting risks to heritage structures, gaps in legal protection, and recommendations for sustainable preservation. The brief **could be** shared with local municipal authorities, heritage departments, and academic institutions to initiate dialogue and encourage formal action as the situation may be.

Preliminary target sites identified for this pilot **might include** prominent and symbolically significant structures such as St. John's Church, the District Library (formerly the British Club), the Tezpur Jail, and the Civil Circuit House near Chitralekha Udyan. Additional sites such as the colonial cemetery near Mission Chariali and several old bungalows in the former planter neighbourhoods **could also be included**, for their architectural integrity and historical relevance. Together, these sites **may represent** a diverse cross-section of colonial urban life spanning governance, religion, leisure, incarceration, and death while providing a foundational landscape for engaging with Tezpur's layered and complex heritage. This may attempt to demonstrate how digital tools, when combined with participatory practices, **can help** not only preserve architectural history but also reanimate it with the voices and memories of the present.

Community Engagement and Decolonizing Perspectives

Engaging with colonial heritage necessarily raises critical ethical and political questions, particularly in postcolonial contexts like Tezpur. Colonial buildings are not passive remnants of the past; they are material symbols of a history marked by extraction, surveillance, displacement, and asymmetrical power. As such, there is always a risk that heritage projects may unintentionally reproduce narratives that glorify or sanitize imperial legacies. However, the alternative erasure through neglect, demolition, or silence can also foreclose the possibility of critical engagement and intergenerational dialogue. This project recognizes that the value of colonial heritage lies not in romanticizing empire, but in confronting its complexities through inclusive and reflective practices.

Central to this initiative is the active participation of local communities in shaping the heritage agenda. Rather than privileging external expert opinions or institutional criteria alone, the project seeks to centre local voices in determining which buildings matter, what they signify, and how they should be remembered. This process includes collecting community narratives, facilitating participatory mapping sessions, and involving residents, educators, and youth groups in site interpretation. In doing so, the project reclaims colonial spaces not by denying their histories, but by inscribing new meanings into them, informed by the lived experiences and memories of those who continue to inhabit or interact with these sites.

Furthermore, the project adopts a decolonizing perspective that calls for the inclusion of indigenous knowledge systems in heritage discourse. This includes attention to traditional construction practices, vernacular spatial memory, and place-based cultural understandings that have long existed alongside or in resistance to colonial urban forms. By acknowledging and incorporating these ways of knowing, the project challenges the dominance of Eurocentric frameworks in heritage preservation and encourages a more pluralistic, ethically grounded understanding of the built environment.

Ultimately, this approach aligns with decolonization scholarship that positions heritage as a site of negotiation, rather than nostalgia. Scholars such as Walter Mignolo and Linda Tuhiwai Smith argue,

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decolonization work requires a rethinking of power relations in knowledge production and cultural representation. In the context of Tezpur, this means treating heritage not as a fixed or frozen category, but as a contested terrain where memory, identity, and politics intersect (Till, 2005; Huyssen, 2003). By foregrounding community agency and encouraging critical reflection, the project aims to foster a more inclusive and transformative heritage practice that is attuned to the needs, values, and aspirations of postcolonial urban communities (Menon, 2012; McCoy, 2014).

Challenges and Opportunities

The proposed digital heritage initiative in Tezpur offers a promising approach to engaging with colonial era sites but faces significant structural, technical, and social challenges. Most sites lack legal protection, leaving them vulnerable to neglect or demolition. Limited resources, including costly technologies like LiDAR and the need for technical expertise, further hinder implementation. Environmental factors such as monsoonal floods and humidity accelerate decay, while community scepticism rooted in painful colonial associations or perceived irrelevance may affect local engagement.

However, the project also presents key opportunities: it can promote heritage-based livelihoods, foster academic collaboration, and influence policy by advocating for the inclusion of neglected sites in official heritage registers. By addressing these challenges and leveraging support, the initiative aims to create a sustainable, community-driven model for digital heritage preservation in small Indian cities.

Conclusion

Tezpur's colonial heritage, though visibly present, remains overlooked in official discourse, academia, and public awareness. This chapter argues for reframing these structures not as imperial monuments, but as contested memory scapes that invite critical reflection and inclusive historical understanding. Rejecting both nostalgia and erasure, it proposes a dynamic heritage approach rooted in ethical engagement, technological tools, and community participation.

Using an interdisciplinary method combining LiDAR, GIS, photogrammetry, oral histories, and participatory mapping the pilot project centers local voices and indigenous knowledge within broader decolonizing efforts. It sees heritage as a space of negotiation, where meaning is continually shaped. Despite legal, financial, and environmental challenges, the initiative offers pathways for youth engagement, livelihoods, academic collaboration, and policy change. As a scalable model, it contributes to reimagining postcolonial heritage as a living, participatory domain. By digitally preserving Tezpur's colonial sites, the project fosters critical memory work, cultural resilience, and intergenerational dialogue.

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Chapter-36: Ethnicity and Backgroud of the Ethnic Movements in North-East India

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Abstract

This article explores the ethnicity and background of ethnic movements in Northeast India, a region characterized by rich cultural and linguistic diversity. It examines how ethnic identity, rooted in shared ancestry, culture, and language, has shaped movements for autonomy, recognition, and self-determination. Highlighting major movements such as those of the Nagas, Kukis, Koch Rajbongshis, Mishings, and Dimasas, the study reveals how socio-political marginalization, historical grievances, and identity assertion have driven continuous mobilization. The study concludes that ethnic movements in Northeast India reflect complex struggles for political, cultural, and economic autonomy within the framework of the Indian nation-state.

1. Introduction

Today across the globe, we generally find that very few states ethnically homogenous populations Most of the population groups are composed of many ethnic communities, jostling for influence and power, or living in an uneasy harmony. Within the same state boarders, at best of times, and in the worst scenario, committing world is 'plural' and the so called nation-state' is rarely a true appellation. As a result of this ethnic movement have become more intense and endemic in the twentieth century, no lens than at any other time in modern history.

For a precise perception of ethnic movements, it is permitted to understand the concept of ethnicity. The word 'ethnic' derived from Greek word 'ethnikas' refers to nations not converted into christianity, races or large groups of people having common traits, and groups in an exotic primitive culture. Ethnicity indicates recognizing a group of people on the basis of common standards or characteristics, shared values, style of life. Symbol of identity and consciousness of kind. Ethnicity is denoting towards identification of a group of people on the basis of certain criteria or markers which they are supposed to share with each other. These markers include culture, race, language, religion, customs, history, economic experience, etc.

Ethnicity is often identified with the ideas of primordialism based on descent, race, kinship, territory, language, history, etc. It is also related to the memory of a golden age which is closely linked to a sense of collective density. Ethnicity entails a subjective belief in common ancestry Ethnic membership is based on group identity and often identities would be invented constructed.

Ethnicity is also a relative term. An ethnic group differentiates itself from another groups which also shares certain attributes which are different from it. To preserve its identity and interests from the perceived or real threats of other ethnic groups and institutions, and process associated with them. Ethnic movements are concerned with the preservation and protection of the cultural identities of the ethnic groups and their other interests. This ethnic problem includes the conflict or movement between the state and district ethnic groups of the people and inter-ethnic conflicts.

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The movements and conflicts revolving around the issues of ethnicity are not new phenomena. It is a worldwide phenomenon. Several multi-cultural and multiethnic assertions of varieties and magnitudes. In India, after independence almost all the major religions of the country have witnessed many kinds of ethnic movements. These movements are for regional autonomy, for creation of separate states and the demand for secession or insurgency. Some of them are violent movements.

The North-East India consist of ethnically and culturally distinct eight adjoining states- Assam, Arunachal Pradesh, Manipur, Nagaland, Tripura, Meghalaya, Mizoram and Sikkim. The entire North-East India is populated by variegated ethnic group of people, it is the most diverse part of a most diverse country. North-East Indian states comprises of so many ethnic groups in their own identity, culture, religion, etc. that is why, mostly the ethnic conflicts and each-every ethnic groups in that region taking pivoted role in the name of their movement to get goals and demands. The region is geographically and culturally remote from the mainland of India has been a hotspot of various ethnic movements since the time of independence of India. Almost all state of North-East India has witnessed one or the other forms of ethnic movements. It is important to note ethnic issues of North-East India are related to the geographical factors, its regional dimensions. The problem of the North-Eastern region insurgency, ethnic movements, riots etc.; have been explained by mainly two perspectives. First, the modernization/ development/ nation-state building; and second, the federation building perspective.

North-east India as a region is a land lock in which different social groups belonging to various racialist origins have migrated from time to time through the history making the region itself into a conglomerate mass of inter-ethnic group interaction and ultimately leading to formation of multi-ethnic, multi-lingual, and multi- cultural region resulting in various ethnic movements and inter-ethnic conflicts in the region, the region itself has become a boiling point of ethnic movements and interethnic conflicts polarizing in and amongst the state vs. ethnic groups, ethnic-g out s vs. ethnic groups, and inter ethnic group vs. inter-ethnic group as well.

2. Background information of ethnic movement in North-East India

North-East India is known to other parts of India and world as the hotspot of ethnic mov ments, extremism and insurgency. In the contemporary period, many ethnic entities in North-East have launched movements against the Government of India. These could be classified keeping in mind the Indian constitution, into three types, constitutional, non-constitutional and mixture of two. The demands of these movement fall under the following categories; (a) Sovereignty Movement; (b) Autonony within the framework of the nation-state of India and (c) Ethnic Rights, Recognition and Promotion etc. The method they adopt to achieve these goals are violent or non-violent or both, which consequently means non-constitutional, constitutional or both

These movements can be further analyzed as: Inter-Ethnic Conflict, Intra-Ethnic Conflict and Ethnic groups vs. state.

North-East India has experienced all forms of ethnic movements dating back to the colonial period and most commonly and vigorously in the Post-independence period which led to the recognition of states right after Independence Bat the irony is that this recognition of states failed to establish peace and security in the region. In the last 60 plus years of India's independence North-east India have seen emergence and settlement of different Ethnic Movements and re-emergence of Ethnic Move me it as well. The various movements in the North-East have all to do with identity.

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Some major ethnic movements in North-East India can be out lined as (i) Naga Movement (ii) Koch Rajbongshi Movement, (iii) Garo Movement, (iv) Kuki Movement (vii) Dima-Hasao Movement (viii) Bodo Movement (viii) Mishing Movement etc.

2.1 Naga Movement

The Nagas, an Indo-Mongoloid people, are among the proudest and most distinctive communities in the North-East. Naga itself is a generic term for a cluster of 32 tribes, five of them in Burma and the remaining scattered within Nagaland (16), Manipur (7), Tirap in Arunachal (3) and the North Cachar and Karbi Anglong district of Assam. The Nagas, the know residence of present Nagaland, like other communities of the region they are also having similar problem but their issues and problems are very much different from the others. 15 In this paper/work/research an attempt is made to discuss the Naga Movement in its chronological order.

Among the ethnic movements in the North-East region, the movement laid down by the Naga National Council for an independent Nagaland deserves special mention. Nagaland had all dimensions relating to the ethnic movement demand or autonomy, secession from India and ethnic conflicts. The Nagas contended that they were never before under any political sovereignty, instead they had always enjoyed their sovereignty with distinct culture, customs and history. They do not recognize the merge of Nagaland with the Indian Union and consider it has done under coercion. Hence Naga did not recognize the Indian constitution, the VI schedule meant for the North-East India and participate in the first general election held in 1952. So, the main theme behind the Naga Movement is the question "we, the Nagas were historically never a part of Indian Union"

The historical Naga Club formed in 1918, requested the Simon commission in 1929 to keep the Naga hills out of the proposed reforms. They wanted an arrangement by which they could remain directly under the control of Britishers so that when they left they could be left alone as an independent nation. Thus, even after the "Nine Point Hydari Agreement' was signed, they declared Nagaland as an independent State unilaterally in August14, 1947. Starting from that point several militant groups like Naga National Council, NSCN etc., fought against Indian army. The Nagas have a long history of bloodshed and insurgency in post-independent years. Even after having several agreements on separate state formation and certain kind of safeguard to the people the problem of secessionist movement is still going on. The politicization of the Nagas was influenced by Zapu Phizo.64

Movement of the Nagas which is often referred to as Naga insurgency is called the Naga national movement by the Nagas. It is the oldest movement relating the ethnicity or believe that they form a nation which is different from other ethnic groups.

2.1.1 Nationalities/Nations in India

This finally led to creation of Nagaland as a separate state on August 1, 1960 out of Assam of which it was a part. It should be noted that there was difference among the Naga leadership over the issue of Nagaland as a separate state within the Union of India and Nagaland as a sovereign state/nation. The former founded Nagaland Nationalist Organization (NNO) and the latter formed the Democratic party of Nagaland. The MNO which was active in getting the Nagaland made a separate state were in favor of giving up the violence and accepting the constitution of India. The question assumed a new dimension following the signing of Shillong Accord in 1975. According to it the Nagas accepted the Indian Constitution, deposited their arms to the government released Naga political prisoners and promised their rehabilitation.

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The signing of Shillong Accord was not welcome by a section of the Nagas. The letter denounced the Accord for compromising their sovereignty and betraying Christianity. They now sought to mix the issue of Naga sovereignty with Mao's ideology of socialism and formed National Socialist Council of Nagaland (NSCN) led by a Tanghkul Naga T. Muivah and Isl a Swu. The NSCN leadership has guided the Naga movement while staying outside India. In their negotiations with the Government of India under the prime Minister ship of Atal Bihari Vajpayee and Dr. Manmohan Sing they have raised two main issues the issue of sovereignty of Nagaland and creation of Nasalim. territory merging all area of the North-Eastern states where Nagas stay. Apart from Nagaland, these states are Manipur. Arunachal Pradesh and Assam, they argue that while creating the boundaries of various states, the Government of India merged the territories inhabited by the Nagas into different states. This divided them. They demand ti at the Nagas should be reunited into Naga im. This demand has provoked opposition from these states. This has repercussion on the ethnic relations within these states. The Nagaland also has witnessed the ethnic riots and conflict between two major tribes of the state- Nagas and Kukis.

In this today's context, we can say the things got a bit changed after the formation of NDA Government. in 2014 at the center. In August 3, 2015, with an aim of ending insurgency in Nagaland, Government signed accord with key outfit NSCN (IM) which Prime Minister Narendra Modi described as a "historie step to usher in peace in the state. The pact was signed the presence of the Prime Minister, Home Minister Rajnath Sing and National Security Adviser Ajit Dov al by the outfits leader T Muivah and Government's interlocutor R.N. Ravi at the PM residence. However, Khaplang group did not stop carrying out the attacks on the Indian Arm forces from their bases in Myanmar. Ultimately end come when NSCN (IM) is still on and the incidence of Namtok Tea Estate in Changlang district of Arunachal Pradesh where the VSCN (IM) group demanded Rs. 4 crores from the management.

2.3 Kuki Movement

The word 'Kuki' is a generic term referring to an ethnic entity spread out in a region straddling north-west Myanmar (Burma), the Chittagong Hill tracts in Bangladesh and North-East India. In Northeast India, they are mainly in the states of Manipur, Mizoram, Assam, Nagaland, Tripura and Meghalaya. The Kukis are one of the most numerous tribe's numerical strength, vast territorial occupation and various armed struples-against the British, India and Myanmar their voice are still suppressed, without any positive sign in future. The reintroduce of Any Kuki Tribes in 2003 to make the Kuki identity inclusive seems to be a temporary solution and for a long-term solution. It would be constructive to consider a uniform pattern of recognition that would go a long way in restoring the Kuki identity to its logical conclusion.

The Kuki Rising of 1917-1919 was the culmination of Kuki movement against British aggression into their territory that began in the 1770s. The resolution of the Kuki as recorded by Higgins indicates the nature of the Kuki Rising of 1917-1919. It is for the preservation of their independence and for the protection of their land culture and custom. The extensive preparations and mobilization of forces and declaration of war as per the Kuki customs throughout the present Indo-Myanmar border demonstrated the Kuki’s determination to defend their territory. After 1919, the ancestral settlement of the Kuki’s was brought under British India and British Burma to keep suppressed. In Manipur, the hill areas affected by the Kuki Rising were brought under civil authority.

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Most states in independent India are organized on ethno-linguistic lines giving due recognition to their ethnic identities, language and cultures. However, the Kuki's argue that this right to govern their own affairs within their traditional territory has been denied to them, while it has long been extended to other major ethnic entities in Northeast India. The demands of the Kuki's for the creation of a Kuki state within the framework of Indian constitution in the 1960s nor the creation of Kukis dominated Sadar Hills into a full-fledged district in the 1970s and 1980s through peaceful means have not been acknowledged both by the Manipur and central Government. The Kukis calm that they have been subjected to political adversity and that their neighboring communities have sufferings of the Kuki people under the state and central Governments have rendered the taken advantage of their consequent vulnerability. The long years of neglect and Kukis economically, socially and politically backward The aspiration of the Kukis for self-determination through peaceful means have been conveniently ignored. The only response they get is repression, deprivation and further discrimination. Thus, MNF and the territorial acquisitiveness and hegemonic politics of the Meiteis and Nagas have led to the emergence of Kuki armed groups in the 1980s.

The Kuki National Organization (KNO) and its armed wing Kuki National Army (KNA) were formed on February 24, 1988, to uphold the right of the Kukis to govern their own affaires within a defined territory (statehood) one part in India and another in Myanmar. During the same year, on May 18, the Kuki National Front (KNF) was formed under the leadership of Mr. Nekholum Kipgent at Molnoj village (Myanmar).

Again, on March 29, 2000, the United Kuki Liberation Front (UKLF) was formed to fight for a separate state of the Kukis in Northeast India.

The long desire to take revenge on the Kukis as historical record shows the subjugation of the Nagas, by the Meiteis with the help of the Kukis, to control them and to face them to pay tribute to the Manipuri King The worst happened on 13 September 1993, when the NSCN (IM) cadres at gunpoint tied up and massacred 107 kuki men (87 died at the spot; 20 later succumbed to injuries), butchering them with matches and spears. There are also report of innocent civilians being killed by the Security Forces; the figure put at 56 by the KNO.

It is very sad to know that the Kukis, even after all these struggles doesn't have a separate district of their own, in any of the State, not to talk of a State. Their demand for a hill district, SADAR Hills, in Manipur has been ignored, even though the demand has been there for more than 40 years. And also, that some of the areas where they are hugely populated (e.g. Kangpokpi in Manipur), falls under the General Seat, even in the State Legislative Assembly. This raise a very important question as to: Do the ruling class (Government. of India) take a struggle seriously only when armed struggle, which manifests itself in the form of violence, is employed?". This is a very valid question, as the centre seemed to engage in a serous dialogue with a community only when there is serious and unwanted violence, from the demanding community.

2.4 Koch Rajbongshi Movement

The Koch Rajbongshi community has been striving for safeguarding their identity for quite sometimes. It has evolved a lot over time. Their effort has taken the shape of the Kshatriya movement and the Kamatapur Movement. At present, they are trying to voice their demand through the Kamatapur Movement which is spear healed by different associations and organizations. Every ethnic group is very enthusiastic to preserve their identity. At present, the Koch Rajbongshi in Assam and

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North-Bengal are jointly striving to preserve their ethnic identity. The Koch Rajbongshi are found in India at West Bengal, Assam, Meghalaya and Bihar. They are also found in Nepal, Bangladesh and Bhutan.

Kamatapur is a demand for statehood comprising areas of both Assam (specially, lower Assam) and the northern tip of West Bengal. In reality, it is far more complex than the Bodo demand for Bodoland, since the territorial contours of the proposed Kamatapur are transnational. The Koch Rajbongshi of both Assam and Bengal are enthusiastic about the demand for Kamatapur.

Kamatapur is a region, whose reconstruction in contemporary political discourse in rooted in history. The present political Movement for Kamatapur draws it inspiration lighly from the history of Kamatapur. The idea is to see the historical Kamatapur kingdom in the present form of a federal unit of India. In the post-independence scenario, 1 his historical region disappeared in the formation of modern Assam, West Bengal & Bangladesh. Like the Kamatapur region, its history also disappeared in the nationalistic history writings of Bengali and Assamese and it became partly Bengali history and partly Assamese history. In Assam, history of Kamatapur became history of Goalpara or West Assam. So, the Rajbongshi language. It became Goalparia dialect of Assam. Indeed, the recent demand for Kamatapur by the Koch Rajbongshi also seek recognition of history and culture of Kamatapur. The historical memory of Kamatapur Kingdom or Coochbehar was so strong among the Koch Rajbongshi that instead of demand for a ethnic Koch Rajbongshi land opted for a regional identity contrary to the contemporary movements for ethnic homelands of Northeast India, which are using identical ethnic rames in their proposed homelands. However, the Koch Rajbongshis' present attempt to disassociate themselves from the Assamese identity and challenging the same by seeking recognition of the Kamatapuri identity in Assam.

It was the Koch Rajbongshi leader, Late Sarat Chandra Singha, or whose initiative the undivided Goalpara district was merged with Assam, history of Assamese loaded with inspiring stories of Koch King Bishwa Singha, Naranarayan and General Chilarai. It is important to note that the prime and the old demand of the Koch Rajbongshis into the Schedule Tribe (ST) category. The demand for Kamatapur is comparatively new in Assam. The All Assam Köch Rajbongshi Sanmilani, which has been demanding the ST status for Koch Rajbongshis of Assam since 1966, once opposed the demand of Kamata Rajya by Kamata Rajya Sangram Parisad in and around 1969. Through the staging of this demand has completed fifteen years now, it remains unfulfilled. Many observers opine that if the Koch Rajbongshis had been given ST status in Assam, the Kamatapur demand from Assam would not have been raised. Moreover, the inclusion of the Koch Rajbongshi dominated areas into the Bodoland Territorial council (BTC) without consulting the Koch Rajbongshi has been also fueled the demand for Kamatapur in Assam.

When protest movement turned to a territorial movement in North Bengal, in Assam Koch Rajbongshi struggle for reservation transformed to mere radical territorial demand in the 90s. Most of the organizations of Koch Rajbongshis emerged in 1990s, such as: Kamatapur People's Party (1996), Kamatapur Liberation Organization (1995), Greater Koch Behar People's Association (1998) and All Koch Rajbongshi Student Union (1993). Despite some problems, the leaders have been trying to run the struggle. The Atul Roy's fraction of AAKRASU has formed, 'Greater Kamatapur United Forum' also with several other organizations of North Bengal. But the movement was, all along under the need of strong and unified leadership. Contrary to such need, the organizations have split into several fractions posing difficulty to the struggle.

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On 30th May, 2010 a National conference was held in Bongaigaon, Assam seeking the solution to the problems of Koch Rajbongshi. Following the national conference, the separate state demand committee and the AAKRASU (Biswajit fraction) came down from the demand for a separate state and vowed to engage in the development of the community.

The Kamatapur Koch Rajbongshi Movement today speaks in many idioms. Cultural demands that seek recognition, moderate political demands that seeks autonomy. and also more militant political culture demands that find expression in the idiom of violence. But through these various expressions the Koch Rajbongshis are trying to say that they are a people with a glorious pat seeking dignity, self-respect, justice and autonomy.

2.5 Mishing Movement

An old tribe of Assam, the Mishing is constitute of several groups like Pa-dam, Minyong, Pa-si, Tangam, Siyom etc. and others. These groups of people are mainly inhabitants of Arunachal Pradesh (erstwhile NEFA). Though the Mishing inhibit Arunachal Pradesh yet a large section of Assam, namely, Tinsukia, Dibrugarh, Dhemaji, Lakhimpur, Sibsagar, Jorhat, Golaghat and Sonitpur. They are linguistically related to the Adis of Arunachal Pradesh. Against the socio-cultural backup, the activities of the Takam Mishing Porin Kebang (TMPK) or All Mishing Student's Union may be focused upon as it has embarked upon formulation of strategies to go ahead with a movement fo the ethnic autonomy for the Mishing in Assam.

The Mishing Student's Organization was first formed in 1933 as was named Asom Mishing Chatra Sanmilan. In the initial years, the Mishing Chatra Sanmilan was a social organization engaged in the social reform activities. On 10th December 1944 in its sixth convention the organization became politically inclined and put forward their demand for 28 seats in the Assam Legislative Assembly for the Tribals. By 1965, the Mishing Chatra Sanmilan organised itself into four more divisions in various parts of Assam. On 16 October 1971 in its meeting the Mishing Chatra Sanmilan was renamed as Takam Mishing Porin Kebang (TMPK).

In September 19889, during the Chief Ministerial rule of Prafulla Kumar Mahanta, the first Mishing National Convention was held in Dhemaji. The main aim was to boost the agitation for the creation of Mishing Autonomous State. The convention had succeeded in bringing together attendance from different Mishing organizations like Mishing Bane Kabang (Mishing National Congress), Mishing Drbu Kebang (Mishing Cultural Association), Mishing Mime Kebang (Mishing Women's Association) etc. The Mishing political leaders also participated in the convention and decided to carry on the agitation for an autonomous state. The Mishing Mimak Kebang (MMK) or the Mishing Sangram Parisad was formed to that it could accommodate all the different Mishing organization Both the TMPK and MMK have taken upon themselves for organizing their demand for the Mishing Autonomou State. The Mishing youth has focused on the non-implementation or even partial implementation of the constitutional provisions including rules and regulations by the government for the deprivation of economic and educational benefits due to the members of the Mishing community, Unable to avoid facilities of education, health care, and employment the feeling of deprivation amongst the Mishing gradually became more and more dominant.

For the Mishing the man question is the survival, preservation and protection of their distinctive identity which forms a sound basis for putting forward the demand for a 'federating unit with adequate autonomy' having a democratic political administrative set-up along with progressive economic

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structure. The Mishings also at one point of time stood for the right to self-determination, as the only way to 'concrete political and social security of their tribe

On 13 June, 1995 a memorandum of settlement was signed during the tenure of Chief Minister Hiteswar Saikia and this came to be known as the Mishing Autonomous Council was constituted for the purpose of granting autonomy under the constitution of India. The signatories of the Accord ware Chief Secretary, Arunodoy Bhattacharjya, Dilip Pegu, Rajkumar Kutum, Rajni / nta Patir representing the Mishing Autonomous Demand committee and Dhaneswar Modi who represented the Mishing Bane Kebang.

On 25 October 1995, the Mishing Autonomous Council Act was passed with the objective to ensure the greates possible autonomy for social, economic, educational, cultural and ethnic development of the Mishing within the constitutional framework. This would include the settlement a eas of the blocks of contiguous revenue villages, each having more than 50% population belonging to the Mishing Community

2.6 Dimasa Movement

The Dimasa people of Northeast India have been demanding a separate state called 'Dimaraji' or 'Dimaland for several decades, it would comprise the Dimasa-inhabited areas, namely Dima-Hasao district parts of Cachar district part of Nagaon district and Karbi Anglong district in Assam together with part of Dimapur district in Nagaland. The word 'Dimaraji' is derived from Dimasa language and its literal meaning is 'Land of the Dimasas'

According to the Dima Halam Daogah Chief Dilip Nunisa, the proposed Dimaraji would comprise three districts: existing Dima Hasao, Garampani district and Borail. The Dima Halam Daoga (DHD) is a descendant of the Dimasa National Security force (DNSF), which ceased operations in 1995. After the peace agreement between the DHD and the central government in the year 2003, the group further broke out and DHD (J) also known as Black Widow was born which was led by Jewel Gorlosa. The Black Widow's declared objective is to create Dimaraji for the Dimasa people in Dima-Hasao district only. However, the objective of DHD (Nunisa Faction) is to include parts of Cachar, Karbi Anglong, and Nagaon district in Assam and sections of Dimapur district in Nagaland. The aim and objectives of the Dimasa people for the movement are-struggle for existence, safeguard and welfare of the Dimasa community for all round developments in education, literacy, various culture, language and socio-economy etc.; Eradicate social evils-illiteracy, untouchable and other superstitions which are detrimental to the society, Preserve rich ancient heritages -traditional cultures, historical relics, identities, claim legitimate constitutional rights and privileges for better growth, safeguard and co-existence among others. The main motto of the movement was "Glorify Dimasa"

The All Dimasa Student's Union (ADSU) apart from safeguarding the common interest of the Dimasa community as a whole launched a democratic political movement on 30th April 2003 staging a demonstration at Jantar-Mantar, New Delhi demanding Dimaraji. The major grievances of the ADSU, today the very existence of the Dimasa people may the aboriginal tribe of the Northeastern states is at stake irrespective of places of their original traditional habitats since the time immemorial in the region. Even after 60 years of Indian independence, there is no trace of least development or change of Dimasa people in any aspects, and on the other hand, numerous problems are cropped up

and added to one after another every day. Till today, our people are almost backward, neglected, deprived of all legitimate constitutional benefits and compelled to remain in despair and resentment. The rapid development of other higher and more intellectual sections of the society causes our people

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'surprised. After careful observations of these grievous situations of our people the ADSU held the government and its admirative policies responsible.

Apart from the demand for Dimaraji, ADSU also raised several demands. One of the demands was to remove non-tribal outside from the Tribal Belt and Blocks of Dimasa inhabited areas. Another demand was to preserve and developed the historical relics of ancient Dimasa Kachari state of Dimapur of Nagaland and Khaspur, Maibong and Mahamaya etc. in Assam. to strengthen the demand of Dimaraji another organization was formed as Dimaraji revival demand Committee (DRDC) in 1994. The organization adopted a policy of parliamentary and extra parliamentary struggle to achieve its goal. Parliamentary struggle, as DRDC meant, was to capture the Autonomous council, MLA and MP seats. It defined the extra-parliamentary struggle as a protest movement demanding Dimaraji separate through procession, dharna, rally etc. Both the ADSU and DRDC had submitted a memorandum before the Prime Minister of India on 1996. In this memorandum, they demanded the creation of revival of a full-fledged Dimaraji state.

The DHD from the very beginning was involved with several armed activities. The armed conflicts resulted in the death of hundreds of people. Moreover, the pressure from the Government nd the operation of the para-military and military forces of Government of India disrupted the life of the people. The ADSU came forward with its agitational programmes. ASDU called a 24-hour Dimaraji Bandh with effect from 5 am of 8 July 2002, in protest against the atrocities of security forces on innocent people in proposed Dimaraji. ADSU strongly condemned the state-sponsored terrorism in Dimaraji. The Jawans, camped at Harinagar Cachar, had tortured the tea tribe, Khasi and Dimasa communities in Khaspur, Goabari area in the Cachar district. The security forces allegedly raped three Khasi girls at the Goabari near Khaspur. They also harassed the Dimasa under the pretext of searching DHD militants in the Indo-Bangladesh border villages like Hawarmah and Khorkhori. The security forces camped at Bamungaon near dali Block had beaten up the villagers of the Longmailu Dimasa village near Udali, Lanka of Nagaon district. The Black Panther's jawans were also looting jewelleries, burning the village houses at Manja-Dimasa Belt and Dhansiri area in Karbi Anglong. As a part of the peace initiative, the DHD signed the cease-fire agreement with Government of the India on 1 January 2003. Its designated camps were established in several part of Karbi Anglong, North Cachar Hills and Cachar districts of Assam. After signing the cease-fire agreement, the DHD had submitted its formal memorandum before the Home Ministry of Government of India, on 23 September 2004, demanding the creation of separate Dimasa state.

2. Conclusion

Ethnicity as an ongoing phenomenon does not leave any space for conclusion. From the observation, it is apparent that the present political situation of the Northeastern region has posed a challenge to social science scholars. An ethnic movement has become one of the most problematic and endemic in postcolonial Northeast India From the above-mentioned movements and many others ethnic movement in this region, like-Karbi Movement, Bodo Movement, Hamaras, Movement, Khasis Movement, Garo Movement, Rabha Movement, Meeteis Movement has witnessed that the region is hotspot of a series of popular movements among various ethnic constituents, particularly the tribal communities around the question of political -economic and cultural autonomy after independence. Almost all the parts of the Northeast India have witnessed ethnic movements. They take the forms of movements for separate states, demand for secession or insurgency. These manifestations of ethnic movements are also called self-determination movements.

Northeast India as a single region has the largest number of the tribal population in the country. They follow different religions especially Christianity, Buddhism, Hinduism and indigenous religions

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tents. They can further be divided between the plain and hill tribes. Almost all states of Northeast India have witnessed one or the other forms of ethnic groups of Northeast India have been involved in ethnic mobilization for different purposes. They have taken recourse to both the violent and non-violent means. Success or failure of ethnic movements depends on political factors. Once one set of demands in ethnic mobilization is accepted, in due course time on other demands the ethnic movements starts. Thus, ethnic mobilization is a continuous political process. Northeast India, with its diverse ethnic communities, has been witnessing struggles ranging from demands for various forms of autonomy to separation from the Indian Union. The Northeast region of India has been marked by sustained separatist insurgencies, mass agitations and ethnic conflicts. This region has been the setting for the earliest and longest lasting insurgency in the century.

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Chapter-37: Proclaiming Heterogeneity, Autonomizing Ethnicity, Centralizing the Marginalized: Postcolonial Rage in Mamang Dai's Poem "The Voice of the Mountain"

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Abstract

Mamang Dai's poem "The Voice of the Mountain" vehemently resists the power dynamics that have culturally, historically and nationally marginalized North-East India, especially Arunachal Pradesh. This paper aims to analyze how the poem explores postcolonial themes such as decolonization, historical revisionism, cultural hybridity, assimilation of identity, and the representation of oppressed voices. This study demonstrates how Dai's poetry creates a counter-narrative that asserts autonomy, embraces ethnicity and reclaims the heritage of her community. Ultimately, this research highlights the significance of Mamang Dai's works in the arena of postcolonial literature, and their relevance in contemporary debates on nation, nationality and nationalism.

Keywords: *Dai, colonization, mountain, resistance, culture, hegemony*

Introduction

In the fifteenth century, the age of exploration in Europe initiated the wrath of two deadly diseases: smallpox and colonization. The former affected one's immune system, and after an endeavour of a hundred years, a successful cure was found. The latter, however, spread through invisible germs that invaded a nation's body politic[1], rendering it sick and vulnerable to the machinations of utterly diseased dictators. It claimed sacrifices of not just lives, but also of identity, independence, and integrity. After two hundred years of struggle, when India finally stood on the verge of a remedy, the British took the "Kohinoor" as a souvenir, and as a parting gift, planted a new variant of the same, rotten colonialism deep into the unfathomable crevices of a million minds. The contagious greed of supremacy gave rise to the monster of internal colonization. Writing from the periphery of postcolonial India, Mamang Dai's poetry offers a relentless resistance to the power politics that determine the relationship between the Indian midland and the geographically aloof, culturally othered North-Eastern region. It is a tough task to pick stanzas from the poem and interpret them thematically, as each line introduces a new concept, a newer tone of protest. The poem presents not only the historical dilapidation of Arunachal Pradesh, the state Dai is from, but also candidly exposes the neglect of the other six North-Eastern states: Mizoram, Manipur, Nagaland, Meghalaya, Sikkim, Tripura, and Assam. "The Voice of the Mountain" functions as an attempt to vaccinate generations of colonized victims against the madness of imperialism.

In the poem, Dai places the persona of the mountain at a "high platform"(line 1), where, from a vantage point, it has seen so much of coerced change, hegemonic subjugation, moral corruption, imperial sludge and colonial dirt flow down the "big river"(line 2) of time, that it "can outline the chapters of the world"(line 5). And the world of North East India is divided into chapters of centre-margin binary, racism, subalternation, endangerment of ethnicity, and state-sanctioned violence. Arunachal Pradesh can minutely map the "crossing crisscrossing" (line 2) of religious propagandists, capitalist bandits in the guise of messiahs, and nationalist sentiment ticklers, upon its soil. They suffered mass conversion into Christianity under the colonisers, falling victim to the empty promise of

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being provided with safety, comfort, and enlightenment. In the poem “Blood of Others”, Naga poet Temsula Ao documents :

"We listened in confusion
To the new stories and too soon
Allowed our knowledge of other days
To be trivialised into taboo..
…..
Schooled our minds to become
The ideal tabula rasa
On which the strange intruders
Began scripting a new history."
(lines 12 - 29)

And their colonial successor- the national homogenizers[2], repeated the same, malicious corruption of the interpolation of nativity, only in a doubly torturous measure, wrapped in the glossy cover of civic development. The dominant narrative remained the same: the incomprehensible must either be commingled or be annihilated. Following the independence of India, many North-Eastern states started separatist movements, claiming autonomy over regional governance and freedom of cultural expression. In 1966, the Mizo National Front Uprising[3] was the first major liberation strike. But the government of India utilized it as an example to strike terror upon those who dare to defy the nation-state, inflicting brutal violence and political conspiracy upon Mizoram. In her poem "An Obscure Place", Dai explains -

"If there is no death the news is silent.

If there is only silence, we should be disturbed"

(lines 17-18)

The tribes of Arunachal Pradesh were bestowed with the false crown of exoticism. But from the colonizer's perspective, the exotic is the regressive, and the regressive never determines the norm for those occupying the hierarchical summit. The first assault of otherization was hurled upon nature. The onslaught of mindless capitalist consumerism was meticulously schemed to further lead the erosion and degradation of the bio-diverse environment, making Arunachal an open treasure chest for economic despotism. In the curling smoke of industrialization, the pristine "star diagram" (line 36) disappeared from the sky. Manipuri poet Robin, S. Ngangom’s poem “Everywhere I Go” is an open inquiry towards the outsiders regarding the truth behind their intentions:

"I’m the anguish of slashed roots,
The fear of the homeless,
And the desperation of former
kisses.
How much land does my enemy
need?"
(lines 32-35)

"The Voice of the Mountain" provides a striking counter discourse against this colonial antagonism towards nature. The tribal community Dai belongs to, is the largest tribe of Arunachal, known as the Adi[4] tribe. They harbour the philanthropic philosophy that asserts that all animate and inanimate entities: birds, mountains, animals, rivers, pastures and insects exist on this earth as rightfully as humans, and are equally sacred. This worldview is known as “Donyi-Polo”. Literally, “Donyi” means “Sun”, and “Polo” means “Moon”. “Donyi-Polo” is the corporeal manifestation of a supreme deity. In

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an article titled “The Nature of Faith and Worship Among the Adis”, Dai interprets it to be the “world spirit”(p. 87). This belief system is intrinsically entwined with ecological harmony and its preservation, unlike the coloniser's Biblical wisdom that instructs mankind to "…fill the earth and subdue it; and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth" (Genesis 1:28). This lethal, Eurocentric view of nature has been countered in the poem, by presenting the mountain as the creator, the preserver, and the destroyer, highlighting nature’s spiritual importance that is native to the mountain tribes. Dai critiques the ethical discrepancy of the country, as the very same India that takes pride in a few eco-feminist movements, such as "Chipko"[5] or "Save Narmada"[6], has such a destructive attitude towards the ancient eco-humanism of Arunachal Pradesh.

To make matters worse within the dominant national imagination, the North Eastern population is often frolicked to be Nepalese, Chinese or referred to by inappropriate, denigrating labels as "Chinki"[7]. Robin S. Ngangom, in his poem “Everywhere I Go”, writes -

"Those who speak the language of progress
Call my homeland a mendicant state
Not knowing its landlocked misery,
Its odd splendour.

And no one knows who picks up its bodies.”
(lines 23-27)

To counter this new form of racism in postcolonial India that has resulted in widespread alienation of the tribals in their own land, Dai empowers her people with a strong sense of autonomous ethnic identity that could resist and subvert the homogenizing tendencies of the national ethnography. She provides a non-violent symbolic discourse to highlight the height of political deprecation the North East endures. For generations, Arunachal Pradesh has dealt with tribal war and communal clashes. Hence, the government enacted AFSPA (Armed Forces Special Powers Act) to maintain public order in disturbed areas. Ironically, the protector became the perpetrator as there was no savagery left that AFSP did not commit: assault, arson, deforestation, demolition of property, and embezzlement. India's seven sister states had to sacrifice the honour of sisterhood as countless rape cases committed by the army still remain unresolved. In 2004, following the alleged gangrape and murder of a female Manipuri activist named Thangjam Manorama, Manipuri women stood protesting against the AFSP, with the gut-wrenching slogan- “Indian Army rape us” (Biswas). The nation-state replied with even more violence and a silencing propaganda. For the mountains, "Peace"(line 26) has always been an evident "falsity"(line 26) but never a deceptive lie in the disguise of truth. Compared to the superhuman inhumanity of the military vehemence that is stamped as permissible, the bloodshed of tribal unrest has been compared to "blood of peonies" (line 33). Their lives remain "forever ancient and new" (line 11). The same old venture to revive and relive traditions is ever interrupted by imposed modernity that aspires to gulp down the warmth of belongingness. The promised illumination never arrives. In a single life, they live the "many lives"(line 14) of the ostracised other, the legally terrorised, allegedly uncouth, uncultured hooligans. Cherrie L. Chhangte, a poet from Mizoram, brilliantly captures the alienation effect on the North-East, in the poem “What Does an Indian Look Like”:

“You look at me, and you see
My eyes, my skin, my language, my faith.
You dissect my past, analyse my present
Predict my future and build my profile.
I am a curiosity, an ‘ethnic’ specimen.
Politics, history, anthropology, 0

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Your impressive learning,
All unable to answer the fundamental question—
"What does an Indian look like?'
—An Indian looks like me, an Indian is Me."
(lines 17-25)

Dai exposes the haphazard, moth-eaten political cartography of India, where the orientation of Indians into a standard Indianness brings only internal partition and no national unity; only the chaos of abandonment and no solace of identity.

The rubric of postcolonial literature undergoes a further revaluation as Dai subverts colonial linguistics and structure in the language of the colonizers. Having never officially written in any other medium but English, the language becomes her very own intrinsic voice of revolt and irony to conspicuously expose the grotesquerie of linguistic imposition on Arunachal Pradesh. Even the structure of the poem flows freely like a river, eluding generic punctuation, rhythm and rhetoric. Just as the British foisted the English language for imperial convenience, mainland India too normalizers the dominant Hindi tongue as the lingual gateway to enter the central historiography. Even in a sovereign land, "such acts"(line 10) of the negation of the fundamental right of free speech, are "repeated" as the tribals speak in "changing languages" (line 11) to be socially a part of India they are already a geographical part of. Ngangom's poem "The First Rain" questions:

"Can poetry be smuggled like guns or drugs?
We've drawn our borders with blood.
Even to write in our mother tongue
We cut open veins and our tongues"
(lines 54-57)

But any other language, no matter how historically enriched, cannot capture the essence of one's mother tongue and its creations, which, for Arunachal Pradesh, is the oral tradition: the stories and rhymes passed down generations. Dai mourns this loss of their traditions, as she writes:

"The words of strangers have led us into a mist
Deeper than the one we left behind"
(lines 25-26)

Arunachal Pradesh does not have an official language. Each tribe has its own dialect, grammar and natural linguistic evolution. Dai's collection of short stories titled "The Legends of Pensam" documents and celebrates the oral tales of the land. "Pensam" is an Arunachali word that means "in between". Arunachal Pradesh has more than fifty dialects, yet, apart from other reasons, a breach in communication is one of the reasons for tribal unrest. But the government, instead of resolving internal struggles, exacerbates them even more, turning the people of the same state against each other. This dirty politics has been repeated again and again in history to corner the tribal population even more, making tribal unrest an irresolvable issue. Their rightful plea for national aid has been rejected time and again. Hence Dai says, "I also leave my spear leaning by the tree and try to make a sign" (line 12), inaugurating a new generation of citizens who will no longer make enemies within their own homes; a generation that knows its true enemies. Contrary to the nation's obstinate belief, she resuscitates and reconstructs the silences and gaps of their traditional narrative and documents them in a neo-literary style that rejects state-approved supremacy of certain languages and hegemonic disparity of the tribal colloquy. Dai inverts the scale of semantic paramountcy as the marginalised know both the centre and the margin. Most North-East Indians can speak at least two Indian languages alongside English. But the self-entitled majority are uneducated about India's cultural diversity. In the beginning of the second stanza, she reduces the homogenizer to a pathetic briber who, out of his own lexical ignorance, brings an unsuitable "gift of fish" (line 8) to a land of rivers. The

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language they want to subdue is the very language that pinpoints their illiteracy. Even though those "lost in translation" (line 38) are absent in the administrative recital of the nation, between the lines of progression and regression, the tales of Arunachal Pradesh exist as they always have, with its episodes of joys and despair, nationalism and betrayal, crescendo and quietude. The distinct accent and pronunciation of tribal languages that the country parodies and demeans as an incoherent "transfer of symbols" (line 14); for Dai, becomes the blaring sign of postcolonial defence. If, by "chance"(line 16) her countrymen strove to fathom even a "syllable"(line 16) the people of the mountain utter, they would realise that the languages they have defamed, have enough narrative strength to reinstruct history, and miraculously rectify the malevolent state apparatus.

The core of postcolonial literature lies in the painful and restorative, relocating and re-enacting endeavour of both personal and collective memory. Dai weaponizes her poem to inscribe a counter memory for Arunachal Pradesh against the official memory of India. Foucault's[8] concept of the archaeology of knowledge defines that a formal archive of memory is a system of rules, practices and discourses that determines what can be said and how. Under the claws of internal colonization, the North-East has been mercilessly denied the right to represent its own culture. Mizo poet Lalrinmawii Khiangte, in her poem titled "For a Better Tomorrow", uses excessive ellipses to denote the gaps between what is promised and what is granted:

"Courage…moral courage… physical courage..."
mental courage…discernment…for withstanding…
complacency…conformity…yet censoring glare…
of…associations in community…church…
government…double standards rampant everywhere!" (lines 7-11)

The worst manifestation of this political chauvinism is that the schemes of fruitless external development are granted by the government, but any attempt by Arunachal Pradesh for internal evolution has been disenfranchised. A region ripe with infantile possibilities is nipped in the bud. While an Indian basks in the manipulated glory of independence, a tribal Indian dies "at the edge of the world"(line 33) as a namesake citizen. The poem challenges the stereotypical encyclopaedic knowledge of the nation-state by presenting Arunachal's raw and collective memory as its only authentic cultural repository. Throughout the poem, the land of the mountains has been painted as an elemental, eternal, momentous, changeless space, contrasted with the threatening surge of change. Its voice merges with "the desert and the rain" (line 16), the "sea waves" (line 15), and "sunlight on the tips of trees" (line 40), signifying the hereditary self-sufficiency of its people. The evergreen remembrance of their roots "escapes the myth of time"(line 42) that devours everything in its course. No matter how much the Indian heartland imposes monochromatic gloom upon Arunachal Pradesh, it still remains the land "where the colour drains from heaven" (line 4). Generations of mass Christianisation fail to erase the ethno-spirituality of its tribes. Amidst the trauma of cultural displacement and diaspora, the North-East invents and reinvents ways of keeping their ethnicity alive. In the poem "One of these Decades", Naga poet Monalisa Changkija writes:

"We will gather around the fire
On moonlit nights as did our forefathers
And silence the gunfire with our songs
Loud and clear across our green hills
In rhythm with all humanity
To keep our date with destiny."
(lines 18-23)

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By invoking "particles" of ancestral reminiscences that "clutch and cling" (line 22), Dai asserts resistance to historical amnesia, winning the tug of war of "end and hope" (line 35). The poem becomes a rectified palimpsest over the illicit palimpsestic memory of India.

The post-colonial resistance in "The Voice of the Mountain" finds its culmination in reformulating and relaunching the imperialists' silencing agenda against imperialism itself. Colonization is carried out under the chokehold of contradicting context and conversation. Dai utilizes the same tactic to re-theorize the protohistory of the periphery. In the poem, the marginal becomes the mainstream, as it comforts the disturbed and disturbs the comfortable. Against the constrained inclusionary jingoism with exclusionary motives, she introduces the most simplified version of nationalism that begins with honouring and unapologetically identifying with one's origins. All attempts to jumble their different aesthetics in the "estuary"(line 2) of acculturation, are met with resilient revolt, mighty and lofty as "mountain peaks" (line 14) . Arunachali poet Ayinam Ering's poem "I am a Tree" accurately captures the resilience of the Arunacahli communities:

"So what if fate
Decides to leave my roots entangled?
I'm alive, from inside
And I've the courage
To keep growing while confined"
(lines 10-15)

The deceptive offering of a new sunrise of advancement is rejected as they prefer to be "the wild bird that sits in the west" (line 18): solemn and free. Even though Arunachal Pradesh finds itself at the receiving end of the violence on three fronts- from the states, the militants, and a corresponding escalation of violence within its own homes, it still struggles and survives, "with happiness to carry on" (line 37) and pass on to the generations to come. After all, for its people, revolution and inborn radicalism are as lucid as knowing that "a cloud is a cloud is a cloud" (line 24).

End Notes..

1. The body politic is a metaphorical interpretation that imagines a nation-state as a physical body and describes it in terms of human attributes.
2. Homogenization is popularly a scientific term, but in the sociological context, it is used to indicate the forced assimilation of socio-cultural differences.
3. The Mizo National Front Uprising was against the government of India, as it demanded the independence of Mizoram. Its revolutionary sentiments greatly affected the other states of North-East India as well.
4. The name Adi means "hill" or "mountain". The Sanskrit connotation is not applicable in this context
5. The Chipko Movement started in the year 1973, in the Himalayan regions of Uttarakhand (erstwhile Uttar Pradesh). The Hindi word "Chipko" means "to cling" or "hugging". To resist deforestation, tribal women stood hugging the trees and did not cease doing so, even before the threat of chainsaws and axes and eventually protected the woodlands.
6. The Save Narmada Movement began in 1985 to protest the construction of large dams on the Narmada River, especially the Sardar Sarovar Dam.
7. "Chinki" is racial, urban slang, used to mock the facial features, especially the monolid and hooded eyes of North-East Indians.
8. Michel Foucault (1926-1984) was a French historian, philosopher, and author.

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Chapter-38: A Review on Life and Works of Ādi Śaṅkarācārya

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Abstract

This paper presents a comprehensive review of the life, philosophy, and enduring legacy of Ādi Śaṅkarācārya (788–820 CE), one of India's most eminent philosophers and theologians. Recognized as the founder of Advaita Vedānta, Śaṅkara's teachings emphasized the non-dualistic nature of reality—asserting the ultimate unity of Ātman and Brahman. The study outlines his early life, spiritual awakening, and significant events such as his initiation into Sannyāsa, his Digvijaya (philosophical conquest across India), and his pivotal debates with contemporary scholars like Maṇḍana Miśra. The review highlights his contributions as a philosopher, poet, and reformer who revitalized Sanātana Dharma during a period of spiritual decline. Śaṅkarācārya's establishment of four principal Maṭhas (monastic centers) across India and his propagation of the Ṣaṇmātā system of worship underscore his vision of religious harmony and cultural unity. The paper concludes by acknowledging Śaṅkarācārya's literary legacy, including his profound commentaries on the Upaniṣads, Bhagavadgītā, and Brahmasūtras, as well as devotional hymns that continue to inspire spiritual and philosophical thought in India and beyond.

Introduction

Ādi Śaṅkarācārya, an influential Indian philosopher and theologian survived in the eighth century CE, viz. 788-820 CE. He was the founder of Advaita Vedānta,which is a non-dualistic school of Hindu philosophy. In addition to being a philosopher, he was also a leader, a poet, a saint, a social reformer, and a historian. In terms of his love and sympathy for all people, he had a unique personality. His intellectual, religious, historical, and social achievements have left a lasting influence. He was, in the fullest sense of *Bhagawadgītā*, a man of action, a *karmayogī*. In order to create four maṭhas, he went from Kanyakumari to Kashmira and from Dwaraka to Jagannathpuri. He has offered commentary on lots of books, including the Upaniṣads, Brahmasūtras, *Bhagavadgītā,* and others, in order to support his Advaita-vāda, a doctrine of monism. Therefore, he was became a *jñānayogī.* He is the author of several devotional stotras dedicated to various gods, including *Viṣṇu, Śiva, Gaṇeśa, Sūrya, Śakti*, and many other Gods. He was also known as *bhaktiyogī*. As he had studied different śāstras, he created his own and added to them with his deep learning. Hence, He was became a *śāstrayogī.* He dedicated his life focusing on preserving *sanātana* Hindu Dharma.

Ādi Śaṅkarācārya was the originator of an era. So, he was also as a *yugapuruṣa*. The entire India and its inhabitants were living in a dark age at the time of Śaṅkarācārya's birth. The entire country was split up into various regions, and the local members in those areas were became enemy with one another. The political situation did not improve the religious situation. The nation was suffering from terminal issues. It was not the role of the religious authorities to guide the common people toward righteousness. Sensual pleasure took the place of false monocracy like self control in society.

Regarding the date of birth and duration of Śrī Śaṅkara, all informations are controvertial and uncertainty. There isn't a single reference to another composition of his works which would

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at least assist the reader in identifying any quotes from Śrī Śaṅkara. Therefore, it is impossible to draw any conclusions about his dates and works.

It is possible that although Śrī Śaṅkara was an Advaitic philosopher, he focused a lot on Advaitic teachings. Therefore, scholars have a tendency to link Śrī Śaṅkara with solely the bhāṣyas on the *prasṭhānatraya*. However, emphasizing *prasṭhānatraya*, bhāṣya does not imply that his work was limited to the major Upaniṣads, *Bhagavadgītā*, and *Brahmasūtra* commentaries. Free from all bonds, Śrī Śaṅkara made pilgrimages to several temples and shrines in order to expand the Advaita religion and philosophy. Thus, the poetic intellect might shape extremely complements of the many Gods and Goddesses from the depths of his immense advaitic heart. He was not just a philosopher but also a well-known poet.

Birth of Ādi Śaṅkara

The problem of insignificance has been observed even regarding Śaṅkara's birth place and parentage also. A small village named Kaladi; spelled Kalati by others, was located on the bank of the Albai river in the state of Kerala. A knowledgeable and devoted Namboodiri Braḥmaṇa named Vidyādhirāja lived in that village. He was blessed with an only son, Śiva-guru. He was one of exceptional academician, gaining profound knowledge of sacred books such as the Vedas, the Vedāngas, and other śāstras. Although he was willing to become a Sannyāsī, he married Āryambā, a girl from a renowned and noble family, and took up household life as per the wishes of his religious master Guru. Both Śivaguru and Āryambā were great devotees of Lord Śiva.[1] After a long period, they blessed with a son by the grace of Lord Śiva. There was a story regarding the birth of Śaṅkara. When Śivaguru and Āryambā began their penance practices and reciting the mantras of Lord Śiva, one day Śivaguru had a dream in which God Śiva asked him if he would have many sons who would live long lives but possess few virtues or if he would have only one intelligent son who would live a short life. The father wisely chooses a knowledgeable son rather than many sons and had Śaṅkara as his son. For everyone who turns to him, the child is the greatest source of happiness. Therefore, Śivaguru named the child as Śaṅkara. However, he was named Śaṅkara since he was born by the mercy of Lord Śaṅkara. Also, it is believed that Śaṅkara was an incarnation of Lord Śiva.[2] It has also been discovered that his parents were Viśvajit and Viśiṣṭa, and that he was born in Chidaṁbaraṁ in south Arcot.[3] However, the earlier viewpoint is more acceptable.

Early life of Ādi Śaṅkara

Śrī Śaṅkara lost his father when he was a young boy. He was raised by his widowed mother, who was very patient, understanding and cooperative. It is possible that Śrī Śaṅkara was a posthumous child.[4] At a very young age, Śaṅkara was initiated and sent to study at the *Gurukula.* At the age of eight, he learned all four vedas and vedāṅgas; at twelve, he learned all the scriptures and śāstras and he wrote his renowned bhāṣyas and commentaries at the age of sixteen and he departed from this life at the age of thirty-two. There is a verse that depicts his life –

aṣṭavarṣe caturvedī dwādaśe sarvaśāstravid I

[1] Swami Mukhyananda, *Ācārya Śaṇkara*, *An Interpretation*, p. 107
[2] Vyāsācala, *Śaṇkaravijaya*, Introduction, p.1
[3] Belvalkar, S.K. , *Shree Gopal Basu Mallik lectures on vedāta Philosophy*, p. 232
[4] Ibid. p.233

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ṣoḍaśe kṛtavāṇ bhāṣyaṁ dwātṛnśe munirabhyagāt II[5]

There are so many unbelievable incidents and events happened in his life. One day, while he was studying at the *Gurukula*, Śaṅkara went to a very poor lady's house to receive his *bhikṣā*. She had nothing to offer except an *amlaka* as her humble *bhikṣā* to Śaṅkara. Śaṅkara was moved by her selflessness and out of compassion prayed to Goddess *Lakṣhmī* in a *śloka.* It is believed that after completion of this stotraṁ, Goddess *Lakṣhmī* physically appeared and showered the poor lady's house with gold coins. This prayer of Śaṅkara has come down to us as the *kanakadhārā stotraṁ*. Reciting the *kanakadhārā stotraṁ*, on a regular basis is said to be a potent remedy for poverty.[6] Śaṅkara continued studying many literatures after returning from *Gurukula*, taking care of his mother and eventually making everyone aware of his brilliance.

The mother of Śaṅkara used to travel a considerable distance each day to bathe in the Albai River. One day, the youth Śaṅkara discovered her lying unconscious on the way to river. After taking her home, he prayed pasionately to the lord that he should make the river flow by the side of his house. And the following day, the river Albai began to flow beside Śaṅkara's house.[7]

Śrī Śaṅkara expressed his desire to become a Sannyāsīn at a very young age, but he did not receive his mother's consent. . He also assured his mother that he would always be ready to attend to her spiritual requirements. The next day, Śaṅkara and his mother went to the river to take a bath. Suddenly, Śaṅkara sensed that a crocodile was grabbing hold of his thigh. Then he shouted out to his mother that the crocodile is dragging him down. The crocodile had promised to let him free if he renounced worldliness. At these remarks, Śaṅkara's mother granted her permission, and the crocodile released him without causing him any significant harm. The sincere mother honored her promise, even though the pain of losing her beloved son was weighing heavily on her thoughts. But she took a promise from Śaṅkara that he would come back to her at the time of her death and perform the last rites. With pleasure, Śaṅkara granted his mother's request.

The story of Śrī Śaṅkara's willingness and interest in leading an austere life is nothing more than a dramatization of his acceptance of self-denial to free himself from a crocodile's grasp. One cannot devote so much time and effort to studying the philosophy of many branches if they have no genuine interest in leading an austere life. Owing to his lack of concern in material things, Śrī Śaṅkara could contribute greatly with his contributions to Advaitic philosophy.

In another view, it can be said that the crocodile incident is an allegory. This interpretation interprets the river as *saṁsāra*, or the river of life that gives rise to births and deaths. The crocodile is *māyā*, living in that river and preying on the jīvās or the individuals. The only way to escape the crocodile's clutches is to renounce; thus, the crocodile, the illusory power, released Śaṅkara from its grasp when he declared, *saṁnyastoham* that I have renounced.[8]

Śrī Śaṅkara's Digvijayaṁ

[5] Tripāthi, Dr. Rudradev, *Saundaryalaharī*, p.21
[6] Swami Tapasyananda, *Śaṅkaradigvijaya,The traditional life of Śrī Śaṅkarācārya*, p.113
[7] Sastry, T. S. Narayana and Kumaraswamy, T.N. , *The age of Śaṅkara,* p.89
[8] Swami Chinmayananda, *Śaṅkara the missionary*, p.67

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After entrusting his mother under the care of his relatives and the protecting hands of the Lord, Śrī Śaṅkara set out alone in search of a Guru to get himself formally initiated into the holy order of Hindu *sannyāsa*. He eventually found his esteemed Guru Govinda Bhagavatpāda near the Narmada River. After, passing a test, he was formally initiated as a complete sannyāsiṇ. Then Guru Govindapāda taught him the philosophy that he had himself learnt from his preceptor,Gauḍapāda . Śaṅkara also pays his respect to his Parama-Guru i.e. Gauḍapāda. Being brought up in poverty Śrī Śaṅkara must have developed his thought of adjuring worldly life. He put on the garments of an ascetic, disgusted by the absurdity of worldly existence. After attaining salvation or non- dual knowledge, he turned himself as a preacher and a prophet.[9] Śrī Śaṅkara's existence came into light at that time, when, in India, Buddhism had already grew and flourished or almost 1200 years and reached great heights of achievements and establishments that had became a threat to Indian philosophy and culture. With the rise of Buddhism, the Hindu *sanātana dharma became* weak and almost extinct. Following a period of study, Śaṅkara began his journey to Kasi in accordance with his Gurudeva's wishes. Gurudeva wanted Śaṅkara to first travel to Banaras and then follow his destiny of becoming one of those wandering religious teachers that were so common in both pre and post Buddhistic India.

This young sage Śaṅkara began studying the scriptures while he was reaching out to Kasi. While Śaṅkara and his students were strolling down the street to take a midday dip in the Gaṅges, an unforeseen event occurred. A *cāṇḍāla* walked by him with a few dogs. The *cāṇḍāla* did not cross the road when the students yelled for him to do so; instead, they got into a heated argument and questioned the Guru about how he could teach Advaitism and carry out such radical observances on a regular basis. Suddenly, Śaṅkara speaks the stotra *maṇiṣāpaṇcaka*, [10] which is full of the monism philosophy. Each stotra closes with the following that he who has learned to look on phenomena in this monistic light is his true Guru, whether he is a *cāṇḍāla* or a twice-born man. According to tradition, Lord *Śiva* appeared as *cāṇḍāla* in order to test Śaṅkara's beliefs.[11] After taking on his true form, he bestowed blessings and gave him the task of penning a commentary on the *Brahmasūtra* of Bādarāyaṇa.

Once upon a time, while walking down Kasi's tiny street, this *sannyāsī* Śaṅkara noticed an elderly man who was learning the grammar. This great ācārya's compassionate heart melts with pity, and he writes his famous *stotra* that is *Bhajagovindastotraṁ*.[12]

An additional insignificant incident in the life of this exceptional being was the composition of the *Devyaḥkṣamāparādhanastotraṁ.* It is said that once upon a time, an elderly man who was over 85 years old, approached Śaṅkara and asked him to write a prayer for mother Goddess because he was unable to write even a line. Out of pure compassion for that old man, Ādi Śaṅkarācārya created the *Devyaḥkṣamāparādhanastotraṁ.*[13] This *stotra* was written by the great saint on behalf of that elderly man who had lived for almost 85 years, although Ādi Śaṅkarācārya had just lived only 32 years.

Śaṅkara left kasi to write a commentary on vyāsa's vedāntic aphorisms for the benefit of all people, following Lord Śiva's directions. He composed his most welknown commentary on

[9] Belvalkar, S.K. , *Shree Gopal Basu Mallik lectures on vedāta Philosophy*, p. 233
[10] Aiyar , C.N. Krishnasami and Tattvabhushan, Paṇḍit Sītānāth*, Śrī Śaṅkarācārya*, p. 78
[11] Belvalkar, S.K. , *Shree Gopal Basu Mallik lectures on vedāta Philosophy* p. 237
[12] Patel, Gautam, *Ādi Śaṅkarā laghuprabandhavāliḥ,* Introduction, p.10
[13] Ibid, p.10

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the *Brahmasūtra* of Bādarāyaṇa in the twelfth year while seated in Himalayan caves. A *brāhmaṇa* once approached Ācārya Śaṅkara with some inquiries concerning the first sūtra found in the third chapter of the *Brahmasūtra.* After eight days of intense conversation, the *brāhmaṇa* revealed his true form as Bādarāyaṇa, bestowed a blessing, and granted him an additional sixteen years of life. Ācārya Śaṅkara began his journey to Prayaga, after composing commentaries. He met Kumārila Bhaṭṭa, the founder of *Pūrvamīmāṁsā* school of Philosophy, and asked him to write a *vārttika* on his commentary. But he had made the decision to destroy himself already. So, he advised Ācārya Śaṅkara to meet Maṇḍana Miśra, a great philosopher of that time and also known as Viśvarūpa, in Mahismati nagari, which is situated on the banks of the Narmada River. It was belived that he was an incarnation of *Brahmā.* After giving this advice, Kumārila surrendered his body.

Śaṅkarācārya gives a very intriguing account of the encounter between him and Maṇḍana Miśra. Ācārya Śaṅkara encountered some maid servants who were carrying water from the well when he arrived at Mahiṣmatī. When he asked them for directions to Maṇḍana's house, they respectfully replied that where a female parrot, captured in the cage at the door, is uttering the words like has the Veda self-validity, know that to be the gate of Maṇḍana's house. Ācārya Śaṅkara arrived at the house and found that the gate was locked. There was no means to let the household know he had come for a visit. The Ācārya entered the house using his *yogic* power where Maṇḍana Miśra was performing śrāddha ceremony of his father. The Ācārya then asked him for a *vedabhiksā*, a *bhikṣā* that involves debates and discussions. Then a long discussion lasted between these two great scholars for several days. The woman who was appointed as the judge in this case was Maṇḍana Miśra's wife, Ubhayabhāratī. When it became impossible to determine the winner of the debate, Ubhayabhāratī., removed two garlands of fresh flowers and placed one around her husband's neck and the other around Ācārya Śaṅkara. According to her, whoever's garland faded first would be deemed the loser of this dispute, and the loser would become the victor's disciple.

As fortune would have it, the garland put around Viśvarūpa's neck faded first, while that on Śaṅkara's neck was still fresh. As per the prior understanding, Viśvarūpa was inducted into the holy order of Sannyāsa and became Śaṅkara's disciple. Later, he was known as Suresvarācārya, the foremost disciple of Śaṅkara.

And that Even after the defeat of her husband, Ubhayabhāratī, the wife of Viśvarūpa was not prepared to surrender. She challenged him that the wife being the better half of a husband, unless she was defeated the defeat would not be complete. Śaṅkara accepted the challenge and a fresh session of argumentation started between them. But she asked certain questions which were impossible to answer for a *brahmacārī*. Then Ācārya Śaṅkara demanded time for months, during which he entered the dead body of King Amaruka, and obtained certain expected experience and left the body and came back to answer the questions of Ubhayabhāratī. She was satisfied by the answers and conceded full victory to Śaṅkarācārya. The most well-known Sanskrit poetry of passionate sentiment, Amaruśataka, was composed by Śaṅkarācārya while he inhabited the body of King Amaruka.[14] It is believed that Ubhayabhāratī was an incarnation of Sarasvatī, the Goddess of knowledge she was born as a human being as the result of a curse. She surrendered her body and returned to her heavenly dwelling when her husband, Maṇḍana Miśra, gave up the householder's life and embraced *sannyāsa*.

[14] Patel, Gautam, *Ādi Śaṅkara laghuprabandhāvaliḥ*, introduction, p.13

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When Śrī Śaṅkara was in Kāśī , he acquired a disciple, named Sanandana. Later, this disciple came to be known as Padmapāda because the river Ganga caused lotuses to bloom at every step of his foot i.e. pāda to give support to him, when once in his extreme devotion to Śrī Śaṅkara, he walked right on the stream to fulfill a command of the master, who was on the other bank.

Śrī Śaṅkara then traveled to Badri on the Himalayas where his Guru Govindapāda and Paramaguru Gauḍapāda were living in the enjoyment *nirvkalpa samādhi.* He made them revert to world conscious -ness by singing the famous *Dakṣhināmurti Stotra* and received their blessings. Ācārya Śaṅkara moved from village to village, covering all important towns, temples and cultural centres of the country along with his four disciples as well as other learned disciples to spread the knowledge of supreme reality, Advaita Brahman. The Ācārya conceived India as one cultural unit from the Himalayas to Kanyakumari and from Kamarupa to Gandhara with his *digvijaya yātrā* for establishing universal brotherhood and the intimate experience of the non-dual reality.

Hari on her behalf, touching her feet. She went to serve Hari after stepping out of her body. Ādi Śaṅkara once developed an intuitive sense that his mother was approaching death when he was stationed in the north. His mother had only allowed him to take *sanyāsa* at the age of twelve after he had assured her he would be there for her when she passed away. Upon learning of his mother's grave sickness, he traveled to Kaladi by himself in order to be by her side as she lay dying. His mother was critically ill and laying in bed when he arrived. He prayed to Lord When Namboodiri Brahmins advised him not to carry out the ceremony because sanyāsis are not permitted to, that's when his issues with his mother's practice began. His neighbors and even his family turned against him, so he made the decision to perform all the rites by himself without assistance. He broke the body into pieces and carried them to the backyard of the home because he was unable to handle it alone. He prepared a pyre out of the plantain tree wood , but he lighted the fire alone in accordance with *Sanātana* Dharma's burial rites because none of his relatives showed up to join him.

The majority of India's significant contributions came from the sages huts, where austerity, self-control, and transcendental meditation were practiced. Śrī Śaṅkara had a similar peaceful environment in which transcendental insight inspired him to write a vast body of work in a variety of Indian philosophical and religious traditions, particularly Advaita.

Ṣaṇmātāsthāpaka

Although Ādi Śaṅkara was regarded as the greatest Advaita philosopher in India, one of his most significant contributions was the founding of Ṣaṇmātā, which means he changed and standardized the six forms of worship—*Gāṇapatyaṁ, Kaumāraṁ*, *Vaiṣṇvaṁ*, *Sauraṁ*, *Śāktaṁ*, and *Śaivaṁ*.[15] *Pañcāyatana Pūjā* was prescribed by him for his own disciples. At Śrīraṅgam and Tiruppati, he was claimed to have installed the *janākarṣaṇa* and *dhanākarṣaṇa* yantras, which have the ability to draw devotees and offerings.[16]

Particularly in Samayamata, a method of *tāntrik* worship and meditation, Śrī Śaṅkara had delivered numerous Hindu religious schools from violent methods and provided them the deserved purity for *Śakti* worship. Hindus have done this since his time. In *Saundaryalaharī*,

[15] *Śaṅkara and Shanmata*, preface.
[16] Ibid

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the *Samayamata* discipline is called *swatantra tantra*, and it contains *jñāna, bhakti, mantra*, and other elements.

In this sacred territory, Ācārya Śaṅkara built four Pīthas at its four corners and a fifth at Kanci. They are *Govardhana maṭha*, *Śāradā maṭha*, *Kālikā maṭha*, *Jyotir maṭha*, and *Kanci Kāmakoṭī maṭha*.Tradition holds that Śrī Śaṅkara was bestowed by Lord *Śiva* with five - *Sphaṭika liṅgās* and a transcription of *saundaryalaharī*, a century-long collection of songs honoring the heavenly Mother. Unfortunately, Śaṅkara misplaced the remaining fifty-nine of these lyrics, which he eventually composed himself. The five sacred sites are where he dedicated the five Sphaṭika liṅgās *Muktiliṅga* at Kedāra, which is close to *Jyotir maṭha*; *Varaliṅga* at Nīlakaṇṭha Kṣetra in Nepal; *Mokṣaliṅga* at Cidaṁbaram; and *Bhogaliṅga* at Śringerī, which is close to *Śāradā maṭha*. At *Kanci Kāmakoṭī maṭha*, yoga is practiced. His followers are still residing there and passing on the teachings of Ādi Śaṅkarācārya, including the Upanisadic philosophy and *Sanātana* Dharma. Ten categories were used by the Ācārya to classify also spiritual leaders - *Sarasvatī, Purī, Bhāratī, Vana, Āraṇya, Tīrtha, Āśrama, Giri, Parvata, and Sāgara*. [17]All of the countries have adhered to these titles.

Govardhana maṭha

This eastern maṭha was established at Jagannātha Purī and the first Ācārya was Padmapāda. Lord *Viṣṇu*, also known as *Jagannātha*, is the deity worshipped here, and *Vimalā* is his *Śakti*.[18] Within this *maṭha*, the Sannyāsins are called *vana* and *āraṇya*, and the brahmacārīs are called *prakāśa*. They take pleasure in studying the *Ṛgveda* in particular and meditating on the *mahavākya prajñānaṁ brahma*, which appears in the Ṛgveda's *Aitereya Upaniṣad*. The Bay of Bengal, or Mahodadhi, is the *tīrtha* in this instance. This *maṭha* is tasked with the spiritual wellbeing of the eastern section of the country.

Śāradā maṭha

The first Ācārya of this southern *maṭha* was Suresvarā, who founded the city of Śringerī, which is today in the state of Karnataka. Lord *Śiva* is the deity worshipped here, and *Śrī Śāradā* is his *Śakti*.[19] The sannyāsins of this *maṭha* are called *Sarasvatī, Bhāratī*, or *Purī*. The name *caitanya* belongs to the brahmacārīs. They take pleasure in studying the *Yajurveda* in particular and reflecting on the *mahāvākya aham brahmāsmi* found in the *Bṛhadāranyakopaniṣad*, a text from the *Śuklayajurveda*. Here, the river Tungabhadrā serves as the *tīrtha*. This *maṭha* is charged with the spiritual wellbeing of the southern region of India. In this *maṭha*, the great Advaitic teacher Śaṅkara is believed to have meditated due to which the authorities erected as a memorial to him, attest to this. It is thought that this *maṭha* is the intended home of the Rāmakṛṣna Mission.

Kālikā maṭha

This western *maṭha* was founded at Dvārakā, in the state of Gujarāt and the first Ācārya was Hastāmalaka. This maṭha's sannyāsins are called *Tīrtha* and *Āśrama*, while the brahmacārīs are called *Svarūpa*. They are instructed to study the *Sāmaveda* in particular and to focus on the *mahāvākya tattvaṁasi*, which appears in the Sāmaveda's *chāndogya upaniṣad*. This place

[17] Mahadevan, T.M.P, *Śrī Śaṅkarācārya,* p.51
[18] Swami Chinmayananda, *Śaṅkara the missionary*, p. 116
[19] Swami Chinmayananda, *Śaṅkara the missionary*, p.117

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is dedicated to the worship of Lord *Śiva* and his *Śakti, Bhadra Kālī*.[20] Here, the river Gomatī serves as the *tīrtha*. This *maṭha* is charged with the spiritual wellbeing of the western section of India.

Jyotirdhāma

This northern *maṭha* was founded at Jyotirdhāma in the Himālayās, close to the well-known pilgrimage site at Badarīnātha. Here, Totaka was the first Ācārya . The sannyāsins assigned to is This *maṭha* is endowed with the spiritual wellbeing of the northern section of India. this *maṭha* are called *Girī, Parvata*, and *Sāgara*. *Ānanda* is the title of the brahmacārīs. It is enjoyable for them to study the *Atharvaveda* in particular and to ponder about the *mahāvākya ayam ātmā brahma*, which appears in the Atharvavedic *māṇḍūkyopaniṣad*. Here, the river Alakānandā serves as the *tīrtha*. Lord *Viṣṇu* is the deity adored, and *Pūranagirī* his *Śakti*.

Kanci Kāmakoti Pītha

This maṭha was first established in Kancipuram by Advaita vedānta teacher Śrī Śaṅkara and later, it was shifted to Kumbakonam, the temple city of south, in the mid 18th century. This maṭha was a branch of Śṛngerī maṭha and became involved with the Kāmākṣhi temple in Kancipuram. The first Ācārya was Śaṅkara himself. The Kāñci Kāmakoti Pītha authorities constructed Śrī Śaṅkarastūpa as a tribute to Śrī Śaṅkara's birthplace, Kālati in Kerala.

Sarvajñapīṭha

Kashmir is an important spiritual center that nurtures the *Śakti* aspect of ultimate truth for sādhakas. According to the traditions, Ādi Śaṅkara founded *sarvajñapīṭha* in Kashmir[21] as he had established himself as the omniscient in front of Devi *Śāradā*.

Mahāsamādhi

According to Śṛngerī pīṭha, Śrī Śaṅkara surrendered his body in Kailasa. Also to scholars, he had left his body in the Himalayas whereas other people pointed it to be happened in Kerala. But, in general, it is believed that after being omniscient, he had travelled to Badarīnātha and entered the bila Holy cave. Śaṅkara was fortunate enough to see Devī Darshana, or the Goddess' vision, in that cave, after which he had never, came out from that place. He had dedicated the Srīcakra in front of her image.

A gigantic life size stone image of Śaṅkara is brought to the *muktimaṇḍapa,* on the banks of Sarvatīrtha, on *vyāsapujā* day every year as a tribute to Vyāsa, the place where Śaṅkara was supposed to have attained nirvana.[22]

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[2] *Brahmasūtrabhāṣya*, Śrī Śaṅkara, Motilal Banarasidas, Delhi, 1964
[3] Walker, Benjamin, Hindu World, Encyclopaedic Survey of Hinduism, Vol. I & II, London , George Allen & Unwin Ltd., 1968

[20] Ibid, p.118

[21] Mahadevan, T.M.P, *Śrī Śaṅkarācārya,* p.39-41

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Chapter-39: Cross-Generational Reading of Advertising Aesthetics: Minimalist versus Elaborate Visual Design

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Abstract

In a time when visual communication is becoming more and more central to the culture of the consumer, the look and feel of advertising have a particular responsibility in framing attention, interpretation, and brand image. This research explores the differences between minimalist and complex advertising aesthetics' perception across three generations: Generation Z, Millennials, and the older generation. Leveraging visual culture studies' theories, semiotics, cognitive aesthetics, and cultural capital, the research situates advertising as a cultural text interpreted differently according to levels of technological exposure, cultural background, and social position. Adopting a mixed-methods approach that includes semiotic analysis of ads and focus group reception studies, the research observes different interpretative patterns across generations.

1. Introduction:

Advertising has long been an art of persuasion that transcends economic concerns to embrace cultural and social aspects. As a system of signs, symbols, and stories that encode and transmit values, identities, and hopes, it presents aesthetic strategies—ranging from minimalist to complex forms—marginally as important tools of persuasion. In the modern digital age, audiences are bombarded with a plethora of visual information, making advertising design an issue not just of imagination but also of mental effectiveness and cultural consciousness.

Minimalism, with its clean lines, reduced imagery, and limited color schemes, is a design aesthetic built around clarity and effectiveness that speaks deeply to digital culture. On the other hand, complex advertising deals with narrative depth, symbolic abundance, and rich visuals, building meaning through complexity and intertextual association. Both styles of aesthetics are important; their reception differs, however, according to different demographic groups, each with its own experiences of technology, culture, and communication.

This article examines how Generation Z, Millennials, and the older generations experience these disparate aesthetic strategies. It suggests that generational differences in advertisement reception are not only determined by personal preferences but also by aggregate social and cultural influences. Drawing on interdisciplinary theoretical models and using a mixed-methods design, this research seeks to advance the body of evidence on advertising aesthetics and consumer psychology.

2. Theoretical Framework

Visual Culture Studies (Mirzoeff, 2011): Advertisements are cultural texts that summarize systems of representation and relations of power and so shape the views of different generations towards brand identities.

Semiotics (Barthes, 1977; Eco, 1976): The images used in advertising act as sophisticated systems of signs. For example, minimalist concepts carry meanings of modernity and

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sophistication, while more complex ads invoke meanings of heritage, luxury, and narrative complexity.

Cognitive Aesthetics (Reber et al., 2004; Zeki, 1999): The more straightforward visuals are processed with more fluency, tending to create instant positive responses from the audience. Alternatively, more complex visuals require greater cognitive load; however, they can engage more profoundly when there is a balance of familiarity and cultural capital.

Cultural Capital (Bourdieu, 1984): The taste of various generations is influenced by educational level, social positioning as well as cultural exposure. Generation Z's globalized digital literacy, Millennials' hybrid cultural orientation, and older generations' traditional media foundation all collectively explain the differences in their aesthetic predispositions.

3. Literature Review:

Evidence suggests that minimalist advertising is useful in grasping the attention of audiences who place a premium on clarity and sophistication, especially among digital natives who are used to de-cluttered visual environments (Tuch et al., 2012). Conversely, complex advertising is likely to appeal to audiences who appreciate narrative complexity, symbolism, and cultural context (Phillips & McQuarrie, 2004).

Generational research identifies that Generation Z is highly invested in speed and authenticity when consuming media (Turner, 2015), whereas Millennials tend to want a harmony between complexity that arises from nostalgia and efficiency (Williams & Page, 2011). Older generations, in contrast, tend to prefer direct communication; however, visual density may be equated with precepts of tradition and prestige (Orth et al., 2010).

While previous literature has separately explored generational taste in equal measure, there is little comparative work analyzing minimalist and ornate aesthetic appeals within each of the three generations. That is what this study will seek to rectify.

4. Analysis

The analysis provided here sheds light on the fact that generational advertising preferences are not fixed or hardwired; instead, they become negotiated outcomes depending upon cognitive fluency, exposure to culture, and different levels of technological immersion at different stages of life. Minimalist versus sophisticated styles of advertising are not only choices in aesthetics; they are reflection points for more fundamental cognitive tendencies, cultural dispositions, and experiential environments. Every generation understands and appreciates advertising aesthetics in its own way, thus the need to comprehend how differences influence involvement and persuasiveness.

Generation Z and Cognitive Efficiency:

Generation Z, often described as being native to the digital world, have an intense bias toward plain and simple advertisement aesthetics, an issue that may be explained by Reber et al.'s (2004) theory of processing fluency. This theory suggests that people find aesthetic pleasure in stimuli that can be processed quickly and effortlessly. For Generation Z, who grew up in an environment of constant rapid digital information, simplicity is all about being efficient, which in turn translates to cognitive satisfaction. Simple designs with clean lines, minimal color usage, and brief textual components meet their demands for speed and clarity in communication. However, their tastes go beyond static simplicity; this generation also appreciates interactive, gamified, and visually dynamic ads, which point towards a more sophisticated appreciation of fluency. Here, fluency is not born out of simplicity alone but out

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of the compelling dynamics of interactivity, where elements like motion graphics, augmented reality, or touch navigation hold their interest. In turn, Generation Z moves between two seemingly opposing poles—simpleness and complexity—by favoring designs that reduce passive cognitive load while they increase active, playful engagement.

Millennials and Hybrid Aesthetics

Millennials adopt a clear dual orientation to advertising aesthetics that mirrors Bourdieu's (1984) idea of cultural capital in its hybrid state. Unlike Generation Z, who have been exposed to a world of computers since birth, Millennials' teenage years unfolded during the bridge era between analog and digital media. They grew up in an environment dominated by television, print, and nascent internet culture, then readily transitioned to the social media-paced, highly visual world of the 21st century. This combination of exposure allows them to operate on both simple and complex advertising platforms equally well. They value simple ads for their effectiveness, simplicity, and consistency with the digital ease that now permeates their adult existence. At the same time, they have a deep regard for rich symbolism, cultural allusions, and narrative complexity that define elaborate designs. Their hybrid taste therefore reflects their role as a "bridge" generation—able to appreciate the newness of contemporary, streamlined design while being responsive to the layered intricacy and storytelling nature of older media conventions. For Millennials, advertising aesthetics become a space of negotiation where clarity and cultural density exist in tandem rather than in opposition.

Older Generations and Cognitive Load

In contrast, older generations exhibit a more cautious approach toward visual complexity in advertising, a tendency that aligns closely with Zeki's (1999) neuroaesthetic theories. Zeki posits that when a stimulus induces cognitive strain, aesthetic pleasure diminishes, as the brain is compelled to exert effort beyond comfortable processing limits. For older adults, detail-overloaded advertisements, fast cuts, or too much symbolism tend to cause mental fatigue instead of interest. This drive for simplicity, straightforwardness, and few distractions in terms of design is therefore understandable. Yet, their distaste for things complicated is not unqualified; where rich advertisements deal with themes involving heritage, cultural memory, or status-based symbolism—e.g., imagery of tradition, craftsmanship, or national pride—older viewers have selective admiration. In such a case, complexity is not felt as daunting but instead as enriching, as it engages cultural familiarity and provokes emotional resonance based on personal and collective memory. This implies that their aesthetic preferences are not only dependent on cognitive ability but also on the significant compatibility of design with cultural values.

5. Summary:

Together, these findings suggest that advertising aesthetics cannot be standardized universally among demographic groups. What appeals to one age group can alienate another if visual techniques are not carefully calibrated to modes of cognitive processing and cultural milieu. Low-key advertising really speaks to younger viewers who see simplicity as a guarantor of efficiency; yet, it threatens to seem unoriginal or shallow to older audiences who take symbolic density as an imperative in certain cultural environments. On the other hand, more complex designs can appeal to Millennials and older generations using the vehicle of narrative and recollection; however, they can overwhelm Generation Z unless

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delivered through interactive or gamified media. The message is unequivocal: good advertising requires cultural and age tailoring. Companies need to work to find a balance between simplicity and richness, efficiency and symbolism, and simplicity and interactivity, depending on the audience segment they aim to target.

6. Findings:

Generation Z showed a clear tendency toward minimalistic advertisements, with 72% of the participants signaling that they prized qualities like "clarity," "modernity," and "speed." Conversely, it was noted that interactive and complex advertisements, i.e., gamified campaigns, generated more emotional activation among this group.

Millennials displayed a bifurcated set of tastes. Simple advertising was especially suited in the areas of tech and health, whereas intricate visual displays were favored in situations that involved retro or experience branding.

Among the older generations, a substantial 68% preferred simple, text-laden ads on the basis of clarity being a top priority. Although complex ads were generally described as "overwhelming," it was observed that heritage brands, including Rolex, and ads for cultural tourism were well-received when they utilized more complex formats.

7. Conclusion:

This article illustrates how advertising aesthetics are being read differently among generations as a result of differences in cultural capital, cognitive fluency, and technological immersion. Minimalism speaks most powerfully to Generation Z and portions of Millennials, whereas complex aesthetics continue to hold sway among heritage, luxury, and experience brands—particularly with Millennials and older generations.

Practice implications: Brands appealing to Gen Z should prioritize clean, unadorned visuals with varying degrees of interactive complexity. Adaptive approaches that combine minimalism with retro or narrative richness can work best with millennials. Older adults need simplicity but can be receptive to complex designs in high-status cultural contexts.

Implications for theory: The research adds to visual culture and semiotics through a demonstration of the ways in which advertising aesthetics are not only symbolic but also generationally located. Future studies might extend this model cross-culturally or consider changes in aesthetic preference over time.

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Chapter-40: A Landscape Of Culture And Haritage In Majuli- A Compehenchive Study

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Abstract

Majuli, the largest river island is gifted by Almighty to the earth. Its physical beauty attracts both the domestic and international world. It is situated in the middle point of the mighty Brahmaputra. The term "Majuli" composes into two words Ma means- Mother and Juli means- lap of Mother. Its land, river, natural beauty, Satra institutions, Mask making, Culture and Colourfull community are the tourist icon in Majuli. In this paper and attend has been made cultural and heritage of Majuli district, Assam.

Introduction:

Majuli is a river island in the northeastern Indian state of Assam. It is the world's largest river islandand at reassure of cultural identity and heritage. Situated in the Brahmaputra River, Majuli is famous not just for its scenery but also for its deep connection to Assamese culture, spirituality, and traditions.

Being an important cultural landmark of Assam, the island is, in fact, often called the cradle of Neo-Vaishnavism, a monotheistic religious movement founded by the saint-scholar Srimanta Sankardeva in the 15th century. Among other innovations the movement entailed the introduction of "Namghar", or prayer houses. These institutions are indeed vital to Majuli's socio-religious life. Satras The island is full of satras – Vaishnavite monasteries, which have evolved into centres of culture with religious teachings, traditional arts, crafts, and the Sattriya variety of dance and music.

Majuli's identity is as intricately connected to its heritage practices in forms of traditional agriculture, handloom weaving, pottery, mask-making, and boat-building. Theislandabounds with a life that bears uniqueness local tribal communities, such as the Mishing, Deori, and Sonowal Kachari-thus adding another layer to the rich mosaic of cultures across the island. Many communities maintained their indigenous customs, language, and festivals from generation to generation, which led to an evident uniqueness of cultural identity in the region.

The heritage of Majuli is at great challenges In preserving it, despite Its cultural wealth. On the island, severe erosion has been witnessed due to shifting Brahmaputra- losing land and livelihoods while threatening the survival of cultural institutions. As Majuli shrinks in size, growing concerns are there over the preservation of tangible as well as intangible heritage.

There have been a number of initiatives by the government and NGOs to sustain its culture and environments. In 2016, the government made Majuli a district which raised major attention towards its preservation requirement. The island is also placed under the preservation efforts. Majuli's cultural identity and heritage gives importance to the socio-cultural fabric of Assam. It is important to preserve this heritage against all challenges

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brought on by the environment and modernity in safeguarding, not only island legacy but people's heritage also.

Historical Background of Majuli District:

It is also a historical and cultural important island in the Brahmaputra River of the Indian state of Assam. It has recently been declared the world's largest river island and, in 2016, it was turned into a district. Here is a brief historical background of this island:

Early History:

Majuli was once a part of the main land but changed its course when Bhramaputra River took a disastrous turn in 13th century. This, over time, formed the island that exists today. From early times ,various tribal groups such as Mishing, Deori, and Sonowal Kacharis inhabited in the region, thus shaping its cultural and tradition lines.

Ahom Era (13th–19th Century)

Majuli, as a religious and cultural center under the Ahom dynasty that ruled from 1228–1826, was also the greatest importance in the 16th century with the rise of Neo-Vaishnavite movement initiated by the saint-scholar Srimanta Sankardeva. Sankardeva and his disciple, Madhavdeva, established many Sattras (monastic institutions), where Vaishnavism became a cause for spreading teachings of devotion to Vishnu. These Satras are also alive in the present and continue to be at the heart of the socio-cultural life of Majuli.

Colonial Periodor19th–20th Century

Majuli was ignored largely from the perspective of development but continued to hold significance in terms of culture. The agrarian society in the island was mainly dependent on agriculture, and Satras, which were the monasteries, functioned as centers of culture and education for the local people.

Post-IndependenceEraor20thCentury-Present

Even after independence, Majuli was incorporated into the district of Jorhat. However, it lost some considerable area to Brahmaputra River through years of constant erosion. Besides, constant floods made life tough for the people living on the island and decreased the area of Majuli significantly.

In 2016, the river island Majuli was announced to be a district. It was the first river island district of India. This move motivated on administrative independence and further improvement of its unique cultural heritage. Today, the religious and cultural legacy is coupled with ecological importance with rich varieties of flora and fauna.

Traditional arts and crafts are emerging, such as pottery and mask-making, and there is also rich spiritual tradition which attracts attention towards this land, especially in festivals like Raas Leela, a dance based on the life of Lord Krishna. The district marks a symbol of Assam's native culture and heritage.

Methodology in the Study:

As such, cultural studies often permit more elastic or free-form methodologies. In most cases Cultural studies researchers will employ a qualitative research method, meaning that they will be using Interested in the causation of events or in the fulfillment of their curiosity by answering questions, rather than in collecting a massive amount of data. The study has been conducted based on both primary and secondary sources of data. It has laid emphasis most on the secondary sources of data. Limited primary data is used. A primary

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source of data has been being collected from the field study and interview from the selected area and individual. Here Descriptive method, Historical method, are also used.

The secondary sources will include all short of published books, journels, magazines, articles and government records are used.

Objective of the Study :

The proposed study is intended to carry out the following objectives in view:

1. Identify the unique cultural identity of Majuli.
2. Study the role of Culture and Heritage in Community life.
3. Evaluate the threats to Cultural Heritage.
4. Propose Sustainable Strategies for Heritage Conservation.

Significance of the Study

There is a great need and significance of the study in relation to the "Cultural Identification and Heritage Preservation in the Majuli district". Some of its key aspects are:

1. Majuli, as this research will serve to support the policy-making process regarding Safeguarding Cultural Identity: The cultural heritage of Majuli carries with its specific legacy attached to it, primarily because of the Neo-Vaishnavite tradition and indigenous community existing there, which therefore needs immediate documentation and preservation.
2. Responsible Cultural Tourism: As tourism rises in Majuli, there is the need for balancing economic benefits with cultural authenticity to avoid commercialization and cultural loss.
3. Vulnerability to Environmental Threats: The island is vulnerable to environmental threats in terms of erosion and flooding induced by the Brahmaputra River, which also threatens both the landscape and regional culture.
4. Research Contribution Towards Empowering Supportive Policy and Preservation Programmes: This research will present critical views concerning heritage preservation policies and programmes concerning tangible and intangible assets in Majuli.
5. Preserving Intangible Heritage: Preserves intangible heritage that includes traditional crafts, festivals, and monastic practices related to preservation of the intangible elements of culture.
6. Promotion of Community-Based Preservation: Involvement of local communities in processes of preserving the site would induce efforts towards inclusive and sustainable preservation of culture, thus empowering the people of Majuli to preserve their cultural customs.

Cultural Identity in Majuli :

Cultural identity is, therefore, the common characteristics, values, and practices that define a group of people and distinguish them from others. This is molded by different elements, among which comes language, religion, traditions, customs, and historical experiences. Cultural identity provides individuals with a sense of belonging and connection to their heritage, hence influencing their worldview and how they interact within the society.

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Cultural identity is therefore one of the evolving concepts as each draws from the collective and individual experiences. It reflects a common belief and value that anchors a community but at the same time can be a dynamic concept changing with the currents of social, political, and economic contexts. For instance, when communities migrate or interact with others, cultural practices are likely to change with new additions while still maintaining a core element of their original identity.

Key Elements of Cultural Identity

Language: In the sphere of cultural identity, perhaps the very significant marker would be language, because it is both a means of communication and a conduit for carrying history, value, and tradition in a culture. The ability to speak a common language defines unity among people in a group, and maintaining the quality of language is always at the center of retaining one's cultural identity.

Religion and Spiritual Beliefs: Religion is important in the building of cultural identity. It touches on issues such as social norms, rituals, festivals, and moral values, which give a sense of belonging and community among people. Common religious practices unite the members of a culture, and festivals related to religion often symbolize the most significant expressions of culture.

Traditions and Customs: Tradition, rites and customs comprise the very fabric of a cultural identity that is passed from generation to generation. It conjures up the collective memory in terms of fairs, clothes, food, and fine arts.

Past and Heritage: The history of a community, its struggles, achievements, and shared experiences make all the difference to cultural identity. This gives one some kind of historical consciousness that helps collective memory and continuity as well as pride. Often enough, cultural identity is underpinned through monuments, literature, oral traditions, among other forms of historical preservation.

Social Values and Norms: Every culture gives values and norms by which its members guide their actions. These might include assumptions about forms of families, social roles, female/male expectations, and moral obligations. Common values strengthen feelings of unity and form a kind of social glue.

Key Elements of Culture:

- **Religious beliefs and practices (e.gVaishanavism)**

Majuli is the world's largest river island in Assam, India, in the Brahmaputra River. It is an important cultural and religious center, particularly of the Vaishnavite tradition. The religious teachings followed there are largely characterized by Vaishnavism, which is a stream of Hinduism, specifically that concerns the worship of Lord Vishnu, most importantly as his avatar Krishna.

Vaishnavism and the Role of Srimanta Sankardeva

The presence of Srimanta Sankardeva (1449–1568) imbues the island of Majuli with much spiritualism as an iconic saint, poet, scholar, and social reformer who established the **Ekasarana** Dharma, a monotheistic worship sect of Vaishnavism. Sankardeva propounded easy, non-ritualistic forms of worship that focused on being devoted to just one god, Lord Krishna. This practice of Vaishnavism also stressed the dignity of equality, opposed the bias

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of the caste system, and the ritualistic practices of the present day orthodox Hinduism. Sankardeva's religious message was propagated through Namghars (prayer halls) and **Sattras** (monastic institutions) and even today, remains a very effective pillar of religious activities in Majuli. The Namghar is a social gathering place with the conduct of prayers, hymns, and other religious discourses. In contrast, the Sattras are sacred places where the bhakats (monks) dwell, seek devotion, and spread the philosophy and cultural movement launched by Sankardeva.

The Vaishnavite religion and culture: Shrimanta Sankaradeva, a 16th Century religious preacher, social reformer, poet, musician and dramatist brought about a cultural renaissance in Assam through an institution known as Sattra (Vaishnavite monastery) which provided the venue and atmosphere for religious, social and artistic activities. This institution not only served as the vehicle for propagating Vaishnavite faith and religion but also helped in making the society free from blind religious dogmas, superstitions and ritualistic processes. After Shrimanta Sankaradeva, the faith was propagated by his two chief apostles Sri Madhavadeva and Sri Damodaradeva. 64 Sattras were established in the 16th and 17th century, of which only 22 remains at present. The rest have either been eroded away or had to be shifted to other places. Majuli is regarded as the nerve centre of Neo–Vaishnavite religion, art and culture.

The Sattras and their influence in ther eligious, cultural and social life of the people have made Majuli the principal seat of pilgrimage for all people in general and the Vaishnavites (followers of Vishnu, who has a thousand Names) in particular. Following are some of the prominent Sattras of Majuli-Auniati Sattra, Uttar Kamalabari Sattra, Dakhinpat Sattra, Natun Kamalabari Sattra, Garmur Sattra, Natun Samuguri Sattra, and Bengenaati Sattra.

- **Traditional Festivals and Rituals and their role in cultural Identity.:**

Majuli is not only known for its natural beauty but also due to vibrant cultural heritage. The island retains a high intensity of Vaishnavite culture with its traditional festivals and rituals determining an important part of the people's cultural identity. A selection of important festivals and rituals observed on Majuli follows:

Raas Mahotsav (Raas Leela):

Raas Mahotsav is one of the most significant festivals of Majuli, in which the life and teachings of Lord Krishna, especially his childhood and youth, are enacted with dance, drama, and music. The festival is performed elaborately because various Sattras of Majuli combine to perform an elaborate show. In most of the Satras Raas Mahotsav is celebrated. Along with these in private haals Rass Mahotsav is also organized.

Ali Ai Ligang:

This is the spring festival of the Mishing tribe, one of the indigenous communities in Majuli. This falls during February, which identifies with sowing paddy. The name "Ali" signifies seeds; "Ai" signifies fruits; and "Ligang" signifies sowing. Ali Ai Ligang is the celebration of agrarian life and the bond between human lives and nature. It is an integral part of the cultural identity of the Mishing community, where strong agricultural roots are preserved and sustainability is practiced. Traditional dances such as Gumrag go a long way in adding some fabulous folklore to Majuli.

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Deori Bihu:

The Deori people, another ethnic group, celebrate Deori Bihu as a festival, which like that of Assamese, Bohag Bihu, marks harvest time. The climax to the harvesting season necessitates this festival, hence, marking the beginning of a new agricultural cycle. The festival serves as a marker of cultural diversity in Majuli. It gathers the Deoris and emphasizes their special ethnic identity within the larger Assamese cultural texture.

Sattriya Dance and Rituals:

This is one of the classical dances of India and originates from the Vaishnavite Sattras of Majuli. The essence of this dance was predominantly performed as a religious ritual and drama with in the Sattras, but essentially included musical and narrative elements based on the life of Lord Krishna. Sattriya is not a dance system; it is their spiritual and artistic life. The practice of it helps in maintaining the legacy of Srimanta Sankardeva's teachings. Further, Vaishnavite tradition is maintained with the help of Sattras. These Sattras function like cultural and religious centers that maintain the island's religious identity.

Ankiya Bhaona (Srimanta Sankardeva's Plays) :

Majuli is known for its strenuous tradition of drama called Ankiya Bhaona, which Sankardeva started as a dramatization of the Bhagavata Purana stories. Such dramas are performed on special religious festivals and celebrations. These programs are vital in providing the youth with moral lessons and religious education. In the meanwhile, it helps sustain oral narration traditions and yet continues to imprint their cultural-spiritual personality.

Janmashtami

Lord Krishna's Birth-day, Janmashtami is another major festival of Majuli. Fasting, prayers, and cultural events are performed by the devotees in the Sattras. In every Namghar Janmastami is celebrated in a grand way. Janmashtami happens to be an important religious practice that heralds the fact that the people of Majuli are part and parcel of the Vaishnavite tradition. Participation of the village community at large during the celebrations gives importance to shared cultural heritage.

Palnamm

It is a five-day festival that starts on the Assamese 25th day of Kartika. It's a very important month in the Hindu calendar from mid-Oct to mid-November. Palnamm is celebrated in a grand way in the Auniati Satra. Thousands of pilgrims visit every year to witness this event. Nowadays, there is a ritual to offer "Salt" to the Lord, as there is a belief that the donation of salt is equivalent to the donation of gold.

- **Art and Crafts:**

Majuli, in particular, is known for its profound cultural heritage. Majuli is a wide and an excellent hub of traditional art and craft that reflects the island's history, spiritual practices, and tribal influences. Therefore, the craftsmanship in Majuli is closely tied to Vaishnavite heritage and indigenous traditions and daily life of this land. That they permit the confluence of religious devotion, environmental sustainability, and ethnic diversity.

Mask Making (Mukha Shilpa)

Majuli is known for its rich tradition in mask making, more particularly in the context of Vaishnavite Sattras. It is above all through the use of masks, of bamboo, clay, and cloth, that Ankiya Bhaona has been performed - a religious theatre form initiated by Srimanta

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Sankardeva. Samaguri Satra plays a vital role in the mask making practices. The raw materials applied to make the masks are natural like bamboo, clay, cow dung, and cloth and are painted with herbal colors.

Pottery

Majuli has had a long history of pottery, primarily by the 'Kumar' community. What makes pottery unique to Majuli is that they do not employ a potter's wheel; instead, pottery hand-shaped by an individual's hands through an ancient tradition passed down from generations. In many villages of Majuli pottery making is a means of livelihood for most of the people. One such type of village is Salmara,Sinatoli. It is hand-shaped and fired in open-air kilns, which is locally sourced and river clay. Pottery from Majuli is used for both everyday and religious usages. Cooking vessels, lamps, and water jars are mostly made; even during festivals, clay idols of the specific event are prepared for worship. Out of all crafts present, perhaps pottery work on Majuli is the most earth-friendly. There is a deep interaction with Mother Nature. This craft mainly survives through the help of female artisans and still meets the demands of utility as well as cultural demands.

Handloom Weaving

Weaving is one of the most significant crafts at Majuli, particularly among the Mishing tribe. These women are known to be more expert weavers, famous not only for their detailed hand woven cloth but also for the Eri and Muga silk. They made various traditional clothes. Fabric Used- Only the natural fibers of cotton, Eri(Ahimsa) silk and Muga silk, used exclusively in Assam are used. Natural dyes prepared from plants and herbs are mostly used to dye the fabrics. These traditional attires of the Mishing peoples-the Gadu, a thick woven shawl- and Ribi Gaseng, a hand woven wrap- are significant cultural emblems. Besides this, the clothing serves various functions in ceremonies, such as a wedding and festivals.

Boat Making

Being a river island in the middle of the Brahmaputra River, making boats is a most important craft here. The boats at Majuli are primarily made from wood and bamboo sourced locally and made through generation-to-generation technique. Most people from the kumar community were expertise in boat making. They take the boat making practice as a source of livelihood. In Salmara village we find a large number of such craftman.

Boats are an integral part of life in Majuli and are used for transportation, for fishing, and even on festivals and rituals. The craft reflects the deep connection of the reverie people with the river and their dependency on traditional knowledge to navigate the reverie landscape.

Conclusion :

The study concludes that with immense cultural, religious, and ecological importance in the district, the heritage of Majuli is under severe threat. The very identity of the island rests in the Vaishnavite traditions, the satras, and all indigenous art forms because it faces extreme environmental challenges, such as river erosion, frequent flooding, and climate change. All these led to the loss of land and important cultural sites, alongside socio-economic factors such as migration, modernization, and lack of adequate infrastructure and funding. Despite all this heritage, no coordinated, overall strategy of preservation has prevented the cultural assets of Majuli from being wasted. This is because traditional knowledge, art forms, and

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practices are gradually funding away from the place as younger generations are moving away or modernization changes the social fabric of the island. Tourism provides economic potential, but unregulated growth remains harmful to the balance between heritage and environment at Majuli.

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Chapter-41: Rice-beer Traditional Beverage of the Bodos

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Introduction

The Bodo community is the largest indigenous group in Assam. Linguistically they are Tibeto-Burman language family. In Assam the Bodos are in District of Kokrajhar, Chirang, Baksa, Udalguri, Sunitpur, Darrang, Golaghat, Karbianglong Kamrup and Goalpara. The Bodos are mainly agriculturist. Rice is the staple food of the Bodos.The Bodos are rich in their traditional culture. Zou (rice-beer) is the traditional beverage of the Bodos. The Bodos celebrate rice-beer in their festivals and ceremonies.

Aims and Objectives of the study:

- The study aims to attempt the indigenous knowledge of the Bodo women to prepare rice-beer.
- The study aims to cultural significance of rice-beer of the Bodos.

Methodology:

Descriptive methods are used in the study. Both primary and secondary sources are used in the study.

Area of the study : The study is Bodos of Dudhnoi area

Explanation:

The Bodos are mainly agriculturist. In a year ,they practice two types of paddy cultivation *Asu* and *Sali* .The Bodos are the hard worker.They takes rice-beer to alleviate the fatigued body after work. Rice-beer is the traditional beverage of the Bodos. The Bodos celebrate rice-beer in their festivals and ceremonies. *Boikhagw* (Boisagu in standard language) is the seasonal as well as agricultural festival of the Bodos. In earlier the Bodos celebrate Boisagw festival in one month. Now the Bodos celebrate Boisagw in seven days from last sangkranti of Chaitra. The Bodos celebrate Boisagw festival with dancing, singing , merry-making and take variety of rice-beer. Magw-Domasi is the harvest festival of the Bodos. In this festival they take community feast called *Bhelagur zanai* and celebrate with different types of cakes and rice-beer.

Ceremonies like birth ,marriage , death and agricultural ceremonies i.g. first paddy plantation ceremony *Gosa Lanai* and last paddy plantation ceremony *Hal Zangkhra* are celebrate with rice-beer.

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The Bodo women have the traditional knowledge to prepared rice-beer which is transfer traditionally from one generation to another generation. They prepared two types of rice-beer *Gisi and Goran* (***Jonga*** and ***Khawnai*** zou in Bodos of Goalpara). Both two types of rice-beer are made of Matha Mairong(normal rice) and Maibra Mairong (sticky rice). Emao is the key medicine to prepared rice-beer.

Material used of rice-beer:

- Rice: matha mairong(normal rice) and maibra mairong(sticky rice)
- Emao :key medicine to prepared rice-beer
- Jonga :rice-beer preserve pitcher

- **Traditional knowledge prepared to rice-beer:**

Emao : *Emao* is the traditional fragmented cake prepared *zou* (rice-beer) of the Bodos. *Emao* is the key medicine to prepared rice-beer.The Bodo women made *emao* with their indigenous knowledge which is transfer from generation to generation. The *emao* is made from the *matha mairong* (normal rice). The Bodo women have the good skill to made *emao.*Firstly *matha mairong* is to soak in water from 1 to1/ 2 hours . After soak they collect the rice from water to be dry. When the rice completely dry then grain in *uwal* (mortar*)* with mixing of wild leaves like-khuser bilai, seni bilai ,anaros bilai, makhana bilai and fanlu goran. When the grained complete then mix with the water and bake the cake of emao. On the new emao, *gornoi emao mukhang gundra* (two old emao powder) sprinkle and cover with paddy straw and preserved for three nights. After that they dry for sun hit for few days and the emao is ready to prepare rice-beer.

- **Jonga zou:** This rice-beer is made from the *matha mairong* (normal rice). To prepared *jonga zou* (rice-beer) , rice is cooked in dryly. After that the rice is poured into the winnower to be cool.When the rice is cool , one or two emao is mix with rice and preserved the jongga for three to five days to ready for rice-beer.

- **Khaonai zou:** To prepared this rice-beer , the ripe rice-beer is soak with water hall night in a big pot . In next day the soak rice-beer big pot place on the oven to cooked. On the top of the big pot, a pot called *makhra du* is place and the top of makhra du , a pot is place to preserved cool water . The joining is plaster with *Jujai* and *sofari* . After that the fire is hit to slowly. Become to hit of fire, rice-beer '*sofari'* become hot and exchange to fogg and hit the makhra du and drop through pipe in the bottle. In this way the *Khaonai Zou* (dry rice-beer) is prepared.
- **Maibra Zou**: This rice-beer is prepared from the maibra mairong (sticky rice). The Bodo women have the traditional knowledge to prepared *maibra zou* (sticky rice-beer). To prepared the *maibra zou* the Bodo women *steamed* the sticky rice.When the rice is cooked they poured steamed sticky rice to winnower to be cool. After cool they mix with the Emao ¼ part and preserved in jonga. After fifteen to twenty days the maibra zou is ready to

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drink. The Bodos preserved the *Maibra zou* (sticky rice-beer) from one to three month.

Cultural significance:

- **Hospitality:** In earlier days the Bodos welcome the guest through rice-beer. This tradition is still now. They filled joyfully to hospitality their guest with *maibra rusi* (juice of sticky rice-beer) .The Bodos offer *maibra rusi* to their one own or beloved in occasion of fairs and festivals.
- **Fairs and Festivals:** The Bodos celebrate *Seasonal and Agricultural* festival *Boikhagu , Harvest festival Magu-Domasi and Religious festivals Kherai*.They also celebrate *Birth ,Marriage ,Death and agricultural ceremonies*.

  i. **Boikhagu** : *Boikhagu* is the greatest seasonal and agricultural festival of the Bodos.This festival is start from last *sankranti of Chaitra* and continue to seven days. On the first day of *Boikhagu* the Bodos clean their houses from inner to courtyard and offer a puja to *chief God Bathou* with rice-beer juice. The Bodos celebrate *Boikhagu* with drinking rice-beer ; dancing ,singing and marry-making.

  i. **Magu-Domasi**: *Magu-Domasi* is the harvest festival of the Bodos.This festival is start from the last *sangkranti of Push* .They take a community feast called *Bhelagur* with rice-beer.
  ii. **Kherai** : *Kherai* is the greatest religious festival of the Bodos. *Bathou* is the chief God of the Bodos. Including Bathou the Bodos offer *eighteen* kind of God and Goddesses of the Kherai. In this puja *zou rosi* (rice-beer juice) is offer of the named of *Bathou Borai.*
  iii. **Ceremonies** : Ceremonies like *birth ,marriage and death* they take the rice-beer. Agricultural ceremonies like *Gosa lanai*(first plantation of paddy) , *hali uthinai* (ending day of paddy plantation) and *engkham gadan zanai* (new rice ceremony) ,the Bodos enjoy with rice-beer.

Medicine:

The Bodos used rice-beer as medicine too. When urine become red then they drink the *jonga zou* and relieved from it. When in indigestion then they take the *Khaonai zou* and relieved .The Bodos are the hard worker. When they filled weak, they take rice-beer and refresh their body. The Bodos practice their cultivation with pair of bulk. When the bulk is become weak then they give to eat *emao* (rice-beer prepared medicine) powder to bulk to become strong .

Conclusion :

Rice-beer is the traditional beverage of the Bodos. The Bodo . *Emao* is the key medicine to prepared rice-beer. *Emao* is made by some wild herb.The Bodos celebrate rice-beer in their *festivals* and *ceremonies*. The Bodos hospitality their guest and beloved one with rice-beer.Traditional rice-beer *zou Gwran , Mibra zou Bidwi and zou Gisi* are got GI Tag refers to

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Geographical Indication tags granted to Bodo cultural products from Assam, India October 2024.

Now the variety of wine is available in the market. But still now the traditional rice-beer *zou* is importance in the Bodo society.

PHOTO GALLARY

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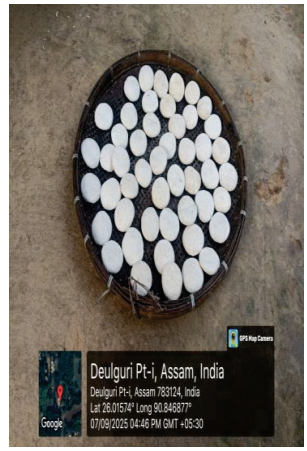
Zoumai



Emao

Pouring the rice

Emao mix to prepared rice-beer

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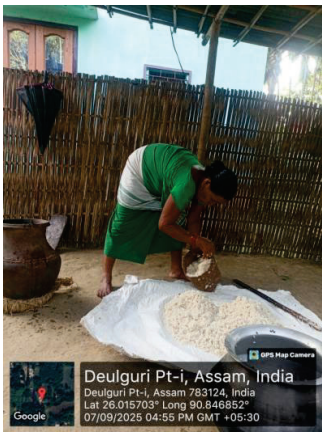
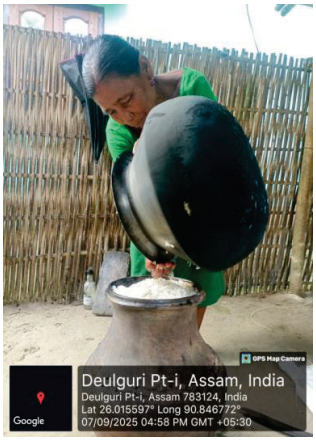
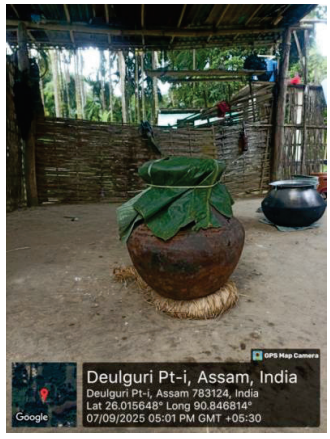


Entry Zoumai to Jongga



Pouring the Hasung Doi in Jongga



Jonga zou

Khaonai zou

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