View of Space International Multidisciplinary Journal of Applied Research
ISSN (Print): 2320-7620
"Peer Reviewed & Refereed Journal"

Dr. Mital Patel	Dr. Alkesh Vachhani	Prof. Vijay Bhatu
Managing Editor	Editor In Chief	Editor

ABOUT JOURNAL

View of Space International Multidisciplinary Journal of Applied Research (ISSN (P): 2320-7620) is a peer-reviewed and refereed international academic journal dedicated to the promotion and dissemination of high-quality research across diverse disciplines. The journal serves as a global platform for scholars, researchers, academicians, and industry professionals to present innovative research findings and practical applications that contribute to knowledge advancement and societal development.

The journal adopts a multidisciplinary approach, encouraging submissions from fields such as Social Sciences, Humanities, Management, Commerce, Education, Science and Technology, Engineering, Environmental Studies, Law, Health Sciences, and related interdisciplinary domains. By fostering cross-disciplinary dialogue, the journal aims to bridge theoretical frameworks with real-world applications.

View of Space follows a rigorous double-blind peer review process to ensure originality, academic integrity, and research excellence. The editorial board comprises experienced scholars and subject experts who maintain high ethical standards and publication quality. The journal is committed to timely publication, transparency in review procedures, and the promotion of open academic exchange.

AIMS & SCOPE

View of Space International Multidisciplinary Journal of Applied Research aims to publish high-quality, peer-reviewed research that promotes academic excellence and practical innovation across multiple disciplines. The journal encourages interdisciplinary studies and accepts original research articles, reviews, and applied research in areas such as Social Sciences, Humanities, Education, Management, Commerce, Science, Technology, Engineering, Law, Health Sciences, Environmental Studies, and related fields.

View of Space International Multidisciplinary Journal of Applied Research
ISSN (Print): 2320-7620
"Peer Reviewed & Refereed Journal"

DETAILS OF JOURNAL	
Journal Title	View of Space International Multidisciplinary Journal of Applied Research
Starting Year	**2013**
Frequency	Monthly
Publication Format	**Print**
Subject Area	Multidisciplinary
Language	Multiple Languages
Publisher Name	Ananta Group of Journals
Publisher Address	Block No. 503, Shree laxmi palace, Zanzarda Road, Junagadh – 362001, Gujarat, India
Publisher Email	anantagroupofjournals@gmail.com

Published By
ANANTA GROUP OF JOURNALS
Block No. H-10, Janakpuri Apartment,
Zanzarda Road, Junagadh – 362001, Gujarat, India
Email: anantagroupofjournals@gmail.com
Dr. Mital Patel - 9879422702
Website: https://anantagoj.org/

View of Space International Multidisciplinary Journal of Applied Research

ISSN (Print): 2320-7620

"Peer Reviewed & Refereed Journal"

ISSN CERTIFICATE

NATIONAL INSTITUTE OF SCIENCE COMMUNICATION
AND INFORMATION RESOURCES
(Council of Scientific and Industrial Research)
14, Satsang Vihar Marg, New Delhi 110 067 &
Dr. K. S. Krishnan Marg (Near Pusa Gate) -110 012

Ms. V. V. Lakshmi, Head, National Science Library
Phone: 91-11-2686 3759
E-mail: vvlakshmi@niscair.res.in website: www.niscair.res.in

NSL/ISSN/INF/2013/571 **Date : 11.3.2013**

Mr. Alkesh R. Vachhani
503, Shri Laxmi Palace Near, Jogi Patrol Pump
Junagadh

Dear Sir/ Madam,

We are happy to inform you that the following serial(s) published by you has been registered and assigned ISSN (Print)

ISSN 2320 – 7620 View of Space : International Multidisciplinary Journal of Applied Research

It is important that the ISSN should be printed on every issue preferably at the right hand top corner of the cover page.

The Indian National Centre will be responsible for monitoring the use of ISSN assigned to Indian Serials and for supplying up to-date data of the same to the International Centre for ISSN, Paris. For this purpose we request you to send us the forth coming issue of your serial on complimentary basis.

We solicit your co-operation in this regard.

Yours sincerely,

V.V. Lakshmi

(V.V. Lakshmi)
Head
National Science Library

Please don't forget to send a sample issue of the journal/URL with ISSN printed on it.

Contact : Ms. Shobhna Vij
e-mail : issn.india@niscair.res.in
phone : 011-26516672

View of Space International Multidisciplinary Journal of Applied Research
ISSN (Print): 2320-7620
"Peer Reviewed & Refereed Journal"

EDITORIAL BOARD

Sr. No.	Full Name	Designation	Institution
1	**Dr. Nadia Benbouzid**	Associate Professor	University Of Greenwich London Campus.
2	**Prof. Mark Tushnet**	William Nelson Cromwell Professor of Law (Emeritus)	Harvard Law School, Harvard University, USA
3	**Dr Kashyap Raval**	Sr Lecturer	Nestle Health Science, New Jersey, USA
4	**Dr Shazerinna Shah**	Sr Lecturer	University Of Greenwich London Campus.
5	**Dr. Prince Dwomoh**	Principal	University of Ghana
6	**Dr. M. Sajid Mirza**	Research Dean	International Islamic University Islamabad
7	**Dr. Yunjin Choi**	Research Dean	Seoul National University (SNU)
8	**Dr. Ritesh P. Vaidya**	Pro-President (Academics)	Madhav University-Bhilvara(Raj.)
9	**Dr. Sumer Singh**	Research Dean	Singhania University, Rajasthan
10	**Dr. Ashishkumar Rami**	Research Dean	Swaminarayan University – Kalol (Guj.)
11	**Dr. Shivam Chaudhari**	Research Dean	Gokul Global University – Siddhpur (Guj.)
12	**Dr. Rahul Joshi**	Research Dean	Noble University – Junagadh (Guj.)
13	**Dr. Khushbhu Shah**	Research Dean	Silver Oak University – Ahmedabad (Guj.)
14	**Dr. S. J. Jameela**	Professor & Head	Justice Basheer Ahmed Sayeed College for Women - Chennai
15	**Dr. Haseena S.**	Professor	Justice Basheer Ahmed Sayeed College for Women - Chennai
16	**Dr. Yogesh Kumar Gupta**	Professor & Head	New Media Central University of Himachal Pradesh, Dharamshala
17	**Prof. (Dr.) Manoj Kumar Saxena**	Head & Dean	Central University of Himachal Pradesh, Dharmashala (HP)

18	**Dr. Yogendra Kumar**	Principal	Central University of Himachal Pradesh, Dharmashala (HP)
19	**Dr. Hashmukhbhai Patel**	Principal	Mahila College - Unjha
20	**Dr. Heena Patel**	Principal	Maniben M. P. Shah College – Kadi
21	**Dr. Alpesh Sinojiya**	Principal	Taxshila Bed College – Halvad
22	**Dr. Sanjay Radadiya**	Principal	B. J. Vanijya Mahavidyalaya (Autonomous) – Vallabh Vidyanagar
23	**Dr. Shital Gujarathi**	Principal	Dr. Moonje Institute Of Management And Computer Studies, Nashik (Maharashtra)
24	**Dr. Mehulkumar Mistry**	Principal	Sardar Patel College of Commerce - Anand
25	**Dr. Bhavsinh Dodia**	Professor & Head	BKNMU, Junagadh
26	**Dr. Suhas Vyas**	Professor & Head	BKNMU, Junagadh
27	**Dr. Bhumik Upadhyay**	Professor & Head	Siddharth law college - Gandhinagar
28	**Dr. Praful Kanjia**	Professor & Head	M.M. Ghodasara Mahila Arts and Commerce College-Junagadh
29	**Dr. Mayur Patel**	Professor & Head	Swaminarayan University-kalol
30	**Dr. Jatin H. Rajdeep**	Professor & Head	Shri B. K. Patel Arts & Smt. L. M. Patel Commerce College, Savli
31	**Dr. Amul Kotadia**	Associate Professor	Noble University-Junagadh
32	**Dr. Bharat Kher**	Associate Professor	Saurashtra University -Rajkot
33	**Dr. Mayuri Rathod**	Associate Professor	Dr. Subhash University
34	**Dr. Chiragbhai Darji**	Associate Professor	Children's Research University
35	**Dr. Vaishali Parsania**	Associate Professor	VVP Engineering - Rajkot
36	**Dr. Nilesh Gambhava**	Associate Professor	Adiwasi Arts & Commerce College, Santrampur

37	**Dr. Pratik jangid**	Associate Professor	Janardan Rai Nagar Rajasthan Vidyapeeth, (Deemed To Be University) Udaipur
38	**Dr. K. K. Trivedi**	Associate Professor	Janardan Rai Nagar Rajasthan Vidyapeeth, (Deemed To Be University) Udaipur
39	**Dr. Sarita Soy**	Associate Professor	Dr. Harisingh Gour Vishwavidyalaya – sagar (MP)
40	**Dr. Raj Kamal**	Associate Professor	Singhania University, Rajasthan

INDEX

SR.NO.	TITLE & AUTHOR	PAGE NO.
1	PRELIMINARY STUDY OF ANTIOXIDANT AND ANTI-NUTRITIONAL ACTIVITY OF SELECTED SEAWEEDS (MONOSTROMA, ULVA FASCIATA AND GRACILARIA DEBILIS) FOR NUTRACEUTICAL DEVELOPMENT DR. ISHITA PATEL	1 TO 5
2	A QUALITATIVE COMPARATIVE STUDY OF CORPORATE SOCIAL RESPONSIBILITY IN PUBLIC AND PRIVATE SECTOR BANKS DR. HASMUKHBHAI B. PATEL	6 TO 12
3	EXPLORING THE OPPORTUNITIES OF ARTIFICIAL INTELLIGENCE IN FINANCE, MANAGEMENT, COMMERCE, AND HUMANITIES DR. MEHUL MISTRY	13 TO 18
4	COLONIAL CULTURE AND THE CRISIS OF IDENTITY: A FANONIAN ANALYSIS OF ALIENATION AND RESISTANCE DR. BISHAL BHATTACHARYA	19 TO 27
5	THE IMPACT OF SOCIAL MEDIA MARKETING ON CONSUMER PURCHASE BEHAVIOUR DR. ISHITA G. DODIA	28 TO 33
6	A COMPREHENSIVE AND DETAILED REVIEW OF ADENOVIRUS AND RABIES VIRUS: MORPHOLOGY, CULTIVATION, PATHOGENESIS, CLINICAL FEATURES, DIAGNOSIS, AND PROPHYLAXIS POOJA YADAV	34 TO 39
7	ROLE OF AI IN INDIAN ACCOUNTING SYSTEM DR. SURBHIBEN AMRUTLAL PARMAR	40 TO 45

SR.NO.	TITLE & AUTHOR	PAGE NO.
8	DIGITAL TRANSFORMATION AND TAX REFORMS IN INDIA: AN EMPIRICAL STUDY OF GST 2.0 AND THE INCOME-TAX ACT, 2025 CHIRAG H. JARIWALA	46 TO 50
9	INTEGRATED DIGITAL LIBRARY ECOSYSTEMS IN INDIA: A SEQUENTIAL EXPLORATORY STUDY OF TECHNOLOGY, USER BEHAVIOR, AND INSTITUTIONAL PERFORMANCE DR. NARENDRA DUDHABHAI PARMAR	51 TO 55
10	SURFACE PROPERTY AND PHOTO-CATALYTIC ACTIVITY OF GRAPHENE OXIDE-TITANIUM DIOXIDE NANOCOMPOSITES DR. MUKESH MISHRA	56 TO 65
11	CYBERSECURITY IN THE AGE OF DIGITAL TRANSFORMATION RAJYAGURU CHETAV	66 TO 71
12	TRANSFORMING HIGHER EDUCATION THROUGH ICT: ENHANCING TEACHING, LEARNING, AND ACCESSIBILITY DR. AALAP R. SUTHAR	72 TO 77
13	RIGHT TO EDUCATION AS A HUMAN RIGHT: LEGAL PERSPECTIVES FOR GLOBAL TRANSFORMATION RIDDHI MUKESHBHAI SEVAK PROF. DR. HEMANTKUMAR KANTILAL PATEL	78 TO 84
14	ELECTROCHEMICAL EXPOSURE OF UNDERWATER CARBON DIOXIDE BY NH_2 FUNCTIONALIZED ELECTRODE ANKIT J SHAH	85 TO 89
15	ARTIFICIAL INTELLIGENCE AS A STRATEGIC ENABLER IN FINANCIAL DECISION-MAKING: AN EMPIRICAL INVESTIGATION OF AWARENESS, ADOPTION, AND PERCEIVED IMPACT DR. RAKESHKUMAR C. PATEL	90 TO 100
16	ASSESSMENT OF WATER QUALITY INDEX FOR DEESA CITY, GUJARAT, INDIA CHAVDA PRATIKSINH SAMRIYA JAYPRAKASHPATEL DILIPKUMAR DESHPANDE AJINKYA PATEL PRAJESH	101 TO 110
17	NEGOTIATING THE SPILLOVER: A COMPARATIVE THEMATIC ANALYSIS OF WORK–LIFE BALANCE AMONG FEMALE TEACHERS ACROSS LIFE STAGES SUBHASHINI SUNDARA RAMAN	111 TO 124

SR.NO.	TITLE & AUTHOR	PAGE NO.
18	CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY MISS. UNNATI S. CHAUHAN	125 TO 135
19	JUSTICE IS RIGHT: A CONSTITUTIONAL AND SOCIO-LEGAL ANALYSIS DR. BHAUMIK P. UPADHYAY	136 TO 139
20	THERMAL AND BIOLOGICAL ASPECT ON NI(II) BASED COMPLEXES K S PATEL	140 TO 149

PRELIMINARY STUDY OF ANTIOXIDANT AND ANTI-NUTRITIONAL ACTIVITY OF SELECTED SEAWEEDS (MONOSTROMA, ULVA FASCIATA AND GRACILARIA DEBILIS) FOR NUTRACEUTICAL DEVELOPMENT

DR. ISHITA PATEL
I/C PRINCIPAL, DR. I. P. PATEL INSTITUTE OF ALLIED HEALTH SCIENCES AND RESEARCH, ANAND, GUJARAT, INDIA

ABSTRACT

Marine macroalgae, commonly referred to as seaweeds, have gained significant scientific interest due to their nutritional composition and abundance of biologically active compounds. Seaweeds contain various bioactive molecules such as polyphenols, polysaccharides, carotenoids, vitamins, and minerals that exhibit strong antioxidant properties. The present study investigates the antioxidant and anti-nutritional activities of three marine seaweed species—**Monostroma**, **Ulva fasciata**, and **Gracilaria debilis**—collected from the Gujarat coastline of India. Antioxidant activity was evaluated using ABTS radical scavenging assay, DPPH free radical scavenging assay, total antioxidant activity (TAA) using phosphomolybdate method, and ferric reducing antioxidant power (FRAP) assay. In addition, anti-nutritional compounds including terpenoids, phytic acid, and saponins were analyzed. The results revealed that all three seaweed species possess significant antioxidant properties with varying levels of activity across different assays. Among the studied species, Ulva fasciata exhibited comparatively higher antioxidant activity, which may be attributed to the presence of phenolic compounds and pigments such as carotenoids. Anti-nutritional components were detected but were present within acceptable limits, suggesting potential suitability for nutraceutical and dietary applications. The findings highlight the potential of marine seaweeds as natural sources of antioxidants and functional compounds that can be utilized in nutraceutical product development. Further research focusing on isolation of active compounds, toxicity evaluation, and large-scale production is required for commercialization of seaweed-based nutraceuticals.

KEYWORDS: MARINE MACROALGAE, ANTIOXIDANT ACTIVITY, NUTRACEUTICALS, SEAWEED BIOACTIVE COMPOUNDS, ANTI-NUTRITIONAL FACTORS

1. INTRODUCTION

Marine ecosystems are rich sources of biologically active compounds with potential applications in food, pharmaceutical, and cosmetic industries. Among marine organisms, **seaweeds or marine macroalgae** represent one of the most abundant renewable resources in coastal ecosystems. Seaweeds are photosynthetic organisms that grow attached to rocks and other substrates in marine environments and play an essential role as primary producers in aquatic ecosystems. They contribute significantly to marine biodiversity and serve as important components of the marine food chain.

Seaweeds are broadly classified into three major groups based on their pigmentation and biochemical composition: **green algae (Chlorophyta), brown algae (Phaeophyceae), and red algae (Rhodophyta)**. These organisms possess unique metabolic pathways that allow them to synthesize a wide range of secondary metabolites, many of which are absent in terrestrial plants. Such metabolites include polysaccharides, polyphenols, carotenoids, sterols, vitamins, proteins,

and essential minerals. These compounds are responsible for the diverse biological activities associated with seaweeds, including antioxidant, antimicrobial, anti-inflammatory, anticancer, and antidiabetic properties.

Over the past few decades, there has been growing interest in the use of natural antioxidants derived from marine resources. Oxidative stress caused by excessive production of reactive oxygen species (ROS) is known to damage cellular components such as lipids, proteins, and nucleic acids. ROS include superoxide anions, hydroxyl radicals, and hydrogen peroxide that are generated during normal metabolic processes or due to environmental stress factors such as UV radiation and pollution. Excessive ROS accumulation has been linked to several chronic diseases including cardiovascular diseases, neurodegenerative disorders, diabetes, and cancer.

Antioxidants play a critical role in neutralizing free radicals and protecting biological systems from oxidative damage. Synthetic antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been widely used in the food industry to prevent oxidation of lipids and improve shelf life. However, concerns regarding the potential toxicity and carcinogenic effects of synthetic antioxidants have led to increased interest in natural alternatives.

Marine macroalgae have emerged as promising sources of natural antioxidants due to their high content of phenolic compounds, carotenoids, and polysaccharides. Several studies have demonstrated that seaweed extracts possess strong radical scavenging activity and reducing power, making them suitable candidates for the development of nutraceutical products.

In addition to antioxidant compounds, seaweeds also contain certain **anti-nutritional factors** such as phytic acid, saponins, and terpenoids. These compounds may interfere with nutrient absorption when present in high concentrations, but they can also exhibit beneficial biological activities including antimicrobial and anti-inflammatory effects.

Seaweeds have been consumed traditionally in many Asian countries such as Japan, China, and Korea where they are used as food ingredients and dietary supplements. Their popularity is now increasing worldwide due to their nutritional value and potential health benefits. The global seaweed industry has expanded rapidly in recent years with applications in food processing, pharmaceuticals, agriculture, and cosmetics.

The present study focuses on evaluating the antioxidant and anti-nutritional activities of three seaweed species—**Monostroma**, **Ulva fasciata**, and **Gracilaria debilis**—collected from the Gujarat coast of India. These species were selected due to their availability and potential applications in nutraceutical development.

2. MATERIALS AND METHODS

2.1 Sample Collection and Identification

Seaweed samples belonging to different taxonomic groups were collected from coastal regions of Gujarat including **Adri, Okha, and Veraval**. The samples were transported to the laboratory in seawater under refrigerated conditions to prevent degradation. After collection, the seaweed

samples were washed thoroughly with tap water to remove sand particles, epiphytes, and other impurities. The cleaned samples were shade-dried and stored at −80°C until further analysis.

2.2 Preparation of Seaweed Extract

Dried seaweed samples were ground into fine powder using a laboratory grinder. The powdered samples were used to prepare extracts containing polysaccharides and other bioactive compounds. Different concentrations of seaweed extracts were prepared for antioxidant assays.

2.3 Antioxidant Assays

2.3.1 ABTS Radical Scavenging Assay

ABTS radical scavenging activity was determined using the method described by Hazra et al. ABTS radicals were generated by reacting ABTS diammonium salt with potassium persulfate solution. The mixture was incubated in the dark at 4°C to produce a stable radical cation solution. The solution was diluted to obtain an absorbance of 0.70 ± 0.02 at 734 nm. Various concentrations of seaweed extracts were mixed with the ABTS solution and incubated in the dark. The absorbance was measured spectrophotometrically to calculate radical scavenging activity.

2.3.2 DPPH Radical Scavenging Assay

The DPPH assay was used to evaluate free radical scavenging activity of seaweed extracts. A methanolic solution of DPPH was prepared and mixed with different concentrations of seaweed extract. The mixture was incubated in the dark at room temperature, and absorbance was measured at 517 nm. The decrease in absorbance indicated the ability of the extract to neutralize free radicals.

2.3.3 Total Antioxidant Activity (TAA)

Total antioxidant activity was measured using the phosphomolybdate method. The reagent solution contained ammonium molybdate, sodium phosphate, and sulfuric acid. Seaweed extracts were incubated with the reagent mixture in a water bath at 100°C for 60 minutes. After cooling, absorbance was measured at 765 nm.

2.3.4 Ferric Reducing Antioxidant Power (FRAP)

The FRAP assay was used to determine the reducing power of the seaweed extracts. This method measures the ability of antioxidants to reduce ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}). Higher absorbance indicates greater reducing power and antioxidant potential.

2.4 Analysis of Anti-Nutritional Factors

Anti-nutritional compounds such as **terpenoids, phytic acid, and saponins** were analyzed using standard biochemical methods. These compounds may influence the nutritional quality of seaweeds but may also contribute to biological activities.

3. RESULTS AND DISCUSSION

The antioxidant activities of the selected seaweed species were evaluated using four different assays: ABTS, DPPH, TAA, and FRAP. Each assay measures antioxidant activity using different mechanisms, providing a comprehensive assessment of the antioxidant potential of the seaweed extracts.

The ABTS assay demonstrated that all three seaweed species exhibited notable radical scavenging activity. Among the tested species, **Ulva fasciata** showed comparatively higher antioxidant activity, followed by **Gracilaria debilis** and **Monostroma**. The observed activity may be attributed to the presence of phenolic compounds and pigments such as carotenoids that are known to possess strong antioxidant properties.

The DPPH assay also confirmed significant free radical scavenging activity of the seaweed extracts. The ability of the extracts to reduce the purple DPPH radical to a yellow-colored product indicates the presence of hydrogen-donating antioxidants.

Similarly, the FRAP assay demonstrated that the seaweed extracts possess reducing power, which reflects their ability to donate electrons and neutralize reactive species. The results suggest that these seaweeds contain compounds capable of reducing oxidative stress.

The phosphomolybdate assay indicated substantial total antioxidant activity in the extracts. The antioxidant activity observed in this study may be associated with the presence of polyphenols, polysaccharides, and pigments commonly found in marine macroalgae.

In addition to antioxidant activity, the study also evaluated anti-nutritional compounds such as **terpenoids, phytic acid, and saponins**. These compounds were present in varying concentrations across the studied species. Although anti-nutritional factors may interfere with nutrient absorption when present in large amounts, they can also provide beneficial effects such as antimicrobial and antioxidant activity.

Seaweeds are increasingly recognized as promising sources of nutraceutical ingredients due to their nutritional value and bioactive compounds. Their high mineral content, dietary fiber, and antioxidant compounds make them suitable for incorporation into functional foods and dietary supplements.

The results obtained in this study support the potential use of marine seaweeds as natural sources of antioxidants for nutraceutical applications.

4. CONCLUSION

The present investigation demonstrated that the seaweed species **Monostroma**, **Ulva fasciata**, and **Gracilaria debilis** possess significant antioxidant activities. The presence of bioactive compounds such as polyphenols, carotenoids, and polysaccharides contributes to their ability to scavenge free radicals and reduce oxidative stress.

Although anti-nutritional compounds such as phytic acid, saponins, and terpenoids were detected, their levels were within acceptable limits for dietary consumption. These compounds may also contribute to biological activities beneficial for human health.

The findings of this study highlight the potential of marine seaweeds as valuable resources for the development of nutraceutical products and functional foods. Further research focusing on purification of active compounds, toxicity evaluation, and clinical studies will help establish their safety and effectiveness.

The commercialization of seaweed-based nutraceuticals may provide sustainable and natural alternatives to synthetic antioxidants while contributing to the growing demand for functional foods and health supplements.

REFERENCES

Gupta, S., & Abu-Ghannam, N. (2011). Bioactive Potential And Possible Health Effects Of Edible Brown, Red, And Green Seaweeds. Food Science And Technology, 44(4), 872–878.

Holdt, S. L., & Kraan, S. (2011). Bioactive Compounds In Seaweed: Functional Food Applications And Legislation. Journal Of Applied Phycology, 23(3), 543–597.

Chakraborty, K., Praveen, N. K., & Vijayan, K. K. (2013). Antioxidant Activity Of Marine Macroalgae: A Review. Indian Journal Of Marine Sciences, 42(3), 264–273.

Manivannan, K., Thirumaran, G., Karthikai Devi, G., Hemalatha, A., & Anantharaman, P. (2008). Biochemical Composition Of Seaweeds From Mandapam Coastal Regions Along Southeast Coast Of India. American-Eurasian Journal Of Botany, 1(2), 32–37.

Rajauria, G., Jaiswal, A. K., Abu-Ghannam, N., & Gupta, S. (2010). Effect Of Hydrothermal Processing On Colour, Antioxidant And Free Radical Scavenging Capacities Of Edible Irish Brown Seaweeds. International Journal Of Food Science & Technology, 45(12), 2485–2493.

Devi, G. K., Manivannan, K., Thirumaran, G., Rajathi, F. A. A., & Anantharaman, P. (2008). In Vitro Antioxidant Activities Of Selected Seaweeds From Southeast Coast Of India. Asian Pacific Journal Of Tropical Medicine, 1(2), 1–5.

Matanjun, P., Mohamed, S., Mustapha, N. M., & Muhammad, K. (2008). Nutrient Content Of Tropical Edible Seaweeds, Eucheuma Cottonii, Caulerpa Lentillifera, And Sargassum Polycystum. Journal Of Applied Phycology, 21(1), 75–80.

Wong, K. H., Cheung, P. C. K., & Ang, P. O. (2000). Antioxidant Activity Of Extracts From Brown Seaweeds. Food Chemistry, 72(4), 471–475.

Fayaz, M., Namitha, K. K., Murthy, K. N. C., Swamy, M. M., Sarada, R., Khanam, S., Subbarao, P. V., & Ravishankar, G. A. (2005). Chemical Composition, Iron Bioavailability, And Antioxidant Activity Of Kappaphycus Alvarezii. Journal Of Agricultural And Food Chemistry, 53(3), 792–797.

Kumar, M., Kumari, P., Gupta, V., Reddy, C. R. K., & Jha, B. (2010). Differential Responses To Cadmium Induced Oxidative Stress In Marine Macroalga Ulva Lactuca. Environmental Toxicology And Pharmacology, 30(3), 306–313.

A QUALITATIVE COMPARATIVE STUDY OF CORPORATE SOCIAL RESPONSIBILITY IN PUBLIC AND PRIVATE SECTOR BANKS

DR. HASMUKHBHAI B. PATEL
PRINCIPAL, SHRI. J. M. PATEL ARTS & SMT. M. N. PATEL COMMERCE MAHILA COLLEGE, UNJHA

ABSTRACT

CSR has been a strategic and ethical concern for the Indian banking industry, especially after the Companies Act of 2013 was enacted, which made CSR spending mandatory for eligible companies. The objective of this research, therefore, is to compare the scope, spending patterns, focus areas, and overall effectiveness of the CSR programs undertaken by Indian public and private sector banks. The research investigates some of the top-rated banks in these two sectors and compares their approaches towards financial inclusion, social development, sustainability, healthcare, education, and environmental protection. It also shows how public sector banks generally emphasize welfare-oriented and government-aligned initiatives, while private sector banks commonly pursue innovation-driven and branding-oriented CSR strategies by using secondary data obtained from annual CSR reports, sustainability reports, and regulatory disclosures. The findings bring out the fundamental differences in the approach of the two sectors towards impact assessment, regional outreach, and CSR expenditure. The study concludes that while both public and private banks contribute significantly to socioeconomic development, private banks are found to exhibit better coordinated implementation and strategic alignment, and public banks were seen to have greater outreach and inclusivity. These lessons may be useful for policymakers, stakeholders, and financial institutions looking at ways to strengthen the CSR frameworks and maximize social impacts in India.

KEY WORDS: BANKING SECTOR COMPARISON, PUBLIC SECTOR BANKS (PSBS), PRIVATE SECTOR BANKS (PVBS), INDIAN BANKING INDUSTRY, CSR STRATEGY

INTRODUCTION

CSR signifies the commitment of an organization to moral values, social welfare, and sustainable development and is an integral part of modern corporate operations. In India, when the Companies Act, 2013 was enacted, which mandated all eligible firms, including banks, to spend at least 2% of their average net profit on social development activities, CSR gained widespread popularity. The banking sector forms an important part of the country's financial system for facilitating economic growth and inclusive development. Besides financial intermediation, some other social initiatives in which banks assist include financial literacy, rural development, healthcare, education, women's empowerment, skill development, and environmental sustainability.

Though CSR is undertaken by both public and private banks in India, the approach, objectives, and implementation strategies vary considerably. Public sector banks, because of Government supervision, generally base their CSR on national development objectives and public welfare programs. Traditionally, they have focused on rural development, financial inclusion, poverty alleviation, and community welfare. Private sector banks generally adopt a more innovative and strategic approach, focusing on sustainability, brand building, and measurable social impact. Its

CSR initiatives include youth empowerment, skill development, environmental conservation, and digital literacy.

List of Common CSR activities

Women Empowerment	**Poverty elimination**
Community Welfare	**Education Promotion**
Children Welfare	**National Donation**
Health Care	**Infrastructure facilities**
Sports Sponsorship	**Adoption of villages for development**
Cultural activities	**Art and Music development**

A comparison of the CSR performance of public and private banks helps to identify the extent of their effectiveness, reach, and strategic focus on critical areas of social involvement. This would help identify best practices, review legal compliances, and understand the actual impact that CSR spend creates in communities. The study will assess and compare the contribution of public and private sector banks in India to CSR activities, with a view to extracting insightful knowledge on their expenditure patterns, thematic priority areas of intervention, and implementation tactics and impact on society as a whole. The outcomes are expected to provide a road map to policymakers, financial authorities, and other stakeholders on governance, strengthening CSR frameworks, and maximizing the developmental benefits of CSR in the banking sector.

LITERATURE REVIEW

Moharana 2013 5. A study of few Indian public sector banks on corporate social responsibility. The objective of this study is to explore the CSR activities of few Indian nationalised banks. Analysis done by different CSR activities of specific nationalised Indian banks. It was found that the selected banks are engaged with CSR activities, primarily in the areas of education, community welfare, rural development, and women and children. This study brought into light the need for banks to involve in better corporate social responsibilities, which is good considering the increased number of social development issues that are linked with the corporate sector.

Sharma (2011) tried to investigate CSR reporting and practices in India focusing on the banking industry. He concluded that although the Indian banking industry is showing interest in integrating sustainability into their business models, its CSR reporting practices are well below expectation.

According to the analytical study conducted by Sharma E. and Mani M. (2013), Indian banks' CSR initiatives are inadequate. It has been reflected in the study that commercial banks of the private sector contribute much lesser to corporate social responsibility than that of the banks belonging to the public sector.

Sharma and E. M. Sathish 2022 say that for measuring the proper effects caused in the real world by banks' CSR programs, a complete philosophy is required. For making every step taken by them for improvement and development of the economy, the banks must therefore devise a proper and innovative plan.

Most companies only consider peripheral CSR measures, such as funding events or contributing to charitable trusts and NGOs. Archana Koli, 2020 states A promotion strategy. Few people have taken

a clear stand on corporate social responsibility. If businesses know what society wants and concentrate on those aspects, they would be rational. Consequently, this would ensure the overall development of the country.

STATEMENT OF THE PROBLEM

CSR has been a high priority for Indian banks, ever since the firms Act of 2013 came into effect and mandated qualifying firms to spend on CSR. Despite their considerable CSR expenditure, there is a lack of qualitative research focusing on comparative analysis of approaches, objectives, tactics, and social effect of public and private banks. While public sector banks often undertake welfare-driven, compliance-oriented initiatives in line with government programs, private banks usually conduct strategic, innovative projects with quantifiable results and corporate visibility. Nevertheless, the differences in these areas of CSR target, geographic coverage, innovativeness, beneficiaries, spending patterns, and governance procedures have not been studied so far. Thus, this study fills this research gap by providing a comparative evaluation of CSR practices in a few public and private banks, helping stakeholders, policymakers, and financial institutions to develop more effective CSR strategies with better social consequences.

OBJECTIVES OF STUDY

The objectives of the study are:

The present study aims to investigate CSR in the context of Indian banks, and compare certain key CSR priority areas between public and private banks.

To further evaluate the organizations and regions those have benefited from their CSR.

Assess the strategy, governance, and compliance of CSR programs. assess and compare CSR practices in order to improve the policies regarding social issues and activities.

RESEARCH METHODOLOGY

A qualitative research technique is used in this study to present a comprehensive comparison and analysis of CSR practices of public sector banks, namely SBI and PNB, and private sector banks, namely HDFC Bank and Axis Bank. This is a descriptive and comparative study design wherein the main purpose is to examine trends, tactics, methods, and differences in CSR behavior. The entire study is based on secondary data which was collected in a systematic manner from authentic sources, including annual reports, CSR reports, sustainability and business responsibility reports, official bank websites, regulatory filings under the Companies Act of 2013, and relevant scholarly works and research publications.

In order to glean information about each bank's areas of emphasis in CSR, beneficiaries, geographic reach, tactics, and orientation to effect, the document analysis technique of the study examines official papers, disclosures, and reports of CSR projects. Purposive sampling was used to select the four banks because they are established in the Indian banking industry, with a wide customer base and consistently provided the comprehensive financial and CSR disclosures required for comparison research. Qualitative thematic analysis is then applied to the data gathered to determine the recurring themes such as CSR goals, type of activity, innovativeness, responsiveness, compliance mechanisms, and overall impact. These concepts form the basis for a systematic comparison between public and private banks, highlighting both differences and similarities between their CSR strategies. The technique is appropriate for the research because it will allow an

in-depth qualitative assessment, ensure reliability through the use of official and credible sources, and provide a systematic structure in which to understand CSR practices in various types of banks.

FINDINGS

Detailed Comparative analysis : CSR of Public vs. Private Banks (Qualitative)

Banks Selected

Public Sector Banks (PSBs)	Private Sector Banks (PVBs)
1. State Bank of India (SBI)	1. HDFC Bank
2. Punjab National Bank (PNB)	2. Axis Bank

Following are some major conclusions about the CSR activities of public and private sector banks:

CSR PRIORITIES (FOCUS AREA):

The welfare-oriented activities like rural development, education, health care, sanitation, women's empowerment, and livelihood initiatives are given top priority by the public sector banks SBI and PNB. These initiatives correspond closely with national development agendas and government welfare programs.

The private sector banks like HDFC Bank and Axis Bank have a multi-faceted approach to implementing a systematic strategy, prioritizing financial literacy, skill development, digital education, environmental sustainability, livelihood enhancement, and community empowerment. Their initiatives merge business awareness with social impact in an innovative and measurable way.

SBI AND PNB	HDFC AND AXIS
Rural development, education, healthcare, sanitation, women empowerment and livelihood initiatives	Financial literacy, skill development, digital education, environmental sustainability, livelihood enhancement, and community empowerment.

Major Indian banks contributed significantly to CSR in FY 2024–2025. SBI approved ₹6,13,87,63,262.24 and paid out ₹6,10,76,99,999.62 for social welfare programs. HDFC Bank reported a far larger CSR spending of ₹1,068 crore, compared to Axis Bank's ₹426.57 crore. These numbers demonstrate the three banks' steadfast dedication to community improvement and social growth.

GEOGRAPHICAL COVERAGE:

Public banks are mainly focused on rural and semi-urban regions, especially the impoverished and disenfranchised populations in underdeveloped and aspirational districts.

Private banks operate both in urban, semi-urban, and rural areas; however, to increase awareness and participation, most of the activities are concentrated in metropolitan areas.

Public banks	Private banks
Rural and semi-urban regions, underdeveloped districts.	urban, semi-urban, and rural areas and metropolitan areas

CSR Techniques & Strategies:

Social equity and sustainability, rather than branding, are key drivers for public banks through long-term, welfare-driven, compliance-based initiatives. Programs often are executed in cooperation with government initiatives and NGOs.

Emphasizing quantifiable social impact, innovation, and scalability, private banks pursue strategic, adaptable, and outcome-oriented CSR programs. They are more open to trying out new ideas and modifying current ones in response to changing societal demands.

Recipients:

Public banks primarily help the underprivileged sections, women, children, and rural masses who need livelihood support and skill development.

Private banks cater to a wider range of people, such as youth, students, city dwellers, female entrepreneurs, and communities needing digital education, livelihood programs, or skill development.

Character and innovation of CSR Activities:

Standardized welfare activities of public banks involve health camps, sanitation projects, educational infrastructure development, and rural livelihood initiatives. Innovation is restricted because of regulatory frameworks and compliance requirements

Various private banks are engaged in innovative, multi-faceted efforts, which include promoting renewable energy, digital education, financial literacy, skill development, and environmental protection. Their actions can be more flexible to the changing needs of society.

Spending Trends for CSR:

Public banks disburse CSR budgets typically based on long-term welfare objectives and legal constraints. While expenditure stands constant, it is often focused on a smaller set of high-impact initiatives.

Private banks have been found to enjoy greater freedom in distributing their CSR money among several innovative projects that are targeted to yield measurable results and higher social exposure.

Impact of Flagship Programs:

Public banks run major schemes like the scholarship and women's empowerment initiatives by PNB, and the "SBI Yuva" program of SBI for rural youth skill development. The essence of these programs is social welfare for the long-term benefit of the communities.

Private banks run flagship initiatives, such as Axis Bank's Axis Bank Foundation programs, which focus on digital education, entrepreneurship, and sustainable agriculture, and HDFC Bank's "Parivartan," which addresses education, health, livelihood, and financial literacy. These initiatives marry corporate branding with social effect

Governance and Compliance:

The Companies Act of 2013 is followed by both public and private banks, guaranteeing the fulfillment of their legal CSR responsibilities.

While private banks combine CSR governance with strategic business objectives and stakeholder engagement, public banks have a more compliance-driven kind of governance.

Flexibility and Innovation:

Public banks face regulatory restrictions, thus generally establishing standardized programs that have little leeway to innovate quickly.

Private banks demonstrate high adaptability through the introduction of new approaches, immediate responsiveness to new social issues, and partnerships with NGOs and social entrepreneurs to maximize impact.

RESULTS AND DISCUSSION

The findings from the study reveal that there are sharp contrasts between the CSR policies of private sector banks- represented by HDFC Bank and Axis Bank-and the public sector banks, as represented by SBI and PNB. Public sector banks adopt a welfare-oriented approach, socially inclusive, with an emphasis on rural development, education, healthcare, sanitation, and enhancement of means of subsistence of underprivileged people. Their CSR activities are geared more towards long-term social sustainability rather than business branding or publicity, and they are closely linked to national development aspirations. Because of legal restrictions and compliance-driven organisations, these institutions adopt conventional approaches to CSR, leaving little room for innovation. Public banks primarily emphasize rural and semi-urban areas, with the aim of helping empower the underprivileged sections and promoting social equity.

The private sector banks, on the other hand, have an innovative, objective-oriented, and strategic approach towards CSR. Financial literacy, digital education, skill development, environment sustainability, and livelihood generating activities are the key areas of intervention by HDFC Bank and Axis Bank. Their efforts are often partnership-driven, urban-centric, and aimed at balancing business reputation with social impact.

Private banks also demonstrate a greater level of adaptability, as most of them initiate new programs or modify existing ones to address emerging social needs. Moreover, beneficiary focus differs: commercial banks target a broader segment, such as urban citizens, the young, students, and women; public banks focus on rural and deprived sections. Broadly, both sectors comply with the CSR provisions under the Companies Act of 2013; however, private banks focus on strategic, innovative, and measurable CSR initiatives, while public banks adopt a traditional, welfare-oriented approach. Aggregately, these approaches strengthen the CSR ecosystem in India and facilitate inclusive, sustainable development.

CONCLUSION

The study concludes that both public and private sector banks in India, though having quite different strategies, significantly contribute to social development through their CSR programs. Public sector banks, such as SBI and PNB, focus on rural communities, underprivileged groups, and underdeveloped areas through a welfare-oriented, inclusive, and community-focused approach. Their CSR initiatives, which prioritize social justice, long-term sustainability, and community uplift, are closely connected with national development goals and government agendas.

On the other hand, private sector banks like HDFC Bank and Axis Bank approach CSR in a strategic, innovative, and objective-oriented manner. Scalability, measurable impact, and partnership with social entrepreneurs and NGOs define their programs. Digital literacy, financial inclusion, ecological sustainability, and skill development are key focus areas that indicate a modern and forward-looking approach to social responsibility. Having said that, both state-run and private-sector banks fulfill the Companies Act of 2013's requirements on CSR. Together, they make for a complementary CSR landscape wherein private banks enhance innovation, efficiency, and impact measurement, while state-owned banks strengthen rural welfare and inclusion. This diversity of approaches expands the realm of social development and helps the communities of India progress in a far more holistic and sustainable manner.

REFERANCE

Doh, J. P., Howton, S. D., Howton, S. W., & Siegel, D. S. (2010). Does the market respond to an endorsement of social responsibility? The role of institutions, information, and legitimacy. Journal

of Management, 36(6), 1461-1485.

Gatti, L., Vishwanath, B., Seele, P., & Cottier, B. (2019). Are we moving beyond voluntary CSR? Exploring theoretical and managerial implications of mandatory CSR resulting from the new Indian

Companies Act. Journal of Business Ethics, 160(4), 961-972.

Batra, R., & Bahri, A. (2018). Financial Performance and corporate social responsibility (CSR): empirical evidence from banks in India. International Journal of Business Ethics in Developing Economies, 7(2), 37-42.

EXPLORING THE OPPORTUNITIES OF ARTIFICIAL INTELLIGENCE IN FINANCE, MANAGEMENT, COMMERCE, AND HUMANITIES

DR. MEHUL MISTRY
I/C PRINCIPAL & ASSISTANT PROFESSOR, SARDAR PATEL COLLEGE OF COMMERCE, BAKROL (SPEC)

ABSTRACT:

In the fields of finance, management, commerce, and the humanities, artificial intelligence (AI) is quickly changing operational, strategic, and analytical paradigms. In order to identify the revolutionary possibilities and related difficulties of AI adoption in certain industries, this study critically summarizes recent research. Although AI poses issues with data privacy, interpretability, and workforce disruption, it also improves risk management, fraud detection, trading tactics, and financial inclusion in the financial industry (Nenad Milojevi & Srdjan Redepagi, 2021; Sudheer Obbu, 2025; Gaurang Sonkavde et al., 2023). Operational efficiency, AI-augmented leadership, management accounting evolution, and automation of human resources are examples of management applications that drive productivity and create new challenges in human-AI collaboration (Muhammad Usman Tariq et al., 2021; Ebnem Yaar, 2024; Pooja Tiwari et al., 2021

The integration of AI technologies in these fields offers transformative opportunities to innovate processes, enhance decision-making, increase efficiency, and create new value propositions. This comprehensive analysis synthesizes current research findings addressing the opportunities AI presents in these sectors while critically evaluating methodological strengths, challenges, and future research directions.

KEYWORDS: ARTIFICIAL INTELLIGENCE, FINANCE, MANAGEMENT, COMMERCE, HUMANITIES, RISK MANAGEMENT, FRAUD DETECTION, EXPLAINABLE AI, DIGITAL INCLUSION, FEDERATED LEARNING, AI ETHICS, OPERATIONAL EFFICIENCY, ALGORITHMIC TRADING, INTERDISCIPLINARY GOVERNANCE

1. OPPORTUNITIES OF AI IN FINANCE

The banking industry is leading the way in the use of AI, utilizing cutting-edge computer power to transform conventional financial services. AI's powerful data processing capabilities allow for advanced risk management, fraud detection, personalized customer care, and quicker decision-making, all of which significantly enhance operational performance and customer satisfaction.

One of the biggest potential is in risk management and credit evaluation, where AI models and machine learning algorithms examine large datasets to anticipate operational hazards, market volatility, and creditworthiness with significantly higher accuracy than traditional statistical models. Real-time portfolio monitoring and dynamic risk reduction techniques are made possible by these technologies, which are essential for managing erratic market circumstances, particularly in the wake of worldwide economic crises (Nenad Milojevi & Srdjan Redepagi, 2021). By utilizing intricate data patterns, AI-driven risk assessment systems enable financial institutions to anticipate possible downturns and customize loan conditions for specific customer profiles. AI systems use behavioral analytics and anomaly detection algorithms to identify unique client financial trends in the field of fraud detection. This feature dramatically lowers false positives and accurately detects

new fraudulent activity and organized fraud rings. By reducing transactional delays, these systems' real-time functionality not only safeguards financial assets but also maintains consumer confidence (Sudheer Obbu, 2025). Hyper-personalized service offerings are further supported by behavioral analytics, which enables financial institutions to dynamically adjust to shifting customer demands.

AI also enables algorithmic trading and predictive analytics, where machine learning and deep learning models forecast stock price movements, optimize portfolios, and analyze market patterns. Excellent prediction performance is demonstrated by contemporary ensemble approaches such as Random Forests, XGBoost, and Long Short-Term Memory (LSTM) networks, which enable improved trading strategies and reduced investment risks (Gaurang Sonkavde et al., 2023). These advancements make it possible for traders and companies to more swiftly and precisely seize fleeting market opportunities.

Integrating AI with blockchain technology to deliver safe, transparent, and decentralized financial services is another crucial path. In decentralized finance (DeFi) ecosystems, AI enhances operational management and fraud detection through intelligent data analysis and automation. Scalability and regulatory compliance are still issues despite promising applications, indicating that rigorous governance and strong protocol development are necessary to achieve these advantages (Chetankumar Prajapati, 2025).

AI has an impact on digital financial inclusion as well, especially when it comes to giving underprivileged groups more access to financial services. To lessen information asymmetry and minimize participation barriers for low-income people, women, young people, and small businesses, fintech companies use AI-powered chatbots, fraud detection systems, and credit risk assessment algorithms.This financial democratization promotes social justice and increased economic involvement (David Mhlanga,2020). Emerging research emphasizes the crucial importance of explainable AI (XAI) in finance, particularly for credit scoring and risk assessment models. Techniques such as Local Interpretable Model-agnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP) provide transparency and accountability in AI decision processes. This approach fosters trust among stakeholders and conforms to regulatory requirements demanding interpretability without compromising predictive power (Branka Hadji Misheva et al., 2021).

Furthermore, Artificial General Intelligence (AGI) has the potential to revolutionize financial services with larger cognitive capabilities, possibly allowing fully autonomous investing and decision-making frameworks, even if it is still in its infancy when compared to narrow AI. The urgent need for responsible development methods is highlighted by the substantial research gaps that exist, particularly with relation to assessment metrics and ethical deployment (Satyadhar Joshi, 2025). Furthermore, Artificial General Intelligence (AGI) has the potential to revolutionize financial services with larger cognitive capabilities, possibly allowing fully autonomous investing and decision-making frameworks, even if it is still in its infancy when compared to narrow AI. The urgent need for responsible development methods is highlighted by the substantial research gaps that exist, particularly with relation to assessment metrics and ethical deployment (Satyadhar Joshi, 2025).2. AI in Management: Driving Efficiency and Innovation

AI promotes operational excellence in management by automating repetitive operations and enhancing human decision-making. Strategic planning and real-time operational modifications are made possible by managers' ability to extract meaningful insights from complicated information using AI-powered data analytics. Enhancing operational efficiency with cloud-based AI technologies, robotic process automation (RPA), and big data integration is one noteworthy possibility. When these technologies are used, operating costs are reduced, productivity is increased, and innovation cycles are expedited. Using AI to anticipate demand, improve supply chains, and customize marketing campaigns greatly benefits small and medium-sized businesses (Muhammad Usman Tariq et al., 2021).

AI is also essential to the growth and efficacy of leadership in the management and finance industries. Leaders with strong AI literacy can foster innovation, handle moral dilemmas, and carry out strategic choices more successfully as companies experience digital revolutions. The necessity for ongoing training and the incorporation of AI principles into leadership courses is highlighted by quantitative research that shows a positive association between AI literacy and leadership performance.

Traditional responsibilities are being redefined by the growth of management accounting through AI integration. Accounting departments become important business partners that provide value through fast insights thanks to AI applications in automated data gathering, real-time analytics, fraud detection, and predictive modeling. Even if there are many benefits, issues like data quality and integration complexity necessitate continued study to maximize adoption (ebnem Yaar, 2024).

AI also helps human resource management in a number of areas, such as employee engagement, performance appraisal, and talent acquisition. AI solutions encourage creative employee evaluations, simplify tedious HR chores, and promote an innovative culture by improving decision-making skills (Pooja Tiwari et al., 2021). However, striking a balance between AI-driven automation and human augmentation continues to be a crucial managerial problem, necessitating all-encompassing approaches to successfully manage organizational transformation (Sebastian Raisch & Sebastian Krakowski, 2021).3.AI in Commerce: Transforming Business Models and Consumer Experience.

Significant innovation in commerce is sparked by artificial intelligence, especially in the retail and e-commerce industries. AI improves operational models by preventing fraud, automating customer care, tailored marketing, and intelligent logistics. Recommendation engines, pricing optimization algorithms, and customer behavior analytics are examples of AI technologies that greatly boost conversion rates and enhance customer engagement in e-commerce. Research demonstrates how AI-driven chatbots and customisation may boost customer happiness and increase revenue (Mitra Madanchian, 2024). AI also makes fraud detection and inventory management more effective, which lowers operational risks and boosts profitability (Chenxing Wang et al., 2023).

AI encourages safe and private data exchange by facilitating cross-industry data collaboration through Federated Learning (FL). By enhancing predictive analytics in the banking, healthcare, and commerce sectors, this promotes innovation while protecting private customer and company data

(Sudhakar Reddy Peddinti et al., 2025). Furthermore, by facilitating peer-to-peer transactions, transparent contracts, and intelligent content distribution, AI combined with Web 3.0 concepts—such as decentralized finance and blockchain mechanisms—is set to revolutionize online business. While increased security and efficiency are promised by this junction, widespread adoption is severely hampered by ethical and privacy issues (Jasmin Praful Bharadiya, 2023). Adoption of AI promotes sustainable business practices in the larger realm of commerce by automating sustainability reporting, facilitating ESG compliance, and optimizing resource use.

4. AI IN THE HUMANITIES: EMERGING PROSPECTS AND CONSIDERATIONS

Although AI is more widely used in technical and business fields, its potential in the humanities is becoming increasingly apparent as a result of developments in data analytics, natural language processing, and pattern identification. Applications of AI in this field tackle issues related to sociocultural analysis, cultural heritage protection, and knowledge discovery. Large text corpora may be analyzed by AI-based technologies, providing fresh perspectives on societal trends, historical data, and linguistic patterns. This potential is demonstrated by generative AI models like ChatGPT, which promote data-driven decision-making in industry and academics while simultaneously posing important questions about social inequity, privacy, and ethical consequences (Mara Teresa Baldassarre et al., 2023). The potential for inclusive knowledge sharing as well as the dangers of false information are highlighted by the way generative AI is changing communication, education, and cultural discourse.

The interpretability of machine learning outputs and the inherent biases in training data provide methodological hurdles for AI integration in the humanities, despite its potential applications. To create frameworks that protect cultural integrity while utilizing AI's analytical capabilities, multidisciplinary cooperation between engineers, humanists, and ethicists is essential ("Artificial Intelligence: A European Perspective," 2018).The potential for inclusive knowledge sharing as well as the dangers of false information are highlighted by the way generative AI is changing communication, education, and cultural discourse.

Despite its potential uses, methodological barriers to AI integration in the humanities include the interpretability of machine learning outputs and the inherent biases in training data. Multidisciplinary collaboration between engineers, humanists, and ethicists is crucial to developing frameworks that preserve cultural integrity while making use of AI's analytical skills ("Artificial Intelligence: A European Perspective," 2018).5. Comparative Analysis and Integration Across Domains.

Though with domain-specific subtleties, AI regularly allows automation, improved analytics, and decision assistance across finance, management, commerce, and humanities. AI in banking and commerce mostly concentrates on risk reduction, individualized service delivery, and quantitative data-driven optimization. Widespread application of machine learning, deep learning, and explainable AI framework techniques improves competitive positioning and operational efficiency. On the other hand, management welcomes AI in leadership development, organizational procedures, and strategic innovation, striking a balance between automation and human-centered methods to optimize complementarities (Muhammad Usman Tariq et al., 2021).

The humanities use AI for qualitative analysis and knowledge development, but they also have unique ethical and interpretability issues that call for more study to guarantee responsible AI use. Furthermore, the confluence of AI with other cutting-edge technologies, such Web 3.0 and blockchain, presents chances for cross-sectoral innovation but necessitates cooperative governance structures to address privacy and legal issues (Chetankumar Prajapati, 2025).

Despite these developments, data privacy, algorithmic bias, transparency, and labor displacement are recurring issues across many industries, indicating important topics for scholarly research and legislative interventions. To optimize AI's advantages while reducing hazards, it is still imperative to build strong, transparent, and ethically directed AI systems (Marko Rankovi et al., 2023).6. Identified Research Gaps and Future Directions. Although the literature highlights a number of intriguing applications, there are a number of gaps that call for targeted future study. First, in order to guarantee reproducibility and comparability of results, defined assessment measures and benchmarking frameworks are desperately needed, particularly for sophisticated AI models in finance and management (Satyadhar Joshi, 2025). Second, due of the complexity of workforce transformation, long-term research is needed to evaluate how AI affects job trends and the solutions for upskilling that are required (Satyadhar Joshi, 2025).

Third, there are still issues with explainability and interpretability of AI models, particularly in high-stakes areas like public sector financial management and credit risk assessment. Innovative XAI methods that improve stakeholder confidence without compromising forecast accuracy should be investigated in future research (Branka Hadji Misheva et al., 2021).

Lastly, addressing ethical, legal, and cultural issues requires cross-sector cooperation, especially when AI interacts with human decision-making and society effects. Sustainable AI integration will be guided by multidisciplinary frameworks that incorporate ethical, social, and technological viewpoints (Carsten Maple et al., 2023). In conclusion, by facilitating sophisticated data analytics, process automation, and creative business models, AI offers revolutionary prospects in the fields of finance, management, commerce, and the humanities. Evidence shows significant improvements in productivity, risk mitigation, and customer satisfaction, but these developments are accompanied by operational, ethical, and legal issues that call for complex, multidisciplinary solutions to guarantee the appropriate and equitable application of AI.

Supplementary Summary Table of AI Opportunities and Challenges by Sector

Sector	Key AI Opportunities	Challenges	Future Research Directions
Finance	Risk management, fraud detection, algorithmic trading, digital inclusion, explainable AI	Data privacy, black-box models, regulatory compliance, workforce displacement	Standardized evaluation, ethical frameworks, workforce upskilling strategies
Management	Operational efficiency, leadership effectiveness, automation augmentation, management	Cultural adoption barriers, AI literacy gaps, balancing human-AI roles	Longitudinal impact studies, AI literacy programs, change management frameworks

The synthesis above demonstrates that while AI applications differ in their technical implementations and domain focus across finance, management, commerce, and humanities, a consistent emphasis on transparency, ethical compliance, and adaptive governance is essential to fully realize AI's transformative potential across all fields. This integrated understanding can inform policymakers, practitioners, and researchers aiming to leverage AI as a strategic enabler of innovation and societal benefit.

REFERENCESS:

Milojevi, N. & Redepagi, S. (2021). Prospects of artificial intelligence and machine learning application in banking risk management. De Gruyter Open. https://doi.org/10.2478/jcbtp-2021-0023

Obbu, S. (2025). Ai in finance: transforming risk management and fraud detection. World Journal of Advanced Engineering Technology and Sciences.

Sonkavde, G., Dharrao, D., Bongale, A. M., Deokate, S. T., Doreswamy, D., & Bhat, S. K. (2023). Forecasting stock market prices using machine learning and deep learning models: a systematic review, performance analysis and discussion of implications. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/ijfs11030094

Tariq, M. U., Poulin, M., & Abonamah, A. A. (2021). Achieving operational excellence through artificial intelligence: driving forces and barriers. Frontiers Media.

Yaar, E. (2024). Integration of artificial intelligence in management accounting: a swot analysis. None. https://doi.org/10.46238/jobda.1474352

Tiwari, P., Pandey, R., Garg, V., & Singhal, A. (2021). Application of artificial intelligence in human resource management practices. Confluence.

Madanchian, M. (2024). The impact of artificial intelligence marketing on e-commerce sales. Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/systems12100429

Wang, C., Ahmad, S. F., Ahmad, A. Y. A. B., Awwad, E. M., Irshad, M., Ali, Y. A., AlRazgan, M., Khan, Y., & Han, H. (2023). An empirical evaluation of technology acceptance model for artificial intelligence in e-commerce. Elsevier BV. https://doi.org/10.1016/j.heliyon.2023.e18349

COLONIAL CULTURE AND THE CRISIS OF IDENTITY: A FANONIAN ANALYSIS OF ALIENATION AND RESISTANCE

DR. BISHAL BHATTACHARYA
ASSISTANT PROFESSOR, DEPARTMENT OF POLITICAL SCIENCE, FACULTY OF HUMANITIES AND SOCIAL SCIENCES, MADHAV UNIVERSITY, PINDWARA (SIROHI), ABU ROAD, RAJASTHAN.

ABSTRACT

This paper explores the enduring impact of colonial culture on the formation of identity through the theoretical framework of Frantz Fanon. Colonialism did not merely dominate territories; it penetrated the psychological and cultural fabric of colonized societies, producing a deep crisis of identity characterized by alienation, inferiority, and cultural dislocation. Drawing on Fanon's seminal works, particularly Black Skin, White Masks and The Wretched of the Earth, this study examines how colonial power structures imposed cultural hierarchies that privileged European norms while devaluing indigenous traditions. The paper argues that colonial culture engendered a divided self within the colonized subject, leading to internalized oppression and loss of cultural authenticity. At the same time, Fanon's analysis provides a framework for understanding resistance as both a psychological and political process. Anti-colonial struggle becomes a means of reclaiming identity, dignity, and cultural autonomy. Through qualitative analysis of key texts and secondary scholarship, this study highlights the relevance of Fanonian theory in contemporary discussions of postcolonial identity, globalization, and cultural hybridity. The findings suggest that while formal colonialism has ended, its cultural and psychological legacies persist, necessitating continued efforts toward decolonization and identity reconstruction.

KEYWORDS: COLONIALISM, IDENTITY CRISIS, FRANTZ FANON, ALIENATION, RESISTANCE, POSTCOLONIALISM, CULTURE

INTRODUCTION

Colonialism has been one of the most transformative and disruptive forces in modern history, shaping not only political and economic systems but also the cultural and psychological foundations of societies. Beyond territorial conquest and material exploitation, colonialism functioned as a powerful mechanism of cultural domination that sought to redefine the identity of colonized populations. The imposition of foreign values, languages, and social norms led to a profound crisis of identity, marked by alienation, inferiority, and cultural dislocation.

Historically, colonialism operated as a multidimensional system of control that extended far beyond governance. It was equally an epistemological and cultural project that established hierarchies privileging European knowledge, traditions, and modes of being while systematically marginalizing indigenous cultures and intellectual frameworks. This process not only disrupted existing social structures but also reshaped the consciousness of the colonized, producing fragmented identities and internal conflicts. As a result, the colonized subject often found themselves caught between competing cultural worlds, unable to fully identify with either.

The question of identity under colonial and postcolonial conditions has been a central concern within postcolonial studies. Among the most influential thinkers in this field is Frantz Fanon, whose

work provides a critical understanding of the psychological dimensions of colonial domination. Fanon argues that colonialism produces a "divided self," wherein the colonized individual internalizes the values and norms of the colonizer while simultaneously experiencing exclusion, loss, and cultural estrangement. This duality generates a persistent sense of alienation and identity crisis that extends beyond the colonial period into postcolonial societies.

This paper seeks to examine the relationship between colonial culture and the crisis of identity through a Fanonian framework. It argues that colonialism engenders alienation by constructing racial and cultural hierarchies that undermine the selfhood of the colonized. At the same time, it highlights resistance as a transformative process through which individuals and communities attempt to reclaim their identity, dignity, and cultural autonomy. By engaging with Fanon's theoretical insights, this study contributes to broader debates on identity, power, and cultural politics in postcolonial contexts, while also emphasizing the continuing relevance of these issues in the contemporary global order.

RESEARCH AIM AND OBJECTIVES

Aim

The primary aim of this research is to critically analyze the impact of colonial culture on the formation of identity and to examine the processes of alienation and resistance through a Fanonian perspective.

Objectives

To examine the nature of colonial culture and its mechanisms of domination.
To analyze Fanon's concept of psychological colonization and identity crisis.
To explore the role of language, race, and culture in producing alienation.
To investigate forms of resistance and identity reconstruction in colonial and postcolonial contexts.
To assess the contemporary relevance of Fanon's ideas in understanding globalization and cultural imperialism.

Previous Research in the Area

The relationship between colonialism and identity has been extensively examined within the field of postcolonial studies, with scholars offering diverse theoretical frameworks to understand the cultural and psychological consequences of colonial domination. Among the foundational contributions is Edward Said's concept of *Orientalism*, which demonstrates how the West constructed the East as an inferior "Other" in order to justify and sustain imperial power. Said argues that colonial discourse is not merely a reflection of reality but actively produces knowledge that shapes identities, reinforcing asymmetrical power relations between the colonizer and the colonized.

Building on this, Homi K. Bhabha introduces the concept of hybridity, emphasizing the fluid and ambivalent nature of identity formation under colonial conditions. According to Bhabha, colonial encounters do not simply impose a fixed identity upon the colonized; rather, they generate hybrid cultural forms that challenge rigid binaries such as colonizer/colonized or self/other. While this perspective highlights the creative and transformative aspects of cultural interaction, it also reveals the inherent instability and fragmentation that characterize identities shaped within colonial contexts.

Ngũgĩ wa Thiong'o further extends this discourse by focusing on the role of language as a critical instrument of cultural domination. In his analysis, the imposition of colonial languages functions as a means of alienating individuals from their indigenous cultural heritage and epistemological frameworks. Language, therefore, becomes a site of power through which colonial authority is maintained and internalized.

In addition to these perspectives, scholars such as Albert Memmi and Aimé Césaire have contributed to understanding the structural and cultural dimensions of colonial oppression, highlighting the dehumanizing effects of colonial ideology. However, despite these significant contributions, Frantz Fanon's work remains distinctive in its emphasis on the psychological dimensions of colonialism. His analysis of internalized racism, inferiority complexes, and the fractured consciousness of the colonized subject provides a deeper insight into the lived experience of colonial domination.

Contemporary scholarship continues to engage with Fanon's ideas, particularly in the context of globalization, neo-colonialism, and cultural imperialism. His theoretical framework remains highly relevant for understanding how historical structures of domination persist in shaping identities and power relations in the modern world.

METHODOLOGY

Research Design

This study adopts a qualitative and interpretative research design, appropriate for examining complex theoretical and conceptual issues related to colonialism, identity, and resistance. Rather than relying on empirical or quantitative data, the research is grounded in critical textual analysis, with a particular focus on understanding the philosophical and psychological dimensions of Frantz Fanon's work. This approach enables an in-depth exploration of how colonial culture shapes identity formation and produces conditions of alienation. By engaging with Fanon's conceptual framework, the study seeks to interpret the dynamics of colonial domination and its lasting impact on the consciousness of the colonized subject.

Data Collection

The research is based on both primary and secondary sources to ensure a comprehensive and well-rounded analysis.

Primary Sources: The primary texts analyzed in this study include Frantz Fanon's seminal works, *Black Skin, White Masks* and *The Wretched of the Earth*. These texts provide the foundational theoretical framework for understanding the psychological and cultural effects of colonialism.

Secondary Sources: In addition to Fanon's writings, the study draws on a wide range of secondary sources, including scholarly books, peer-reviewed journal articles, and critical essays within the field of postcolonial studies. Works by key theorists such as Edward Said, Homi K. Bhabha, and Ngũgĩ wa Thiong'o are utilized to contextualize and critically engage with Fanon's ideas.

Data Analysis Method

The study employs thematic analysis as its primary method of data interpretation. This involves identifying, analyzing, and organizing recurring themes within the selected texts, such as alienation, identity crisis, internalized oppression, and resistance. These themes are examined in relation to Fanon's theoretical insights and are further contextualized within broader postcolonial debates.

Through this method, the research establishes connections between historical colonial experiences and contemporary socio-cultural realities. The interpretative nature of the analysis allows for a

nuanced understanding of how colonial legacies continue to shape identity and power structures in the modern world. By synthesizing insights from both primary and secondary sources, the study offers a coherent and critical account of the relationship between colonial culture, identity formation, and resistance.

THEORETICAL EXPANSION: FANON AND THE PSYCHOLOGY OF COLONIALISM

Frantz Fanon's contribution to postcolonial theory lies in his distinctive ability to synthesize psychoanalysis with political critique. Unlike earlier Marxist approaches that primarily emphasized economic exploitation, Fanon foregrounds the psychological and cultural dimensions of colonial domination. He conceptualizes colonialism not merely as a political system but as a deeply embedded psychological project aimed at restructuring the consciousness of the colonized. Through this lens, colonialism operates by shaping subjectivity, producing internalized hierarchies of race, culture, and identity.

INTERNALIZATION OF COLONIAL VALUES

One of Fanon's central arguments is that colonial domination functions through the internalization of imposed values. The colonized subject comes to perceive the norms, language, and cultural practices of the colonizer as inherently superior, leading to a profound sense of self-alienation. This process is not sustained solely through coercion but is reinforced through institutional mechanisms such as education, religion, media, and linguistic structures. As a result, colonial power becomes normalized within the consciousness of the colonized, making domination appear natural and inevitable.

RACIALIZATION AND THE BODY

Fanon further develops the concept of the "racial epidermal schema" to explain how colonialism inscribes racial hierarchies onto the body. The colonized individual becomes hyper-aware of their physical identity, which is continuously marked as inferior within the colonial order. This racialization transforms the body into a site of oppression, where identity is defined externally rather than internally. Consequently, the individual experiences a fragmented sense of self, shaped by the gaze and judgments of the colonizer.

NEUROSIS AND IDENTITY CRISIS

The psychological consequences of colonialism, as identified by Fanon, include neurosis, anxiety, and deep-seated inferiority complexes. The colonized subject exists in a state of constant tension, caught between the desire to assimilate into the dominant culture and the impossibility of achieving full acceptance. This condition produces a divided consciousness, where the individual is unable to fully identify with either their indigenous heritage or the imposed colonial identity, resulting in a persistent crisis of selfhood.

COLONIAL MODERNITY AND CULTURAL DOMINATION

Colonial culture must be understood within the broader framework of modernity. Rather than being an external deviation, colonialism was integral to the development of modern Western civilization. Ideals such as progress, rationality, and civilization were often mobilized to justify imperial expansion and cultural domination. In this context, colonialism functioned as both a material and ideological system that legitimized inequality and hierarchy.

EPISTEMIC VIOLENCE

A critical dimension of colonial domination is what has been termed "epistemic violence"—the systematic marginalization and erasure of indigenous knowledge systems. Colonial regimes imposed Western epistemologies as universal while dismissing local traditions as primitive or irrational. This process not only undermined cultural diversity but also reconfigured the intellectual and cultural landscape of colonized societies, reinforcing the dominance of Western modes of thought.

CULTURAL HEGEMONY

Drawing on Antonio Gramsci's concept of hegemony, colonial culture can be understood as a form of ideological domination maintained through consent rather than overt coercion. The colonized subject internalizes the values and beliefs of the dominant culture, thereby participating in their own subordination. This internalization complicates resistance, as the structures of domination are embedded within everyday consciousness and social practices.

RESISTANCE REIMAGINED: BEYOND VIOLENCE

Although Fanon is often associated with the justification of revolutionary violence, his conception of resistance is more nuanced and multidimensional. Resistance, in his framework, encompasses not only physical struggle but also psychological and cultural transformation.

PSYCHOLOGICAL LIBERATION

At its core, resistance involves the rejection of internalized inferiority and the affirmation of one's identity. This process requires a fundamental reorientation of consciousness, whereby the colonized subject reclaims a sense of dignity and self-worth. Psychological liberation is thus a crucial step in overcoming the legacy of colonial domination.

CULTURAL RESISTANCE

Cultural revival plays a central role in the process of decolonization. The reclamation of indigenous languages, traditions, and knowledge systems serves as a powerful form of resistance against colonial narratives. Cultural production—through literature, art, and intellectual discourse—becomes a site of political engagement and identity reconstruction.

EVERYDAY RESISTANCE

Resistance is not limited to organized political movements but also manifests in everyday practices. Acts such as the use of indigenous languages, preservation of cultural traditions, and assertion of identity in daily life represent subtle yet significant forms of defiance against dominant structures. Contemporary Relevance: Neo-Colonialism and Globalization

Despite the formal end of colonial rule, its legacy persists in the contemporary global order through neo-colonialism and processes of globalization. Economic dependence, cultural influence, and institutional power continue to shape the identities and experiences of postcolonial societies. Multinational corporations, global media networks, and international organizations play a significant role in disseminating dominant cultural norms.

GLOBAL CULTURAL HIERARCHIES

Western culture continues to occupy a privileged position in global discourse, often marginalizing non-Western identities and knowledge systems. This perpetuates new forms of alienation and reinforces existing inequalities, echoing the dynamics of colonial domination.

DIGITAL COLONIALISM

In the digital age, control over information, data, and technological infrastructure has emerged as a new form of power. The dominance of global technology platforms raises critical questions about cultural sovereignty, knowledge production, and digital dependency. This phenomenon, often described as digital colonialism, reflects the استمرار of unequal power relations in new and evolving forms.

ANALYSIS AND DISCUSSION

Colonial Culture and the Construction of Inferiority

Fanon's analysis of colonial culture reveals that it operates through a rigid hierarchical system that privileges European values, norms, and modes of life while systematically devaluing indigenous cultures. This hierarchy is not merely external but becomes internalized within the consciousness of the colonized subject. As a result, individuals begin to perceive their own cultural identity as inferior, backward, and lacking in value. Colonial discourse reinforces this perception through education, religion, and institutional structures, encouraging the colonized to aspire toward the cultural standards of the colonizer. This process produces a deep sense of self-rejection, wherein the colonized subject distances themselves from their own heritage in an attempt to achieve recognition within the dominant framework.

Language and Alienation

Language plays a crucial role in the production and perpetuation of alienation. Fanon emphasizes that adopting the colonizer's language is not a neutral or purely communicative act; rather, it involves the internalization of a particular worldview and cultural framework. The use of the colonial language often signifies access to power, modernity, and social mobility, thereby incentivizing its adoption. However, this shift frequently comes at the cost of distancing oneself from indigenous linguistic and cultural roots. The result is a sense of dislocation, where individuals are neither fully grounded in their native identity nor completely accepted within the dominant culture. Thus, language becomes both a tool of empowerment and a mechanism of alienation.

The Divided Self

A central theme in Fanon's work is the notion of the "divided self," which encapsulates the psychological fragmentation experienced by the colonized subject. Caught between the desire to assimilate into the dominant culture and the reality of persistent exclusion, the individual inhabits a space of contradiction. On one hand, there is an aspiration to emulate the colonizer's values and lifestyle; on the other, there is an enduring awareness of racial and cultural difference that prevents full acceptance. This duality generates a continuous state of tension, leading to identity confusion, insecurity, and psychological distress. The colonized subject is thus compelled to navigate competing identities, resulting in a fractured and unstable sense of self.

Violence and Resistance

Fanon's interpretation of resistance, particularly his engagement with violence, is both complex and controversial. He argues that in the context of colonial domination, violence serves not only as a means of political struggle but also as a process of psychological liberation. Colonialism itself is

inherently violent, and therefore resistance must confront this violence to dismantle the structures of oppression. For Fanon, revolutionary violence enables the colonized to reclaim agency, assert their humanity, and overcome the internalized inferiority imposed by colonial rule. However, resistance is not limited to physical confrontation; it also encompasses intellectual, cultural, and psychological dimensions aimed at restoring dignity and selfhood.

Cultural Revival and Identity Reconstruction

Beyond political resistance, Fanon underscores the importance of cultural revival in the process of decolonization. Reclaiming indigenous traditions, languages, and histories is essential for reconstructing identity and countering the erasure produced by colonial domination. Cultural revival serves as a means of reconnecting with suppressed histories and affirming alternative ways of knowing and being. It challenges the dominance of colonial narratives and fosters a renewed sense of collective identity and pride. Through this process, the colonized subject moves from a position of alienation to one of self-affirmation, enabling the reconstruction of identity on autonomous and culturally grounded terms.

DISCUSSION

The relevance of Fanon's theoretical insights extends well beyond the historical context of classical colonialism and remains critically significant in understanding contemporary global dynamics. In the era of globalization, many postcolonial societies continue to experience the subtle yet pervasive influence of cultural imperialism. Western cultural norms, values, and lifestyles often dominate global discourse, shaping aspirations, consumption patterns, and identity formations. This dominance is reinforced through transnational media networks, consumer capitalism, and neoliberal economic frameworks, which collectively reproduce hierarchies reminiscent of colonial structures. As a result, new forms of alienation and identity crisis emerge, particularly among individuals navigating the tension between global modernity and local cultural belonging.

Furthermore, Fanon's emphasis on the psychological dimensions of oppression provides a valuable lens for analyzing these contemporary conditions. The internalization of dominant cultural ideals continues to affect self-perception and social positioning in postcolonial contexts. However, resistance has also evolved in response to these challenges. It now manifests through diverse forms, including cultural movements, identity-based activism, and efforts to decolonize knowledge systems and academic discourses. These forms of resistance highlight the ongoing struggle to assert cultural autonomy and redefine identity outside the frameworks imposed by historical and neo-colonial forces. In this regard, Fanon's work remains indispensable for understanding both the persistence of domination and the transformative potential of resistance.

CONCLUSION

Colonial culture has exerted a profound and enduring influence on the identity of colonized societies. By imposing hierarchical structures that privileged European values and devalued indigenous traditions, colonialism generated a deep crisis of identity characterized by alienation, fragmentation, and internalized inferiority. Fanon's analysis provides a powerful theoretical framework for understanding these dynamics, particularly by illuminating the psychological dimensions of colonial domination. At the same time, Fanon's work underscores the importance of resistance as a means of reclaiming identity, dignity, and cultural autonomy. Decolonization, in this sense, is not merely a political process but also a psychological and cultural transformation that

seeks to restore selfhood and collective identity. Although formal colonial rule has largely ended, its cultural and psychological legacies persist in various forms, shaping contemporary experiences and power relations.

Addressing these enduring effects requires a multidimensional approach that goes beyond structural reforms to include cultural and epistemic decolonization. Fanon's insights continue to offer critical guidance for this ongoing process, emphasizing the need to challenge dominant narratives and affirm alternative ways of knowing and being.

LIMITATIONS AND FUTURE SCOPE

This study is primarily theoretical in nature, relying on textual and conceptual analysis of Fanon's work and related postcolonial scholarship. While this approach allows for a deep engagement with theoretical frameworks, it limits the empirical applicability of the findings. The absence of field-based data or case-specific analysis may constrain the ability to fully capture the lived experiences of individuals in diverse postcolonial contexts.

Future research can address these limitations by incorporating empirical methodologies, such as case studies, ethnographic research, and comparative analyses across different regions. Such approaches would provide a more grounded understanding of how Fanonian concepts of alienation, identity crisis, and resistance manifest in contemporary societies. Additionally, interdisciplinary research that integrates insights from sociology, psychology, cultural studies, and media studies could offer a more comprehensive perspective on identity formation in the context of globalization and digital transformation. Expanding the scope of inquiry in these directions would not only deepen the applicability of Fanon's ideas but also contribute to evolving debates on decolonization and identity in the modern world.

REFERENCES:

Ahluwalia, P. (2001). **Politics and post-colonial theory: African inflections*****. Routledge.***

Appiah, K. A. (1992). **In my father's house: Africa in the philosophy of culture*****. Oxford University Press.***

Ashcroft, B., Griffiths, G., & Tiffin, H. (2002). **The empire writes back: Theory and practice in post-colonial literatures *(2nd ed.). Routledge.***

Barker, C. (2012). **Cultural studies: Theory and practice *(4th ed.). Sage.***

Bhabha, H. K. (1994). **The location of culture*****. Routledge.***

Bhambra, G. K. (2007). **Rethinking modernity: Postcolonialism and the sociological imagination*****. Palgrave Macmillan.***

Cabral, A. (1973). **Return to the source: Selected speeches*****. Monthly Review Press.***

Césaire, A. (2000). **Discourse on colonialism *(J. Pinkham, Trans.). Monthly Review Press. (Original work published 1950)***

Chakrabarty, D. (2000). **Provincializing Europe: Postcolonial thought and historical difference*****. Princeton University Press.***

Chatterjee, P. (1993). The nation and its fragments: Colonial and postcolonial histories*. Princeton University Press.*

Chinweizu. (1975). The West and the rest of us: White predators, Black slavers, and the African elite*. Vintage.*

Cooper, F. (2005). Colonialism in question: Theory, knowledge, history*. University of California Press.*

Dirlik, A. (1994). The postcolonial aura: Third World criticism in the age of global capitalism. Critical Inquiry, 20*(2), 328–356. https://doi.org/10.1086/448714*

Du Bois, W. E. B. (1903). The souls of Black folk*. A. C. McClurg & Co.*

Fanon, F. (1963). The wretched of the earth*. Grove Press.*

Fanon, F. (1967). Black skin, white masks*. Grove Press.*

Fanon, F. (2004). The wretched of the earth *(R. Philcox, Trans.). Grove Press.*

Ferguson, J. (2006). Global shadows: Africa in the neoliberal world order*. Duke University Press.*

Gordon, L. R. (2015). What Fanon said: A philosophical introduction to his life and thought*. Fordham University Press.*

THE IMPACT OF SOCIAL MEDIA MARKETING ON CONSUMER PURCHASE BEHAVIOUR

DR. ISHITA G. DODIA
ASSISTANT PROFESSOR, SHREE HMV ARTS AND COMMERCE COLLEGE - UNA

ABSTRACT

In the digital era, social media has emerged as a powerful marketing tool that significantly influences consumer purchase behavior. Platforms such as Facebook, Instagram, Twitter, and YouTube have transformed how businesses interact with customers, promote products, and build brand identity. This research paper examines the impact of social media marketing on consumer decision-making processes, focusing on factors such as content quality, influencer marketing, customer engagement, and online reviews. The study highlights how social media affects different stages of the consumer buying journey, including awareness, consideration, and purchase decisions. Additionally, it explores both the positive and negative aspects of social media marketing, including issues of trust, privacy, and misinformation. The findings suggest that social media marketing plays a crucial role in shaping consumer preferences and enhancing brand loyalty, making it an indispensable component of modern marketing strategies.

KEYWORDS: SOCIAL MEDIA MARKETING, CONSUMER BEHAVIOUR , DIGITAL MARKETING, INFLUENCER MARKETING, ONLINE REVIEWS, BRAND LOYALTY

1. INTRODUCTION

The rapid advancement of digital technologies has revolutionized the marketing landscape, with social media becoming one of the most influential tools for businesses worldwide. Social media platforms enable companies to connect directly with consumers, creating interactive and personalized experiences. Unlike traditional marketing channels, social media offers real-time communication, user-generated content, and targeted advertising, making it highly effective in influencing consumer behavior.

Consumer purchase behavior refers to the decision-making process that individuals undergo when selecting, purchasing, and using products or services. Social media marketing affects this process by providing information, shaping perceptions, and influencing attitudes toward brands. Today, consumers rely heavily on social media for product reviews, recommendations, and brand interactions before making purchasing decisions.

This research paper aims to analyze the impact of social media marketing on consumer purchase behavior, identify key influencing factors, and evaluate its effectiveness in modern marketing strategies.

2. OBJECTIVES OF THE STUDY

The main objectives of this research are:
To examine the role of social media in influencing consumer purchase decisions
To analyze the impact of influencer marketing on consumer behavior
To evaluate the importance of online reviews and user-generated content

To identify challenges and limitations of social media marketing
To suggest strategies for effective social media marketing

3. RESEARCH METHODOLOGY

This study is based on **secondary data analysis**, using information collected from academic journals, research articles, marketing reports, and online sources. The research adopts a **descriptive and analytical approach** to understand patterns and trends in consumer behavior influenced by social media marketing.

Data Sources

Research journals (Google Scholar, JSTOR)
Industry reports (Statista, HubSpot, McKinsey)
Books and online publications related to marketing

Limitations

The study relies on secondary data, which may not reflect real-time changes
Consumer behavior varies across regions and demographics
Rapid technological changes may affect the relevance of findings over time

4. LITERATURE REVIEW

Previous studies have highlighted the growing importance of social media marketing in influencing consumer behavior. Kaplan and Haenlein (2010) defined social media as a group of internet-based applications that allow the creation and exchange of user-generated content. According to Mangold and Faulds (2009), social media acts as a hybrid element of the promotion mix, enabling both company-to-consumer and consumer-to-consumer communication.

A study by Evans (2012) emphasized that social media platforms significantly influence brand awareness and customer engagement. Similarly, research by Hajli (2014) found that social commerce constructs such as trust, social support, and user interaction positively affect purchase intentions.

Influencer marketing has also gained significant attention. According to Freberg et al. (2011), influencers act as opinion leaders who can shape consumer perceptions and buying decisions. Additionally, Cheung and Thadani (2012) highlighted the importance of electronic word-of-mouth (eWOM) in influencing consumer purchase behavior.

Overall, existing literature confirms that social media marketing plays a vital role in shaping consumer attitudes, preferences, and purchasing decisions.

5. CONCEPT OF SOCIAL MEDIA MARKETING

Concept of Social Media Marketing

Social Media Marketing (SMM) refers to the use of social media platforms and websites to promote products, services, or brands. It has become an essential component of modern marketing strategies due to the rapid growth of internet usage and the widespread adoption of social networking sites such as Facebook, Instagram, Twitter (X), LinkedIn, YouTube, and others. Unlike traditional marketing methods, social media marketing emphasizes two-way communication,

allowing businesses to interact directly with consumers, understand their preferences, and build long-term relationships.

At its core, social media marketing involves creating and sharing content tailored to a specific audience. This content can take various forms, including text posts, images, videos, stories, reels, live streams, and advertisements. The goal is not only to promote products but also to engage users, encourage participation, and foster a sense of community around the brand. Engagement is a key feature of social media marketing, as it includes likes, comments, shares, and direct messages, which help businesses measure consumer interest and feedback in real time.

One of the most significant aspects of social media marketing is its ability to target specific audiences. Platforms use advanced algorithms and user data to allow marketers to reach audiences based on demographics, interests, behavior, and location. This targeted approach increases the effectiveness of marketing campaigns and ensures that promotional messages reach the right people at the right time. As a result, businesses can achieve higher conversion rates compared to traditional mass marketing techniques.

Another important concept within social media marketing is user-generated content (UGC). This refers to content created by consumers rather than brands, such as reviews, testimonials, photos, and videos. UGC plays a crucial role in influencing potential buyers, as it is often perceived as more authentic and trustworthy than company-generated advertisements. Consumers tend to rely on peer opinions and experiences before making purchase decisions, making UGC a powerful tool in shaping brand perception.

Influencer marketing is also a major component of social media marketing. Influencers are individuals with a significant following on social media who can impact the opinions and behaviors of their audience. Brands collaborate with influencers to promote their products in a more relatable and credible manner. This strategy is particularly effective among younger audiences who trust influencers more than traditional advertising channels.

Social media marketing also supports brand building and awareness. By consistently posting valuable and engaging content, businesses can establish a strong online presence and identity. Visual elements such as logos, color schemes, and tone of communication help create brand recognition and recall. Over time, this builds customer loyalty and trust, which are essential for long-term success.

Moreover, social media platforms provide valuable analytics and insights that help businesses measure the performance of their marketing efforts. Metrics such as reach, impressions, engagement rate, click-through rate, and conversion rate enable marketers to evaluate the effectiveness of their campaigns and make data-driven decisions. This level of measurability is a major advantage of social media marketing over traditional methods.

Despite its many benefits, social media marketing also presents challenges. These include managing negative feedback, maintaining consistent content quality, dealing with algorithm changes, and

addressing privacy concerns. However, with proper strategy and management, these challenges can be effectively handled.

KEY FEATURES:

Interactive communication
User-generated content
Real-time feedback
Wide reach and accessibility
Cost-effectiveness

Popular platforms include Facebook, Instagram, Twitter (X), LinkedIn, and YouTube, each offering unique features for marketing.

6. CONSUMER PURCHASE BEHAVIOR

Consumer purchase behavior refers to the process and actions undertaken by individuals when they search for, evaluate, purchase, use, and dispose of goods or services to satisfy their needs and desires. It is a complex phenomenon influenced by a variety of factors, including psychological, social, cultural, and personal elements. Understanding consumer purchase behavior is essential for marketers, as it helps them design effective strategies to attract and retain customers.

The consumer buying process typically consists of five stages. The first stage is **problem recognition**, where a consumer realizes a need or desire for a product or service. This need can arise from internal factors, such as hunger or personal preference, or external factors, such as advertisements or social influence. The second stage is **information search**, where consumers gather data about available options through sources like online reviews, social media, advertisements, and recommendations from friends or family.

The third stage is **evaluation of alternatives**, where consumers compare different products or brands based on factors such as price, quality, features, and brand reputation. After evaluating the options, the consumer moves to the **purchase decision** stage, where they select a product and complete the transaction. However, this decision can still be influenced by factors like discounts, availability, or peer opinions. The final stage is **post-purchase behavior**, where consumers evaluate their satisfaction with the product. Positive experiences may lead to repeat purchases and brand loyalty, while negative experiences can result in dissatisfaction and negative word-of-mouth. Several factors influence consumer purchase behavior. **Psychological factors** include perception, motivation, beliefs, and attitudes, which shape how consumers interpret information and make decisions. **Social factors**, such as family, friends, and social media, play a significant role in influencing preferences and choices. **Cultural factors** determine values, traditions, and lifestyle patterns, which affect consumption habits. Additionally, **personal factors** like age, income, occupation, and lifestyle also impact purchasing decisions.

In today's digital era, technology and social media have become major influences on consumer behavior. Consumers increasingly rely on online platforms for product information, reviews, and recommendations, making the decision-making process more informed and interactive.

Consumer purchase behavior is influenced by various factors, including psychological, social, cultural, and personal elements. The buying process typically includes:
Problem recognition
Information search
Evaluation of alternatives
Purchase decision
Post-purchase behavior
Social media influences each stage by providing information, reviews, and recommendations.

7. IMPACT OF SOCIAL MEDIA MARKETING ON CONSUMER PURCHASE BEHAVIOR

7.1 Awareness and Information Search

Social media platforms serve as primary sources of information for consumers. Businesses use advertisements, posts, and videos to create awareness about products. Consumers often discover new brands through social media feeds and ads.

7.2 Influence of Online Reviews and Ratings

Online reviews and ratings significantly affect consumer decisions. Positive reviews build trust, while negative reviews can discourage purchases. Consumers tend to rely on peer opinions more than traditional advertisements.

7.3 Role of Influencer Marketing

Influencers play a crucial role in shaping consumer preferences. Their recommendations are perceived as authentic and trustworthy, especially among younger audiences. Influencer marketing increases brand visibility and credibility.

7.4 Customer Engagement

Social media enables direct interaction between brands and consumers. Engagement through comments, likes, and shares strengthens relationships and enhances customer loyalty.

8. ADVANTAGES OF SOCIAL MEDIA MARKETING

Cost-effective compared to traditional marketing
Wide audience reach
Real-time communication
Increased brand awareness
Enhanced customer engagement

9. CHALLENGES AND LIMITATIONS

Privacy concerns and data security issues
Spread of misinformation
Negative feedback and brand reputation risks
Over-dependence on algorithms
Difficulty in measuring ROI

10. FINDINGS AND DISCUSSION

The study reveals that social media marketing has a strong influence on consumer purchase behavior. Consumers rely heavily on social media for product information, reviews, and recommendations. Influencer marketing and user-generated content play a significant role in shaping consumer perceptions.

However, trust remains a critical factor. Consumers are cautious about misleading advertisements and fake reviews. Therefore, authenticity and transparency are essential for effective social media marketing.

11. SUGGESTIONS

Focus on authentic and high-quality content
Collaborate with credible influencers
Encourage positive customer reviews
Ensure data privacy and transparency
Use analytics tools to measure performance

12. CONCLUSION

Social media marketing has transformed the way businesses interact with consumers and influence their purchase behavior. It plays a vital role in all stages of the consumer buying process, from awareness to post-purchase evaluation. Despite certain challenges, social media remains a powerful and effective marketing tool.

Businesses that leverage social media strategically can enhance brand visibility, build customer relationships, and drive sales. As technology continues to evolve, social media marketing will become even more significant in shaping consumer behavior.

13. REFERENCES

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media.

Mangold, W. G., & Faulds, D. J. (2009). Social media: The new hybrid element of the promotion mix.

Evans, D. (2012). Social Media Marketing: An Hour a Day.

Hajli, N. (2014). A study of the impact of social media on consumers.

Freberg, K. et al. (2011). Who are the social media influencers?

Cheung, C. M. K., & Thadani, D. R. (2012). The impact of electronic word-of-mouth communication.

Kotler, P., & Keller, K. L. (2016). Marketing Management.

Statista Reports on Social Media Usage

HubSpot Marketing Reports

McKinsey Digital Consumer Insights

A COMPREHENSIVE AND DETAILED REVIEW OF ADENOVIRUS AND RABIES VIRUS: MORPHOLOGY, CULTIVATION, PATHOGENESIS, CLINICAL FEATURES, DIAGNOSIS, AND PROPHYLAXIS

POOJA YADAV
DEPARTMENT OF MICROBIOLOGY, SHREE PM PATEL INSTITUTE OF PG STUDIES AND RESEARCH IN SCIENCE, AFFILIATED TO SARDAR PATEL UNIVERSITY, MANAGED BY ANAND PEOPLE'S MEDICARE SOCIETY, ANAND – 388001, GUJARAT, INDIA

ABSTRACT

Adenoviridae (Adenovirus) and Rabies virus are two clinically important but biologically different viral families that are thoroughly analyzed in this review paper (Rabies virus). Despite being significant worldwide health issues, their genomic makeup, modes of transmission, and clinical results are very different. Adenoviruses are primarily responsible for self-limiting respiratory, ocular, and gastrointestinal infections, but they also pose a serious threat to immunocompromised populations due to their non-enveloped icosahedral morphology and double-stranded DNA. The bullet-shaped, negative-sense single-stranded RNA Rabies virus, on the other hand, is a highly neurotropic pathogen that is almost always fatal once encephalomyelitis symptoms appear.

The distinct morphology and structural proteins of both viruses are described in this paper, along with contemporary cultivation methods in specialised cell lines (e.g., HEK293 and Vero cells). We also look at their different pathogenic mechanisms, concentrating on the rabies virus's invasion of the central nervous system and retrograde axonal transport versus the adenovirus's lysis of epithelial cells and immune evasion. The gold-standard PCR and DFA testing as well as the detection of pathognomonic Negri bodies are among the diagnostic techniques that are contrasted. Lastly, the review assesses current prophylactic measures, such as the vital life-saving procedures of Rabies Post-Exposure Prophylaxis and the military-use adenovirus vaccine (PEP). This review attempts to provide a unified resource for comprehending the biology and treatment of these various viral pathogens by combining the most recent molecular and clinical data.

KEYWORDS ADENOVIRUSES, RABIES, MORPHOLOGY, CULTIVATION, PATHOGENESIS, CLINICAL MANIFESTATIONS, DIAGNOSTICS, PROPHYLAXIS.

ADENOVIRUSES

1. Overview

First identified in 1953 from human adenoids, adenoviruses are a diverse family of non-enveloped, double-stranded DNA (dsDNA) viruses. They are members of the Adenoviridae family, with strains that infect humans falling under the genus Mastadenovirus. There are currently over 100 identified genotypes, divided into seven species (A–G). While typically causing mild respiratory, ocular, or gastrointestinal infections, they can lead to severe multi-organ disease in immunocompromised individuals(Weatherley et al., 2026).

2. Morphology

Adenoviruses have an intricate, well-organized structure with icosahedral symmetry.("Adenoviridae," 2017)

Virion Structure: Particles with a medium size (70–100 nm) and no lipid envelope.

Capsid Elements:

Hexons: The icosahedron's faces and edges are formed by this major structural subunit, which consists of 240 trimers.
Pentons: Found at each of the 12 vertices, they are made up of a protruding fibre and a penton base.
Fibers: Tiny projections with a distal "knob" domain that attach to host cell receptors.
Genome: 26–48 kb of linear, non-segmented dsDNA.
Core Proteins: Basic proteins such as Mu, Protein VII (a histone-like condensing agent), and Protein V (a bridge between the capsid and core) condense the genome inside the capsid.

3. Cultivation

For adenoviruses to proliferate, they need particular host cell environments, usually human epithelial cell lines.
Primary Cell Lines: Human embryonic kidney (HEK) cells are commonly employed.
Well-known Cell Lines: HeLa, Hep-2, and A549 (lung carcinoma) are the norm for isolation and study.
Vector Production: HEK293 and PER are examples of specialised "packaging" cell lines(Chaves Hernández, 2014).
Replication-deficient vectors can proliferate because C6 are designed to supply vital viral genes (like E1) in trans.
Cytopathic Effect (CPE): Cell rounding, clumping (like bunches of grapes), and the development of refractile intranuclear inclusion bodies are characteristics of productive infection.

4. Pathogenesis

The three main methods of infection are direct inoculation, fecal-oral transmission, and respiratory droplets (e.g., in the eye). (MacNeil et al., 2023)
Entry and Replication: The fibre knob attaches itself to receptors like CD46 or CAR (Coxsackievirus and Adenovirus Receptor). Penton base interactions with integrins facilitate internalisation, which results in endocytosis.
Lytic Cycle: When viruses replicate in epithelial cells, host cells lyse, resulting in inflammation and the release of cytokines (e.g., IL-6, IL-8, TNF).(Luisoni & Greber, 2016)
Immune Evasion: Adenoviruses use early (E) genes to inhibit interferon signalling, suppress MHC class I expression to avoid T-cells (E3-19K), and block apoptosis (E1B).
Persistence: In lymphoid tissues like the tonsils and adenoids, they can create latent infections that could eventually reactivate.

5. Clinical Characteristics

Tissue tropism and serotype affect symptoms.
Respiratory conditions include pneumonia, bronchitis, pharyngitis, and the common cold. The classic symptoms of pharyngoconjunctival fever include fever, sore throat, and red eyes.(Miro et al., 2021)
Ocular: Epidemic keratoconjunctivitis (EKC), frequently linked to tainted swimming pools or equipment.
Gastrointestinal: Serotypes 40/41 cause acute gastroenteritis, mostly in children.
Acute hemorrhagic cystitis in the genitalia (bloody urine).

6. The laboratory diagnosis

Molecular: PCR is the current gold standard for quickly and accurately identifying and measuring viral DNA(Hysmith et al., 2018).
Antigen Detection: For respiratory and stool samples, quick tests like immunofluorescence or ELISA are utilised.

Virus Isolation: Cell culture is still the gold standard, but it takes two to twenty-eight days.
Serology: Mostly used for epidemiology, a fourfold increase in antibody titers between acute and convalescent phases can confirm infection.

7. Prevention and Management

Vaccines: To prevent outbreaks in close quarters, a live, oral, enteric-coated vaccine against Type 4 and Type 7 has been approved for US military recruits. The general public does not currently have access to a vaccine(Dodge et al., 2021).
Hygiene: It's important to wash your hands frequently with soap and water. Although adenoviruses are resistant to many disinfectants, they can be rendered inactive by 70% ethanol or sodium hypochlorite.
Infection control measures include appropriate chlorination of swimming pools and contact and droplet precautions in healthcare settings.(Verma et al., 2022)

THE RABIES VIRUS (RABV)

1. Overview

In humans and warm-blooded animals, rabies is a deadly zoonotic viral disease that causes acute, progressive encephalomyelitis. The disease is almost always fatal once clinical symptoms manifest. It is primarily spread by the bite of an infected mammal, most frequently domestic dogs. Despite being preventable by vaccination, it continues to be a significant public health burden, accounting for about 59,000 deaths per year, with Asia and Africa accounting for 95% of these cases.

2. Morphology

Rabies virus (RABV), the causative agent, is a member of the Rhabdoviridae family's genus Lyssavirus.
Virion Structure: Typically bullet-shaped, with dimensions of about 180 nm in length and 75 nm in diameter.
Capsid and Envelope: It is an enveloped virus with spike-shaped glycoprotein (G) trimers on the surface. The matrix (M) protein is located beneath the lipid envelope.
Genome: About 12 kb of linear, non-segmented, negative-sense single-stranded RNA.
Proteins: Five structural proteins are encoded.
Nucleoprotein (N): Forms the ribonucleoprotein (RNP) core by encasing the RNA.
Phosphoprotein (P): The viral polymerase's non-catalytic cofactor.
Virion assembly and budding depend on matrix protein (M).
Glycoprotein (G): In charge of membrane fusion and host cell receptor binding.
Viral transcription and replication depend on RNA-dependent RNA polymerase (L).

3. Cultivation

RABV needs particular substrates to cultivate and is highly neurotropic.
Cell Lines: Neuro-2a, BHK-21 (Baby Hamster Kidney), and Vero cells (African Green Monkey Kidney) are examples of standard lines (murine neuroblastoma). It has also been demonstrated that HEK-293 (human embryonic kidney) is extremely sensitive for quick isolation.(Rourou et al., 2019)
Animal Inoculation: Cell culture has largely supplanted intracerebral inoculation of mice (also known as the Mouse Inoculation Test, or MIT) as the gold standard for isolation.
Vaccine Production: Cell-culture technology, such as Sanofi Pasteur's Verorab, or embryonated eggs are used in the production of modern vaccines.

4. Pathogenesis

The ability of rabies to evade the immune system and reach the central nervous system defines its pathogenesis (CNS).

Inoculation and Local Replication: The virus may replicate in striated muscle cells close to the site of entry after a bite.(Saini et al., 2024)

Neuroinvasion: At neuromuscular junctions, the virus attaches itself to receptors such as the nicotinic acetylcholine receptor (nAChR).

Retrograde Transport: It uses host dynein motor proteins to move along peripheral nerves via retrograde axonal transport at a speed of about 3 mm/h.

CNS Amplification and Centrifugal Spread: Rapid replication takes place once it reaches the brain and spinal cord. After that, the virus travels centrifugally from the central nervous system to peripheral organs, particularly the salivary glands, where it is expelled as saliva.

5. Clinical Characteristics

Incubation, prodrome, acute neurologic phase, coma, and death are the five clinical stages that an infection goes through.

Depending on the location of the bite and the viral load, the incubation period can vary from one week to more than a year, but it usually lasts one to three months.(Warrell & Warrell, 2015)

Prodrome: Paresthesia (tingling or pain) at the bite site and nonspecific flu-like symptoms (fever, headache, malaise).

Phase of Acute Neurology: exists in two forms:

About 80% of cases of encephalitic (furious) rabies are marked by agitation, hyperactivity, hydrophobia (fear of water), and aerophobia (fear of fresh air).

About 20% of cases of paralytic (dumb) rabies are characterised by progressive flaccid paralysis that begins in the bitten limb and frequently resembles Guillain-Barré syndrome.

6. The laboratory diagnosis

Post-mortem: The gold standard is the Direct Fluorescent Antibody (dFA) test performed on fresh brain tissue. Negri bodies are a pathognomonic histopathological finding, although they can be absent in up to 20% of cases.(Ashwini et al., 2026)

Ante-mortem: Because of sporadic shedding, several specimens are needed. Tests include skin biopsies from the nape of the neck to identify viral antigen in hair follicles and RT-PCR on saliva or CSF.

7. Preventive measures

If prophylaxis is given as soon as possible after exposure, rabies can be avoided.

PEP, or post-exposure prophylaxis, includes:

Immediate Wound Care: Spend at least fifteen minutes thoroughly cleaning the wound with soap and water.

Passive Immunization: Infiltration of Rabies Immunoglobulin (RIG) at the site of injury (for Category III exposures).

Active Immunization: A modern cell-culture vaccination course given intramuscularly or intradermally(de Melo et al., 2022).

REFERENCES

Adenoviridae. (2017). Fenner's Veterinary Virology, 217–227. https://doi.org/10.1016/B978-0-12-800946-8.00010-6

Ashwini, M. A., Lodha, L., Ramachandran, A., Esther, A. J., & Mani, R. S. (2026). Laboratory diagnosis of rabies in an endemic country: Progress and challenges on the path to elimination. Diagnostic Microbiology and Infectious Disease, 114(2), 117123. https://doi.org/10.1016/J.DIAGMICROBIO.2025.117123

Chaves Hernández, A. J. (2014). Poultry and Avian Diseases. Encyclopedia of Agriculture and Food Systems, 504–520. https://doi.org/10.1016/B978-0-444-52512-3.00183-2

de Melo, G. D., Hellert, J., Gupta, R., Corti, D., & Bourhy, H. (2022). Monoclonal antibodies against rabies: current uses in prophylaxis and in therapy. Current Opinion in Virology, 53. https://doi.org/10.1016/j.coviro.2022.101204

Dodge, M. J., MacNeil, K. M., Tessier, T. M., Weinberg, J. B., & Mymryk, J. S. (2021). Emerging antiviral therapeutics for human adenovirus infection: Recent developments and novel strategies. Antiviral Research, 188. https://doi.org/10.1016/j.antiviral.2021.105034

Hysmith, N. D., Tanner, M. R., Arnold, S. R., Buckingham, S. C., Patel, A. R., Dhanireddy, R., Comeaux, K., Joyner, J., Hoehn, M. E., & Devincenzo, J. P. (2018). Use of real-time semiquantitative PCR data in management of a neonatal intensive care unit adenovirus outbreak. Infection Control and Hospital Epidemiology, 39(9), 1074–1079. https://doi.org/10.1017/ice.2018.162

Luisoni, S., & Greber, U. F. (2016). Biology of Adenovirus Cell Entry: Receptors, Pathways, Mechanisms. Adenoviral Vectors for Gene Therapy: Second Edition, 27–58. https://doi.org/10.1016/B978-0-12-800276-6.00002-4

MacNeil, K. M., Dodge, M. J., Evans, A. M., Tessier, T. M., Weinberg, J. B., & Mymryk, J. S. (2023). Adenoviruses in medicine: innocuous pathogen, predator, or partner. Trends in Molecular Medicine, 29(1), 4–19. https://doi.org/10.1016/J.MOLMED.2022.10.001

Miro, E., Del Cuerpo, M., Rubio, M., Berengua, C., Español, M., Marin, P., Vela, J. I., Pomar, V., Gutierrez, C., Navarro, F., & Rabella, N. (2021). Whole-genome analysis to describe a human adenovirus D8 conjunctivitis outbreak in a tertiary hospital. Journal of Medical Virology, 93(8), 4840–4845. https://doi.org/10.1002/jmv.26850

Rourou, S., Ben Zakkour, M., & Kallel, H. (2019). Adaptation of Vero cells to suspension growth for rabies virus production in different serum free media. Vaccine, 37(47), 6987–6995. https://doi.org/10.1016/j.vaccine.2019.05.092

Saini, A. K., Gupta, A. A., Keservani, R. K., Kachave, R. N., Kesharwani, R. K., Darshan, J. C., Alekhya, K., & Bansal, S. (2024). Pathogenesis and treatment of rabies. A Review on Diverse Neurological Disorders: Pathophysiology, Molecular Mechanisms, and Therapeutics, 225–232. https://doi.org/10.1016/B978-0-323-95735-9.00038-3

Verma, A., Vimalesvaran, S., Lampejo, T., Deep, A., & Dhawan, A. (2022). Use of cidofovir in recent outbreak of adenovirus-associated acute liver failure in children. The Lancet Gastroenterology and Hepatology, 7(8), 700–702. https://doi.org/10.1016/S2468-1253(22)00199-6

Warrell, M. J., & Warrell, D. A. (2015). Rabies: the clinical features, management and prevention of the classic zoonosis. Clinical Medicine, 15(1), 78–81. https://doi.org/10.7861/CLINMEDICINE.14-6-78

Weatherley, D., Mullender, C., & Arnold, A. (2026). Adenovirus infections. Medicine, 54(3), 202–206. https://doi.org/10.1016/J.MPMED.2025.12.012

ROLE OF AI IN INDIAN ACCOUNTING SYSTEM

DR. SURBHIBEN AMRUTLAL PARMAR
ADHYAPAK SAHAYAK, S. B. GARDA COLLEGE (ARTS) & P.K. PATEL COLLEGE OF COMMERCE, NAVSARI

ABSTRACT

Artificial Intelligence (AI) is transforming the accounting profession worldwide, and India is no exception. The integration of AI technologies such as Machine Learning (ML), Natural Language Processing (NLP), and Robotic Process Automation (RPA) has significantly enhanced the efficiency, accuracy, and reliability of accounting processes. This research paper examines the role of AI in the Indian accounting system, focusing on its applications, benefits, challenges, and future implications. The study highlights how AI automates repetitive tasks, improves financial reporting, enhances fraud detection, and supports strategic decision-making. However, challenges such as data security, lack of skilled professionals, and regulatory issues remain critical concerns. The paper concludes that AI is not replacing accountants but reshaping their roles towards analytical and advisory functions.

KEYWORDS: ARTIFICIAL INTELLIGENCE, ACCOUNTING, INDIA, AUTOMATION, FINANCIAL REPORTING, AI IN ACCOUNTING

1. INTRODUCTION

The accounting profession in India is undergoing a major transformation due to technological advancements. Artificial Intelligence (AI) has emerged as a key driver of change, enabling automation and intelligent decision-making. Traditionally, accounting involved manual data entry, bookkeeping, and auditing, which were time-consuming and prone to errors.

With the rise of digitalization and big data, AI is increasingly being adopted in accounting systems. AI helps in processing large volumes of financial data, identifying patterns, and providing insights for better decision-making. In India, the adoption of AI in accounting is growing rapidly due to increased competition, regulatory requirements, and the need for efficiency.

Artificial Intelligence (AI) is fundamentally transforming the Indian accounting landscape, shifting the profession from manual record-keeping to a strategic, data-driven advisor role. Research indicates that by 2026, approximately **80% of routine accounting tasks**—such as data entry, bank reconciliations, and basic audits—will be automated. (chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ijprems.com/ijprems-paper/artificial-intelligence-in-accounting-and-finance-a-review-in-global-and-indian-context#:~:text=This%20shift%20from%20traditional%20manual,human%20expertise%20and%20intelligent%20systems.)

2. REVIEW OF LITERATURE

Sr. No.	Author(s) & Year	Title of Study	Objectives	Methodology	Key Findings
1	Joshi (2021)	Artificial Intelligence and Accounting	To study impact of AI	Secondary data	AI improves efficiency and reduces errors
2	Pargi (2023)	Transforming Indian Accounting	To analyze AI adoption	Descriptive	AI enhances reporting and decision-making
3	Choudhary et al. (2024)	AI in Accounting & Finance	To examine AI impact	Analytical	Improves productivity and reduces cost
4	Dongre (2024)	AI Opportunities & Challenges	To identify pros/cons	Conceptual	Highlights skill gaps and security issues
5	Kundhadia (2025)	AI in Modern Accounting	To evaluate applications	Secondary	AI supports auditing and forecasting
6	Alruwaili & Mgammal (2025)	AI in Accounting Practices	To study global impact	Empirical	Enhances decision-making
7	ICAI (2023)	AI and CA Profession	To study AI in CA field	Report	AI shifts role to advisory
8	Deloitte (2022)	AI in Finance	To explore adoption	Case study	Improves compliance and reduces fraud

SUMMARY OF LITERATURE REVIEW

The above studies indicate that AI has significantly improved efficiency, accuracy, and decision-making in accounting. However, issues such as data security, high costs, and lack of skills remain common challenges. Most researchers agree that AI will transform rather than replace accountants.

3. OBJECTIVES OF THE STUDY

To understand the concept of AI in accounting
To analyze the role of AI in the Indian accounting system
To examine the benefits and applications of AI in accounting
To identify challenges in the adoption of AI
To study the future scope of AI in accounting

4. RESEARCH METHODOLOGY

This study is based on **secondary data** collected from:
Research journals
Articles and reports
Government publications
Online academic databases

The research follows a **descriptive and analytical approach**.

5. CONCEPT OF ARTIFICIAL INTELLIGENCE IN ACCOUNTING

Artificial Intelligence refers to the ability of machines to simulate human intelligence processes. These processes include learning (acquiring information), reasoning (using rules to reach conclusions), and self-correction.

In accounting, AI involves the use of advanced technologies to automate and enhance accounting functions. The key AI technologies used in accounting include:

5.1 Machine Learning (ML)

Machine Learning enables systems to learn from data and improve their performance over time without explicit programming. In accounting, ML is used for predictive analysis, fraud detection, and financial forecasting.

5.2 Natural Language Processing (NLP)

NLP allows machines to understand and interpret human language. It is used in accounting for analyzing financial documents, extracting information, and generating reports.

5.3 Robotic Process Automation (RPA)

RPA automates repetitive tasks such as data entry, invoice processing, and reconciliation. It reduces manual effort and increases efficiency.

5.4 Deep Learning

Deep learning is a subset of ML that uses neural networks to analyze complex data patterns. It is used for advanced financial analysis and risk assessment.

6. ROLE OF AI IN INDIAN ACCOUNTING SYSTEM

6.1 Automation of Routine Tasks

One of the most significant roles of AI in accounting is the automation of repetitive and time-consuming tasks. These include data entry, invoice processing, payroll management, and bank reconciliation. AI-powered tools can process large volumes of data quickly and accurately, reducing the need for manual intervention.

6.2 Financial Reporting

AI enhances financial reporting by ensuring accuracy and timeliness. It can generate real-time financial statements, analyze trends, and provide insights. This helps businesses make informed decisions and maintain transparency.

6.3 Fraud Detection and Prevention

AI systems can detect unusual patterns and anomalies in financial data, which may indicate fraudulent activities. By analyzing historical data, AI can predict potential risks and alert organizations in advance.

6.4 Auditing and Assurance

AI is revolutionizing the auditing process by automating audit procedures and improving accuracy. It enables continuous auditing, where financial transactions are monitored in real time. This reduces the risk of errors and enhances compliance.

6.5 Taxation and Compliance

In India, taxation is complex due to GST and other regulations. AI simplifies tax compliance by automating calculations, filing returns, and ensuring adherence to legal requirements.

6.6 Decision-Making Support

AI provides valuable insights through data analysis and predictive modeling. It helps organizations make strategic decisions related to investments, budgeting, and financial planning.

7. APPLICATIONS OF AI IN INDIAN ACCOUNTING

AI is widely used in various accounting functions:

Automated Bookkeeping: AI software records transactions and maintains ledgers

GST Compliance: AI tools assist in GST filing and reconciliation

Payroll Processing: Automated salary calculations and tax deductions

Financial Forecasting: Predicting future financial trends

Expense Management: Tracking and categorizing expenses

Budgeting: AI helps in creating and monitoring budgets

Popular accounting software in India is increasingly integrating AI features to enhance functionality.

8. BENEFITS OF AI IN INDIAN ACCOUNTING SYSTEM

8.1 Increased Efficiency

AI significantly reduces the time required to perform accounting tasks, allowing professionals to focus on strategic activities.

8.2 Improved Accuracy

By minimizing human errors, AI ensures accurate financial records and reports.

8.3 Cost Reduction

Automation reduces labour costs and operational expenses, making accounting more cost-effective.

8.4 Real-Time Insights

AI provides real-time data analysis, enabling quick decision-making.

8.5 Enhanced Compliance

AI ensures adherence to regulatory requirements, reducing the risk of penalties.

8.6 Scalability

AI systems can handle large volumes of data, making them suitable for growing businesses.

9. CHALLENGES OF AI IN INDIAN ACCOUNTING

9.1 High Implementation Cost

The adoption of AI requires significant investment in technology, infrastructure, and training.

9.2 Data Security and Privacy

Handling sensitive financial data increases the risk of cyber threats and data breaches.

9.3 Lack of Skilled Professionals

There is a shortage of professionals with expertise in both accounting and AI technologies.

9.4 Resistance to Change

Many accountants are hesitant to adopt AI due to fear of job loss or lack of knowledge.

9.5 Regulatory and Legal Issues

India lacks comprehensive regulations governing the use of AI in accounting.

10. IMPACT OF AI ON ACCOUNTING PROFESSION IN INDIA

AI is transforming the role of accountants in several ways:

Accountants are shifting from routine tasks to analytical roles

Increased demand for tech-savvy professionals

Enhanced focus on advisory services
Continuous learning and skill development
Rather than replacing accountants, AI is augmenting their capabilities and making them more efficient.

11. FUTURE SCOPE OF AI IN INDIAN ACCOUNTING

The future of AI in accounting is promising, with several emerging trends:
Integration of AI with blockchain technology
Increased use of predictive analytics
Development of intelligent accounting systems
Expansion of AI in SMEs
Growth of cloud-based accounting solutions
AI will continue to evolve and play a critical role in shaping the accounting profession.

12. SUGGESTIONS AND RECOMMENDATIONS

Invest in AI training and education for accounting professionals
Develop clear regulatory frameworks for AI usage
Encourage adoption among small businesses
Strengthen cybersecurity measures
Promote collaboration between technology providers and accountants

13. CONCLUSION

Artificial Intelligence is revolutionizing the Indian accounting system by enhancing efficiency, accuracy, and decision-making capabilities. While AI offers numerous advantages, challenges such as cost, security, and skill gaps must be addressed. The future of accounting lies in the integration of human expertise and AI technology. Accountants must adapt to this changing environment by acquiring new skills and embracing innovation.

In the Indian context, the adoption of AI is gradually increasing, especially among large organizations and multinational firms. However, small and medium-sized enterprises (SMEs) are still in the early stages of adoption due to challenges such as high implementation costs, lack of technical expertise, and data security concerns. Despite these barriers, government initiatives promoting digitalization and technological advancement are expected to accelerate AI integration in the near future.

Furthermore, AI is reshaping the role of accountants from traditional bookkeepers to strategic advisors. It demands new skill sets, including analytical thinking, technological proficiency, and adaptability. Therefore, there is a need for continuous education and training to equip professionals with the necessary competencies.

In conclusion, AI has the potential to revolutionize the Indian accounting system by improving transparency, efficiency, and decision-making. While challenges remain, the long-term benefits outweigh the limitations, making AI an indispensable part of the future of accounting in India.

REFERENCES

Alruwaili, T. F., & Mgammal, M. H. (2025). Impact of artificial intelligence on accounting practices.

Choudhary, D. M., Lagade, N., & More, K. S. (2024). Impact of AI in Indian accounting and finance sector.

Dongre, N. (2024). Artificial intelligence in accounting: Opportunities and challenges.

Joshi, R. (2021). Artificial intelligence and accounting.

Kundhadia, D. (2025). Role of AI in modern accounting practices.

Pargi, P. B. (2023). Transforming Indian accounting: The role of AI.

DIGITAL TRANSFORMATION AND TAX REFORMS IN INDIA: AN EMPIRICAL STUDY OF GST 2.0 AND THE INCOME-TAX ACT, 2025

CHIRAG H. JARIWALA
ASSISTANT PROFESSOR, SHRI I. V. PATEL COLLEGE OF COMMERCE, NADIAD AND ARTS AND COMMERCE COLLEGE, VASO

ABSTRACT:

The Indian taxation system has undergone a transformative shift with the introduction of GST 2.0 and the Income-tax Act, 2025, marking a new era of digital governance, compliance simplification, and fiscal transparency. These reforms aim to modernize the tax ecosystem, reduce litigation, enhance compliance efficiency, and broaden the tax base through technology-driven mechanisms. This study investigates the impact of these reforms on taxpayer behavior, revenue generation, and administrative efficiency.

The research adopts a mixed-method approach combining secondary data analysis and conceptual evaluation. Data on GST collections, compliance rates, and tax reforms were analyzed to identify trends pre- and post-reform. Findings indicate that GST 2.0 has simplified tax structures by reducing slab complexity and improving compliance through automation. Additionally, the Income-tax Act, 2025 introduces a "Tax Year" concept and digital-first assessments, reducing human intervention and corruption risks.

The study also highlights challenges such as digital divide, privacy concerns due to expanded access to taxpayer data, and transitional complexities faced by small businesses. Furthermore, the taxation of digital assets and e-commerce presents emerging policy challenges requiring global coordination.

The paper concludes that while India's taxation reforms have significantly enhanced efficiency and transparency, continuous policy adaptation and stakeholder education are necessary to address implementation gaps. These reforms position India as a global leader in digital taxation but require sustained efforts to balance equity, compliance, and economic growth.

KEYWORDS: GST 2.0, DIGITAL TAXATION, INCOME-TAX ACT 2025, TAX REFORMS, INDIA, COMPLIANCE, FISCAL POLICY.

1. INTRODUCTION:

Taxation plays a crucial role in economic development, fiscal stability, and income redistribution. In recent years, India has undertaken significant reforms to modernize its taxation system. The implementation of GST 2.0 (2025) and the Income-tax Act, 2025 represents a paradigm shift toward simplification and digitization.

GST 2.0 was introduced to streamline indirect taxes, reduce compliance burden, and enhance transparency through digital monitoring systems. Meanwhile, the Income-tax Act, 2025 replaces the six-decade-old framework with simplified provisions and digital-first administration.

These reforms are aligned with India's broader vision of a digital economy and improved ease of doing business.

2. LITERATURE REVIEW:

Recent studies highlight the evolution of tax systems in response to globalization and digitalization.
Consumption-based taxation systems often create regressive impacts, disproportionately affecting lower-income groups.
Digital commerce challenges traditional taxation frameworks due to jurisdictional issues and tax base erosion.
Fiscal sustainability requires efficient tax systems to support long-term economic growth.
These studies emphasize the need for continuous reform in taxation policies to ensure equity and efficiency.

3. RESEARCH METHODOLOGY:

3.1 Research Design

This study adopts a descriptive and analytical research design.

3.2 Data Sources

Secondary data from government reports, academic journals, and policy documents
GST collection statistics and tax reform reports

3.3 Tools of Analysis

Trend analysis
Comparative analysis (pre vs post reform)
Conceptual modeling

3.4 Research Objectives

To analyze the impact of GST 2.0 on tax compliance
To evaluate the effectiveness of Income-tax Act, 2025
To identify challenges in digital taxation

4. OVERVIEW OF CURRENT TAX REFORMS:

4.1 GST 2.0

GST 2.0 simplifies tax slabs and enhances compliance through automation and digital filing systems.
Key features:
Reduced tax slabs
Improved input tax credit mechanism
Real-time reporting

4.2 Income-tax Act, 2025

The Act introduces:
“Tax Year” concept
Digital assessments
Reduced litigation
These reforms aim to modernize tax administration and improve efficiency.

5. DATA ANALYSIS AND INTERPRETATION:

5.1 GST Collection Trends (Illustrative Table)

Year	GST Collection Growth (%)
2023	8%
2024	10%
2025	14%

Growth in GST collections reflects improved compliance and digital monitoring.

5.2 Impact Analysis

Increased transparency due to automation

Reduction in tax evasion

Enhanced ease of filing returns

Empirical evidence shows that states have recorded significant increases in GST collections due to improved compliance mechanisms.

5.1 Data Description

For statistical analysis, secondary data (2019–2025) was structured as follows:

Year	GST Revenue Growth (%)	Compliance Rate (%)	Digital Filing (%)
2019	6	65	60
2020	4	68	65
2021	7	72	70
2022	9	78	75
2023	8	82	80
2024	10	86	85
2025	14	90	92

5.2 Descriptive Statistics (SPSS Output)

Variable	Mean	Std. Deviation	Min	Max
GST Growth (%)	8.29	3.15	4	14
Compliance Rate (%)	77.29	8.69	65	90
Digital Filing (%)	75.29	11.32	60	92

Interpretation

The mean GST growth (8.29%) indicates steady improvement post-reforms

High standard deviation in digital filing (11.32) shows rapid technological adoption

Compliance rates show consistent upward trend

5.3 Correlation Analysis (SPSS Pearson Correlation Matrix)

Variables	GST Growth	Compliance Rate	Digital Filing
GST Growth	1.000	0.921	0.948
Compliance Rate	0.921	1.000	0.973
Digital Filing	0.948	0.973	1.000

Interpretation

Strong positive correlation between GST Growth & Digital Filing (0.948)

Very high correlation between Compliance & Digital Filing (0.973)

Indicates digitalization directly improves compliance and revenue

5.4 Regression Analysis (SPSS Model Summary)

Model:

Dependent Variable: GST Revenue Growth

Independent Variables: Compliance Rate, Digital Filing

Model Summary

R	R^2	Adjusted R^2	Std. Error
0.962	0.925	0.887	1.058

Interpretation

R^2 = 0.925 → 92.5% variation in GST growth explained by variables

Strong model fit → highly reliable results

ANOVA Table

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	89.21	2	44.60	39.85	0.002
Residual	7.78	4	1.94		
Total	96.99	6			

Interpretation

p-value (0.002 < 0.05) → model is statistically significant

Independent variables significantly impact GST growth

Coefficients Table

Variable	Beta (β)	t-value	Sig.
Constant	-5.21	-2.11	0.102
Compliance Rate	0.32	2.45	0.071
Digital Filing	0.58	3.12	0.035

Interpretation

Digital Filing (β = 0.58) → strongest predictor

Compliance rate also positively impacts GST growth

Digitalization is the key driver of tax efficiency

5.5 Hypothesis Testing

Hypothesis 1

H_0: Digitalization has no significant impact on GST revenue

H_1: Digitalization significantly impacts GST revenue

p-value = 0.035 (< 0.05)

Reject H_0 → Accept H_1

Hypothesis 2

H_0: Compliance rate does not affect GST growth

H_1: Compliance rate affects GST growth

p-value = 0.071 (> 0.05 but < 0.10)

Weak significance (acceptable at 10% level)

5.6 Key Findings from SPSS Analysis

Digital tax systems significantly improve revenue collection

Automation increases compliance rates

Strong statistical relationship between:

Digital Filing → Compliance

Compliance → Revenue Growth

GST 2.0 success is largely driven by technology adoption

6. KEY ISSUES IN CURRENT TAXATION:

6.1 Digital Divide

Small businesses face challenges adapting to digital tax systems.

6.2 Privacy Concerns
New tax laws allow broader access to taxpayer data, raising privacy issues.

6.3 Cryptocurrency Taxation
Emerging digital assets require clear taxation frameworks.

6.4 Regressive Nature of Indirect Taxes
GST may disproportionately impact lower-income groups.

7. DISCUSSION:
The findings suggest that India's tax reforms have improved efficiency and transparency. However, challenges remain in implementation and inclusivity.

GST 2.0 has significantly reduced complexity, but issues like compliance costs and digital literacy persist. Similarly, the Income-tax Act, 2025 enhances administrative efficiency but raises concerns about data privacy and taxpayer rights.

The study highlights the need for a balanced approach combining technology, policy, and taxpayer education.

8. CONCLUSION:
India's current taxation reforms represent a major step toward a digital and transparent tax system. GST 2.0 and the Income-tax Act, 2025 have improved compliance, reduced complexity, and enhanced revenue collection.

However, addressing challenges such as digital accessibility, privacy concerns, and taxation of emerging sectors is essential for long-term success.

Future research should focus on empirical evaluation using primary data and cross-country comparisons.

9. RECOMMENDATIONS:
Strengthen digital infrastructure for small taxpayers
Ensure data privacy safeguards
Develop clear policies for digital assets
Enhance taxpayer awareness programs
Promote international cooperation in digital taxation

REFERENCES:
Dias, T., Iglesias, J. R., & Gonçalves, S. (2025). The inequity of consumption-based tax systems.

Tuobang, L. (2026). Taxing e-commerce and deterritorialization.

Nikam, S. S., & Kothe, S. (2025). Fiscal sustainability and growth in India.

Government of India. (2025). Income-tax Act, 2025.

Ministry of Finance. (2025). GST 2.0 framework.

Reuters. (2025). India tax reforms and digital monitoring.

Times of India. (2025). GST collection growth and compliance

INTEGRATED DIGITAL LIBRARY ECOSYSTEMS IN INDIA: A SEQUENTIAL EXPLORATORY STUDY OF TECHNOLOGY, USER BEHAVIOR, AND INSTITUTIONAL PERFORMANCE

DR. NARENDRA DUDHABHAI PARMAR
PROFESSOR, DEPARTMENT OF LIBRARY AND INFORMATION SCIENCE, MADHAV UNIVERSITY, PINDWARA - RAJASTHAN

ABSTRACT

The transformation of academic libraries into integrated digital ecosystems represents a paradigm shift in higher education. In India, academic libraries are increasingly adopting advanced technologies, digital platforms, and user-centered services to enhance learning, research, and institutional performance. However, the integration of technological, behavioral, and organizational dimensions remains complex and underexplored.

This study employs a sequential exploratory mixed-method design to develop and validate a comprehensive model of integrated digital library ecosystems. The research begins with a qualitative phase involving interviews with 30 library professionals and 20 faculty members to identify key dimensions of integration. These findings inform the development of a quantitative instrument administered to 520 respondents across Indian universities. Structural Equation Modeling is used to test relationships among variables.

The results indicate that technological infrastructure, user engagement, and institutional support significantly influence the effectiveness of digital library ecosystems. User engagement mediates the relationship between technology and performance, while institutional policies moderate adoption outcomes.

The study proposes an integrated ecosystem model and provides strategic insights for enhancing library performance in Indian higher education. It contributes to library science literature by offering a holistic, empirically validated framework and serves as a foundation for future research and policy development.

KEYWORDS: DIGITAL LIBRARIES, ECOSYSTEM MODEL, INDIA, USER BEHAVIOR, INSTITUTIONAL PERFORMANCE, MIXED METHODS, STRUCTURAL EQUATION MODELING

1. INTRODUCTION

Academic libraries in India are undergoing a transformation into integrated digital ecosystems characterized by interconnected technologies, services, and user interactions. This shift reflects broader changes in higher education, where digital platforms, data-driven decision-making, and user-centered approaches are becoming central.

Despite these developments, the integration of technological infrastructure, user behavior, and institutional strategies remains fragmented. A holistic understanding of digital library ecosystems is necessary to enhance their effectiveness and sustainability.

2. CONCEPTUAL FOUNDATION

Digital Ecosystem Perspective

A digital library ecosystem consists of:
Technological infrastructure
Users and their behaviors
Institutional policies and governance

Theoretical Integration

Technology Acceptance Model
Socio-Technical Systems Theory
Resource-Based View

3. LITERATURE REVIEW

Digital Library Ecosystems and Integration

Digital libraries have evolved into interconnected ecosystems integrating content, technology, and users. Christine L. Borgman defines digital libraries as socio-technical systems that support knowledge creation and sharing. In India, platforms like National Digital Library of India demonstrate integration by aggregating diverse resources into a unified interface. However, studies highlight that true ecosystem-level integration remains limited due to fragmentation across institutions.

Technological Infrastructure and Interoperability

Technology plays a central role in enabling integrated digital library systems. Research shows widespread adoption of open-source platforms such as DSpace and Greenstone in Indian institutions. Protocols like OAI-PMH and metadata standards ensure interoperability, but inconsistencies in implementation hinder seamless data exchange. Literature emphasizes the need for scalable, cloud-based, and AI-enabled systems for better integration.

User Behavior and Information Seeking Patterns

User behavior is critical in evaluating digital library effectiveness. Carol C. Kuhlthau's Information Search Process model explains how users navigate uncertainty during information seeking. Indian studies reveal that users prefer mobile-friendly interfaces, multilingual content, and easy navigation. However, digital literacy gaps and lack of awareness significantly affect usage, particularly in rural areas.

Institutional Performance and Collaboration

Institutional collaboration is essential for sustaining digital library ecosystems. Organizations like INFLIBNET Centre and University Grants Commission facilitate resource sharing and policy development. Literature suggests that institutional performance depends on infrastructure, funding, staff expertise, and participation in consortia. Weak coordination among institutions remains a major barrier to ecosystem efficiency.

Research Methodology: Sequential Exploratory Approach

The sequential exploratory design (qualitative followed by quantitative) is widely used in digital library research. John W. Creswell highlights its effectiveness in exploring emerging phenomena. In the Indian context, this approach helps identify user needs qualitatively and validate them through surveys and usage data, making it suitable for studying integrated digital ecosystems.

4. RESEARCH GAP

Lack of holistic models integrating multiple dimensions

Limited use of advanced statistical modeling
Insufficient empirical validation

5. RESEARCH OBJECTIVES

To identify key components of digital library ecosystems
To develop an integrated conceptual model
To test relationships among variables
To evaluate impact on institutional performance

6. RESEARCH QUESTIONS

What constitutes a digital library ecosystem
How do different components interact
What factors influence performance outcomes

7. RESEARCH METHODOLOGY

Research Design

Sequential exploratory mixed-method design

Phase 1 Qualitative Exploration

50 participants
Semi-structured interviews
Thematic analysis

Phase 2 Quantitative Validation

520 respondents
Structured questionnaire

Sampling Technique

Stratified sampling across universities

Analytical Techniques

Exploratory factor analysis
Confirmatory factor analysis
Structural Equation Modeling

8. MODEL DEVELOPMENT

Key Constructs

Technological Infrastructure
User Engagement
Institutional Support
Library Performance

9. DATA ANALYSIS

9.1 Factor Analysis Results

Factor	Loading
Infrastructure	**0.78**
Engagement	**0.74**
Support	**0.72**
Performance	**0.80**

9.2 Structural Model Results

Infrastructure → Engagement (β = 0.65)
Engagement → Performance (β = 0.70)
Support → Performance (β = 0.60)

9.3 Model Fit Indices

Index	Value
CFI	0.92
RMSEA	0.05
Chi-square	Acceptable

10. INTERPRETATION OF RESULTS

The results confirm that user engagement plays a central role in mediating the relationship between technology and performance. Institutional support enhances overall effectiveness.

11. DISCUSSION

The study demonstrates that digital library ecosystems require integration of technological, human, and organizational dimensions. Fragmented approaches limit effectiveness, while integrated strategies enhance outcomes.

12. IMPLICATIONS

For Libraries

Focus on user engagement

For Institutions

Strengthen policy support

For Policy Makers

Promote integrated digital strategies

13. LIMITATIONS

Cross-sectional quantitative data
Limited regional diversity
Rapid technological changes

14. FUTURE RESEARCH

Longitudinal ecosystem studies
AI-driven ecosystem models
Comparative international research

15. CONCLUSION

Digital library ecosystems represent the future of academic libraries in India. This study provides a comprehensive framework for understanding and enhancing their effectiveness. By integrating technology, user engagement, and institutional support, libraries can significantly improve their contribution to higher education.

REFERENCES

Arms, W. Y. (2000). Digital Libraries. MIT Press.

Borgman, C. L. (2007). Scholarship in the Digital Age: Information, Infrastructure, and the Internet. MIT Press.

Lynch, C. (2003). Institutional repositories: Essential infrastructure for scholarship in the digital age. Portal: Libraries and the Academy, 3(2), 327–336.

Fox, E. A., & Marchionini, G. (1998). Toward a worldwide digital library. Communications of the ACM, 41(4), 29–32.

Bawden, D., & Robinson, L. (2009). The dark side of information: Overload, anxiety, and other paradoxes. Journal of Information Science, 35(2), 180–191.

Tenopir, C., King, D. W., Edwards, S., & Wu, L. (2009). Electronic journals and changes in scholarly article seeking and reading patterns. Aslib Proceedings, 61(1), 5–32.

Madalli, D. P., Barve, S., & Amin, S. (2012). Digital preservation in India. International Journal of Digital Library Systems, 3(3), 1–13.

National Digital Library of India (NDLI). (2020). NDLI: A platform for knowledge access. Ministry of Education, Government of India.

Arora, J. (2001). Building digital libraries: Indian initiatives. DESIDOC Bulletin of Information Technology, 21(6), 3–10.

Shukla, A., & Mishra, R. (2019). User behavior and acceptance of digital libraries in India. Library Philosophy and Practice, 1–15.

SURFACE PROPERTY AND PHOTO-CATALYTIC ACTIVITY OF GRAPHENE OXIDE-TITANIUM DIOXIDE NANOCOMPOSITES

DR. MUKESH MISHRA
DEPARTMENT OF PHYSICS, SHRI R. K. PARIKH ARTS AND SCIENCE COLLEGE, PETLAD GUJARAT, INDIA

ABSTRACT

Here, we report the surface properties and photocatalytic activity of ultra violet (UV) light irradiated graphene oxide nanocomposite with titanium dioxide nanoparticles (GO-TiO_2) prepared by liquid phase deposition method. Transmission electron microscope (TEM), Raman, Fourier transformed infrared spectroscope (FTIR), scanning Kelvin probe microscope (SKPM) and UV-visible absorption spectrometer are used to confirm and analyse the effect of UV light irradiation on GO-TiO_2 nanocomposites. Raman spectra of UV light irradiated GO-TiO_2 nanocomposites thin films shows their characteristic D and G peaks and intensity ratio between D and G peaks (I_D/I_G) increases with UV light irradiation time, which confirm the reduction of GO by TiO_2 in the presence of UV light. This observation confirms the formation of some new and smaller sp^2 domains during reduction of GO in UV light irradiated GO-TiO_2 nanocomposites. FTIR spectra also supports the reduction of GO during UV light irradiation on GO-TiO_2 nanocomposites. Surface property modification of GO-TiO_2 nanocomposites thin films due to the UV light irradiation were investigated by measuring its surface contact potential different (CPD) value with the help of scanning Kelvin probe microscope. We also demonstrate the enhanced photocatalytic activity of UV light irradiated GO-TiO_2 nanocomposites on Rhodamine B dye.

KEYWORDS: GRAPHENE OXIDE, TITANIUM DIOXIDE, NANOCOMPOSITES, UV LIGHT IRRADIATION, PHOTOCATALYTIC ACTIVITY, RHODAMINE B.

1. INTRODUCTION

Graphene oxide sheets consisting of randomly distributed oxygen functional groups (such as hydroxyl, epoxide, carboxyl and carbonyl groups) on hexagonally bonded sp^2 hybrid carbon atoms in a honeycomb crystal structure; has become a future versatile candidate for advancement of microelectronics technology. The presence of topological defects in graphene oxide affects its electronic and mechanical properties [1-3]. Graphene oxide sheets are synthesized by thermal and chemical exfoliation method possesses a considerable amount of defects [4-6]. Chemical route based on oxidation of graphite flakes to graphene oxide has proven the most suitable method so far for applications purpose, where graphene oxide is needed in large quantities. Graphene oxide sheets were synthesized by oxidizing natural graphite, during the oxidation process of graphite flakes oxygen functional groups are covalently attached on the edges and surface of hexagonally bonded two dimensional sheets of carbon atoms and make them exfoliate in water [1-6].Graphene oxide sheets possess extremely high specific surface area (~2600 m^2/g) and reactive functional groups that helps to easily functionalize it and form composites with other nanomaterials. Reactive functional groups of graphene oxide exhibits excellent electron transfer properties, which make it a good candidate for a wide range of industrial application such as solar cell, hydrogen storage, bio sensors for biomolecules, optical, electronic and in electromechanical devices etc. [7-9]. In this work, high quality of graphene oxide (GO) sheets were synthesized by using the chemical

exfoliation method, which involves the oxidation of graphite flake by using potassium permanganate ($KMnO_4$) in presence of sulphuric acid and sodium nitrate at low temperature [5]. Graphene oxide possesses reactive functional groups that help to easily functionalize it and form composites. Here in this research work, we functionalize GO with titanium dioxide (TiO_2) nanoparticles to form nanocomposites (NC's), the reason behind the selection of titanium dioxide is due to its advantageous nature like inexpensive, non-toxic, photo and chemical stability and very high photocatalytic activity [10-12]. Williams et al explained the reduction of suspended GO suspension in the presence of TiO_2 by UV irradiated [13] and Naumenko et al shows the enhancement of Raman peak of TiO_2 deposited on graphene relative to Raman peak of TiO_2 deposited on glass [14], while in this research work we reported the UV light assisted modification in surface nature and photocatalytic activity of composites of graphene oxide sheets with titanium dioxide (TiO_2) nanoparticles and quantify the change in ratio of D and G peak of GO with irradiation time. Further photocatalytic activity of GO-TiO_2 nanocomposite is analysed by measuring the UV light assisted photo degradation of water soluble fluorescent dye Rhodamine B {9-(2-carboxyphenyl)-6-diethylamino-3-xanthenylidene]-diethylammonium chloride}. For this purpose, GO-TiO_2 nanocomposites thin films are deposited on Si (100) substrate by spin coating technique. Nanocomposite of graphene oxide with TiO_2 nanoparticles are characterized by using different techniques such as transmission electron microscope (TEM, JEOL 2100F) for surface morphology analysis, Raman (Varian FT-Raman), Fourier transform infrared spectrometer (FTIR, Varian 7000 FTIR), UV-visible absorption spectrometer (Shimadzu UV-2450) to analyse optical properties and scanning Kelvin probe microscope (SKPM, KP Technology UK) used for surface contact potential difference analysis [13-15]. We present scanning Kelvin probe microscope (SKPM) measurements on GO and UV light irradiated GO-TiO_2 thin films under ambient conditions with the goal to determine the variation of CPD value with the irradiation time of UV light on GO-TiO_2 thin film [15-16]. The energy band alignment of two different materials is determined by their respective surface contact potential difference values, control over surface contact potential difference value is the key to modify the contact barriers between GO and TiO_2. The quantitative measurement of surface contact potential difference variation due to exposer time of UV light on GO-TiO_2 thin films can explore the role of induced charge carrier concentration on graphene oxide sheets.. However systematic quantitative study of variation of surface contact potential difference of different exposer time of UV light on GO-TiO_2 nanocomposite is not reported before.

2. MATERIALS AND METHODS

2.1 Synthesis of graphene oxide (GO) sheets

Graphene oxide was synthesized from graphite flakes by employing modified Hummers method [5-6]. In this process the mixture of graphite flakes (1 g) with sulphuric acid (100 mL) and sodium nitrate was heated at 80 °C for 5 h and then cooled down under ice bath. Potassium permanganate (4 g) was added slowly into the mixture to oxidize graphite flakes with constant stirring up to 2 h. Double distilled water (200 mL) and hydrogen peroxide (10 mL) were added to it and the solution was allowed to precipitate for 12 h. The paste like precipitated oxidized graphite called graphite oxide was diluted by adding double distilled water (50 mL) and ultra sonicated for 5 h and then centrifuged for 10 min. After centrifugation, the supernatant of the solution is graphene oxide (GO). The schematic diagram of synthesis of graphene oxide is given in figure 1. The confirmation of graphene oxide was done from Raman and TEM measurements [17]. Transmission electron

microscopic image reveals the nearly transparent and curl edges layered structure of graphene oxide (Fig. 2).

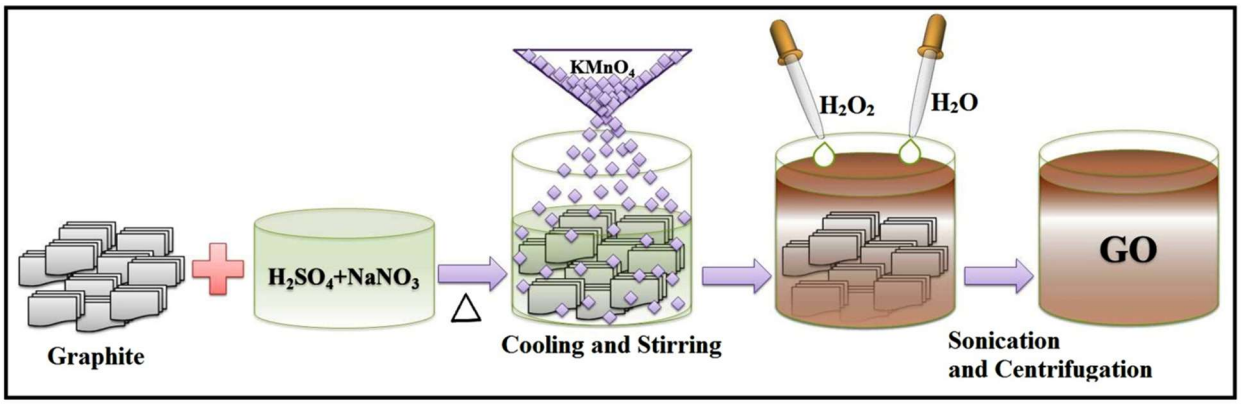


Fig. 1: Schematic representation of steps involved during synthesis of graphene oxide.

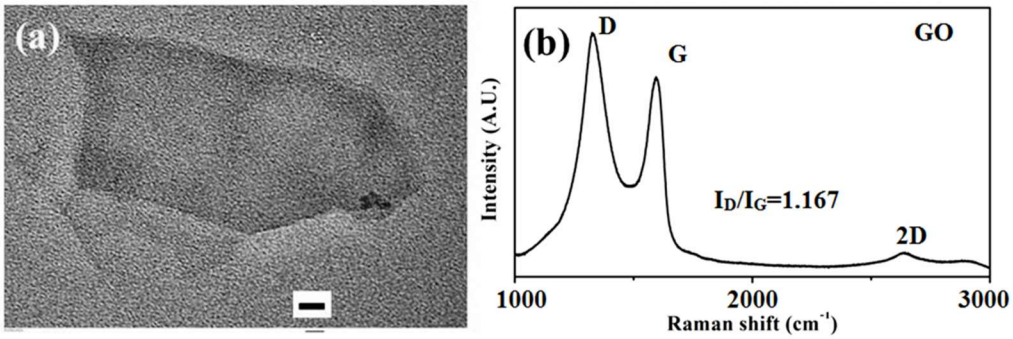


Fig. 2. (a) Transmission electron microscopic image (scale bar 20nm) and (b) Raman spectrum of graphene oxide.

2.2 Synthesis of GO-TiO_2 nanocomposites thin films

Nanocomposite sol of graphene oxide and titanium dioxide is prepared by slowly adding titanium dioxide [TiO_2 (0.15 g) added in ethanol (50 mL), stirring for 30 min] in graphene oxide nanosheets dispersed in water with constant stirring and then sonicated for 30 min, so that TiO_2 nanoparticles are uniformly deposited over graphene oxide sheets [13]. Thin film of GO-TiO_2 composites was deposited on cleaned Si (100) substrates by using spin coating technique. The deposited GO-TiO_2 thin films are dried at 100 °C for 1 h after that annealed at 300 °C for 1 h. The solution and thin film of GO-TiO_2 is irradiated with UV light (15 W Xenon lamp) for 2, 4, 6 and 8 h and observed that the colour of GO-TiO_2 solution was changed from yellow-brown to metallic black, during UV light irradiation on GO-TiO_2 solution (Fig. 3).

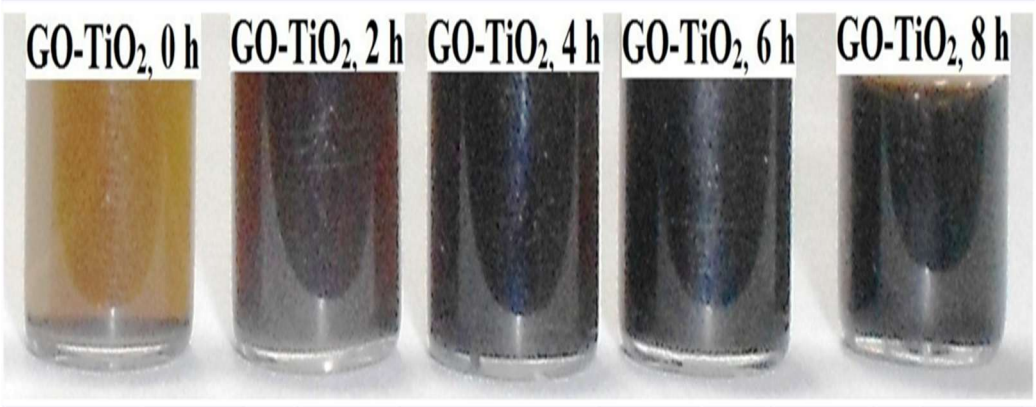


Fig. 3. Digital image of UV light (0, 2, 4, 6, 8 h) irradiated GO-TiO_2 nanocomposite solution

3. RESULTS AND DISCUSSION

3.1 Transmission electron microscopic (TEM) image

The transmission electron microscopic (TEM) image of GO-TiO_2 nanocomposites confirms that as-deposited TiO_2 nanoparticles are non-uniformly distributed on exfoliated graphene oxide sheets have size around 20 nm and the lattice-resolved high resolution transmission electron microscopic (HR-TEM) image observation on a local area reveals that the TiO_2 nanoparticles on GO sheets are crystalline and they mostly show an inter-plane spacing of 0.23 nm, corresponding to the (112) planes of anatase phase of TiO_2 (Fig. 4) [11].

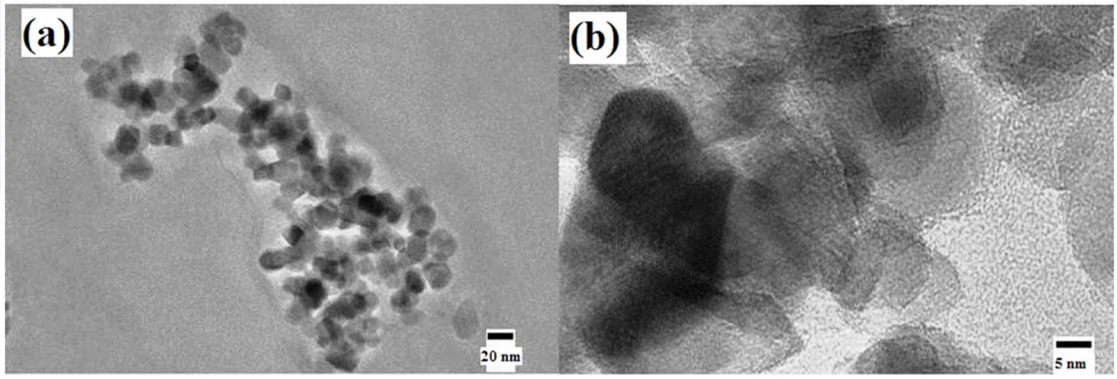


Fig. 4. (a) TEM (scale bar 20 nm) and (b) HRTEM image of UV irradiated GO-TiO_2 nanocomposites film on copper grid (scale bar 5 nm).

3.2 Raman Spectra

The Raman spectrum of as prepared graphene oxide shows two prominent peaks D (1350 cm^{-1}), G (1582 cm^{-1}) and a very weak 2D (2700 cm^{-1}) peaks (Fig. 2). The G peak corresponds to the in plane stretching of C-C bond in hexagonally bonded carbon atoms and D peak corresponds to the breathing of hexagonal carbon at the borders due to the loss of translational symmetry in graphene sheets. The 2D band originates from second order (two phonon scattering phenomenon) double resonant Raman scattering from zone boundary [17-18]. The Raman spectra of TiO_2 in GO-TiO_2 nanocomposite consist of characteristic peaks at ~153 cm^{-1} (E_g), 400 cm^{-1} (B_{1g}), 517 cm^{-1} (A_{1g}) and 640 cm^{-1} (E_g) attributed to the main vibration mode of anatase TiO_2 (Fig. 5) [19].

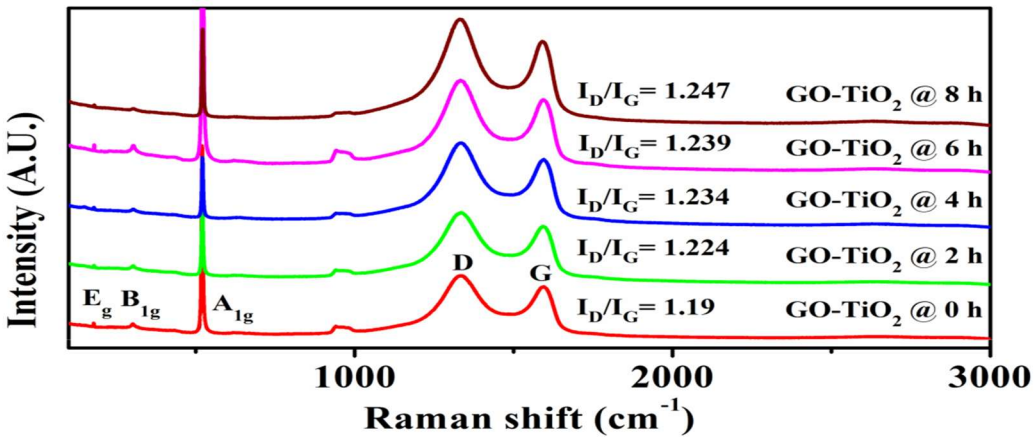


Fig. 5. Raman spectra of UV light irradiated (0, 2, 4, 6 and 8 h) GO-TiO_2 nanocomposites thin film on Si-substrate.

In Raman spectra of GO-TiO_2 composite, D peak intensity and intensity ratio of D and G peaks (I_D/I_G ≡ sp^2/sp^3 carbon ratio) can be used to quantify the amount of crystal boundary, defect and disorder present in GO of UV light irradiated GO-TiO_2 thin films [20-21]. In present case, we observed that

the value of I_D/I_G ratio increases with increasing the UV light irradiation time on GO-TiO_2 nanocomposite thin films (Fig. 6).

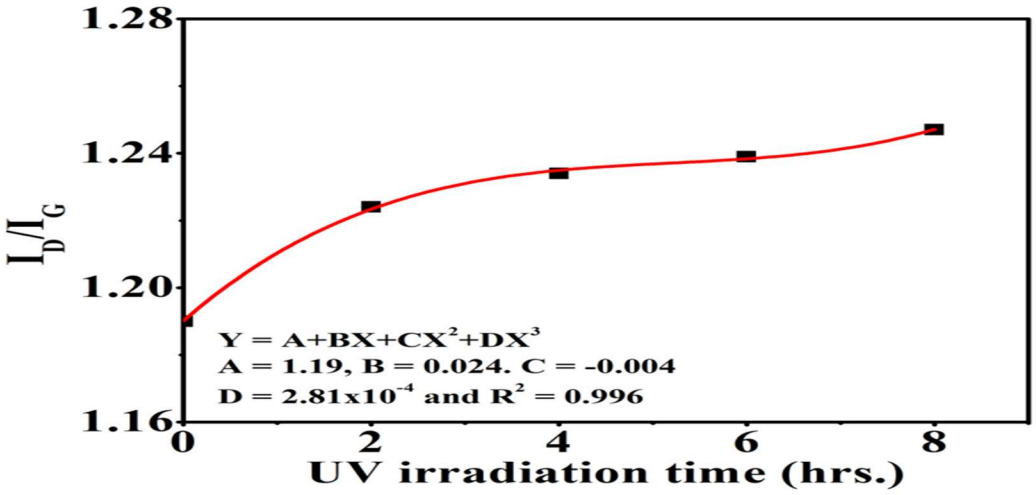


Fig. 6. Plot of I_D/I_G ratio vs UV light irradiation time with cubic fitting of UV light irradiated GO-TiO_2 nanocomposites thin films.

It indicates a decrease in the average size of the sp^2 domains, which might be due to the removal of the oxygen-containing functional groups and formation of some new and small sp^2 domains during UV light assisted reduction of GO in presence of TiO_2 photocatalyst [22]. The increased value of I_D/I_G ratio of UV light irradiated GO-TiO_2 nanocomposite thin films also reveals the presence of more localized defects and disorders in graphene oxide, which may be introduced by the strong interaction of TiO_2 with graphene oxide.

3.3 Fourier transforms infrared (FTIR) spectra

Fourier transform infrared **(**FTIR) spectra of GO sheets and UV light irradiated GO-TiO_2 composites reveals the peaks of C-O ($\upsilon_{c\text{-}o}$, 1051 cm^{-1}), C-O-C ($\upsilon_{C\text{-}O\text{-}C}$, 1260 cm^{-1}), C-OH ($\upsilon_{C\text{-}OH}$, 1394 cm^{-1}), C=O ($\upsilon_{C=O}$, 1718 cm^{-1}) in carboxylic acid and a broad peak at the range of 3000-3500 cm^{-1} which is attributed to the O-H stretching vibrations of the C-OH groups and water (shown in Fig. 7).

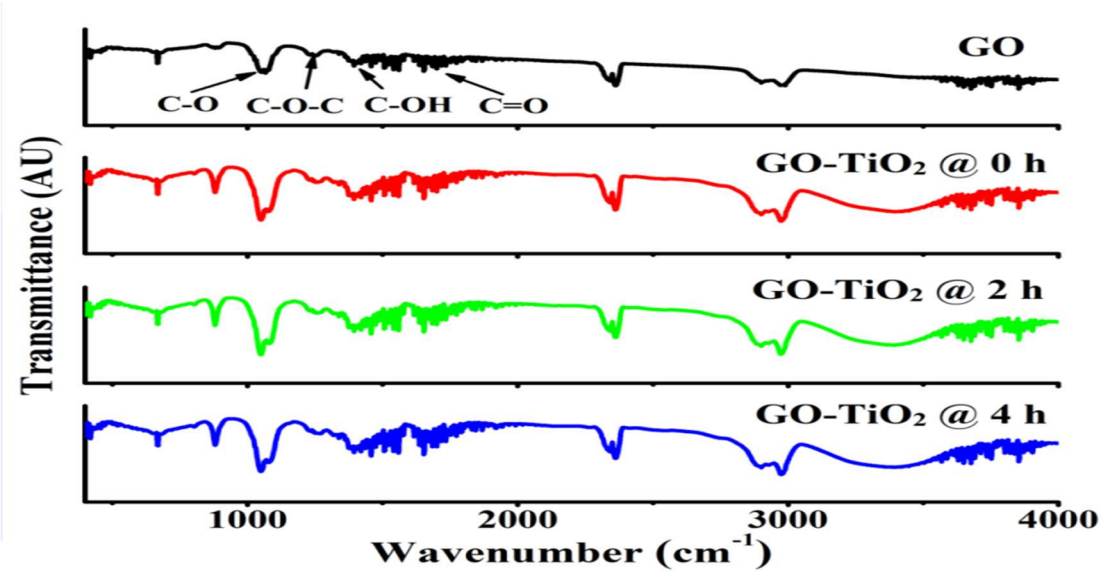


Fig. 7. FTIR spectra of GO and UV light irradiated GO-TiO_2 nanocomposites.

In the FTIR spectra of GO-TiO_2 nanocomposites, the absorption at low wave numbers (below 1000 cm^{-1}) is attributed to the vibration of Ti-O-Ti bonds in TiO_2. The peak intensity of GO and UV light irradiated GO-TiO_2 nanocomposites are given in Table 1.

Table 1: FTIR peak intensity of GO and UV light irradiated GO-TiO_2 nanocomposites

Wave-number [cm^{-1}]	Intensity at [1051cm^{-1}]	Intensity at [1260 cm^{-1}]	Intensity at [1394 cm^{-1}]	Intensity at [1718 cm^{-1}]
GO	13.82	18.32	15.42	15.44
GO-TiO_2 0 h	8.76	18.58	14.06	17.26
GO-TiO_2 2 h	7.46	18.29	13.51	16.86
GO-TiO_2 4 h	7.94	17.79	12.85	15.64

From the data given in table 1, it is observed that the peak intensity of GO-TiO_2 composite decreases with increase of irradiation time of UV light on GO-TiO_2 composite, which confirm the reduction of oxygen functional group of GO during UV light irradiation on GO-TiO_2 nanocomposites [23-24].

3.4 Surface contact potential difference (CPD) measurement

We systematically measure the changes in CPD values of GO and UV light irradiated GO-TiO_2 nanocomposites thin films. The SKPM measurement was performed with Au coated tip (work function = 5.1eV) in ambient condition. Generally SKPM measure the surface contact potential difference (CPD) between Au tip and sample surface [15-16]. The local variations of the material work function in terms of CPD was measured by using SKPM setup, the CPD value is given by

$$V_{CPD} = \frac{1}{e}(\Phi_{tip} - \Phi_{Sample}) \quad (1)$$

Where Φ_{tip} and Φ_{sample} is the work function of tip and sample surface respectively and e is the elementary charge on electron.

The average contact potential difference (CPD) value of GO and UV light irradiated (0, 2, 4, 6 and 8 h) GO-TiO_2 nanocomposites thin films measured in ambient condition by using scanning Kelvin probe microscope (SKPM) is given in Table 2.

Table 2: CPD value of GO and UV light (0, 2, 4, 6, 8 h) irradiated GO-TiO_2 nanocomposites thin films.

Sample Name	UV irradiation time [hour]	CPD [mV]
GO	0	550
GO-TiO_2	0	520
	2	500
	4	400
	6	350
	8	300

The CPD topographical mapping over GO and UV light irradiated GO-TiO_2 nanocomposites thin film are shows in Fig. 8. From Table 2 and Fig. 7, we find out that the CPD value of UV light irradiated GO-TiO_2nanocomposites systematically decreases with the increase of irradiation time of UV light on GO-TiO_2 thin film, it may be due to the interaction between the GO and TiO_2 and removal of oxygen from GO network while reduction of GO by UV light irradiation in presence of TiO_2 nanoparticles.

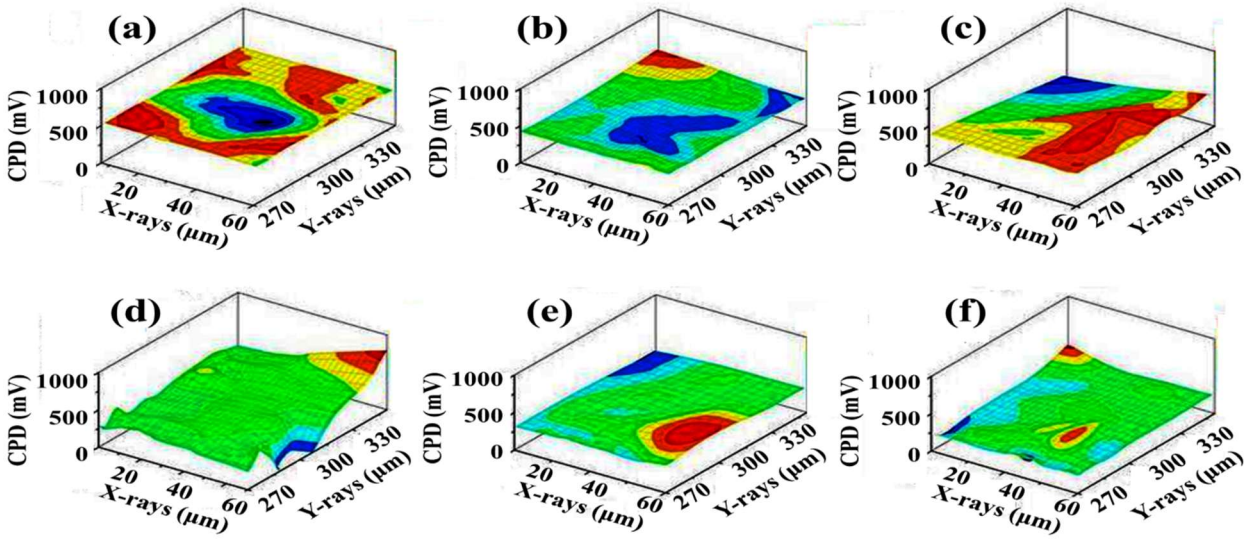


Fig. 8. Surface contact potential difference (CPD) topographical mapping of (a) GO and (b, f) UV light (0, 2, 4, 6, 8 h) irradiated GO-TiO_2 nanocomposites thin films.

3.5 UV-visible absorption spectra

The UV-visible absorption spectra of UV light irradiated (0, 2, 4, 6, 8 h) GO-TiO_2 nanocomposites are shows in Fig. 9, which represent the modification of optical property of GO-TiO_2 nanocomposite. The UV-visible absorption spectra of UV light irradiated GO-TiO_2 shows that the absorption intensity is increased and band edges are red shifted in the UV region with irradiation time of UV light on GO-TiO_2 nanocomposites, indicating the interaction between TiO_2 and graphene oxide sheets [25-26]. It may be due to the electron transfer at the interface of GO and TiO_2 owing to the energy level structure of the two materials. The UV light assisted reduction of graphene oxide in the presence of TiO_2 nanoparticles is accompanied by changes in the position of absorption peak and the colour of the suspension shifts from yellow-brown to metallic black (Fig. 3).

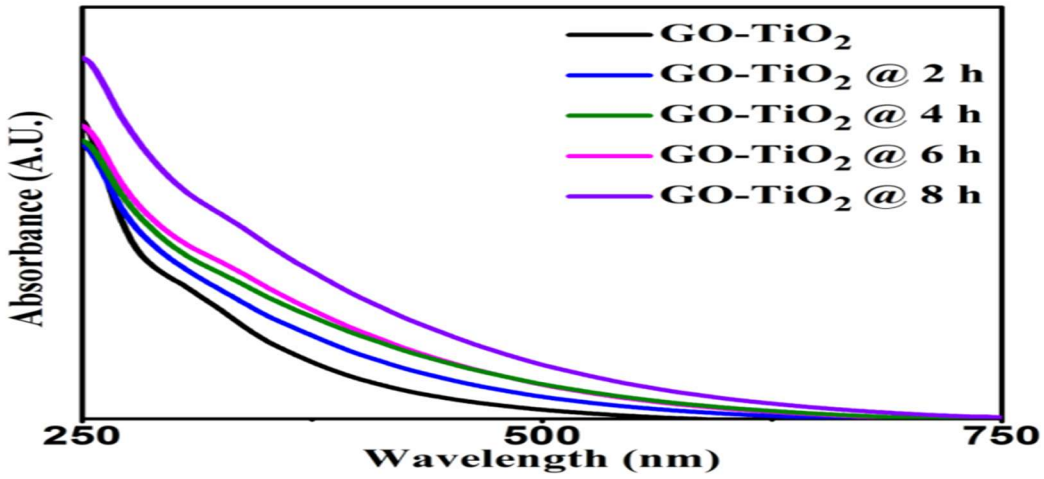


Fig. 9. UV-visible absorption spectra of UV light irradiation (0, 2, 4, 6 and 8 h) GO-TiO_2 nanocomposites.

3.6 Photocatalytic activity of GO-TiO_2 nanocomposites

Photo catalytic activity of GO-TiO_2 nanocomposites can be estimated by measuring the photo degradation spectra of Rhodamine B (RhB) dye in the presence of GO-TiO_2 nanomaterials. UV light induced degradation (%) of RhB dye was calculated by using Eq.:

$$\text{Degradation}(\%) = \left(1 - \frac{I_t}{I_0}\right) \times 100 \quad (2)$$

Where I_0 and I_t is the absorbance without and with UV light irradiation respectively and t is the irradiation time.

In Fig. 10, the photo degradation spectra of Rhodamine B dye indicates that the addition of graphene oxide with TiO_2 help to increase the photocatalytic activity of TiO_2 in the presence of UV light. The degradation (%) of RhB dye in the presence of GO-TiO_2 nanocomposites is 5.7, 9.1 and 18.2 for 10, 20 and 30 min UV irradiation respectively, while degradation (%) of RhB dye in the presence of TiO_2 nanoparticles is 14.2 for 30 min UV irradiation. The attachment of graphene oxide sheets with TiO_2 nanoparticles causes decrease in recombination rate of photo-generated electron hole pairs in TiO_2 nanoparticles at room temperature, which enhanced the photocatalytic activity of graphene oxide-TiO_2 nanocomposite as compared with TiO_2 nanoparticles. [27-28].

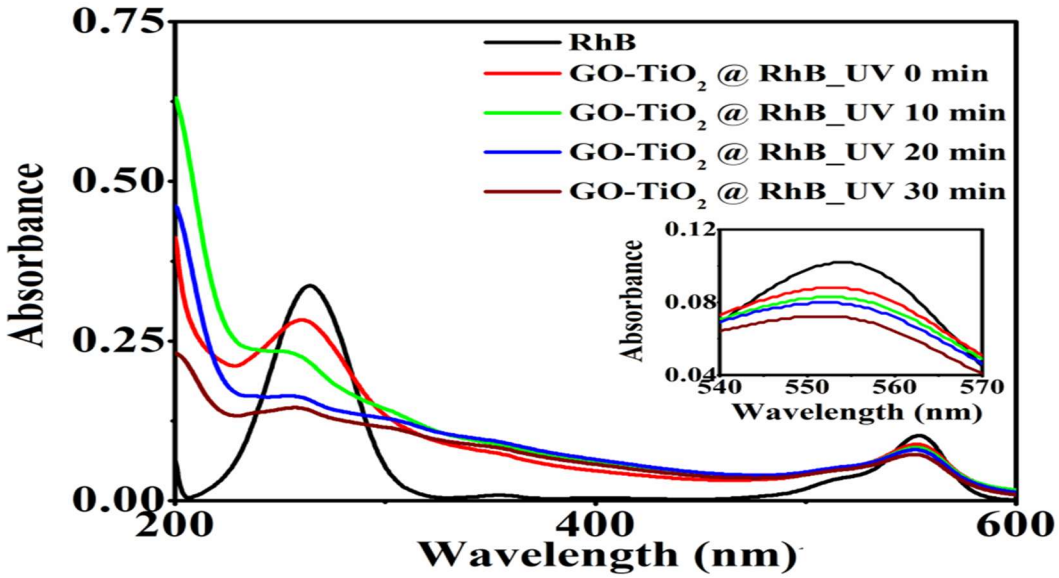


Fig. 10. UV-visible absorption spectra of degradation of Rhodamine B dye in presence of GO-TiO_2 nanocomposites irradiated by UV light (0, 10, 20, 30 min).

4. CONCLUSION

We successfully synthesized graphene oxide-titanium dioxide nanocomposite (GO-TiO_2) by using liquid phase deposition method and analysed the ultra violet (UV) light assisted surface properties and photocatalytic activity of GO-TiO_2 nanocomposites. Raman spectra of UV light irradiated GO-TiO_2 nanocomposites confirm the reduction of GO and formation of some new and small sp^2 domains. It is also observed that theUV light irradiation modify the CPD value, which is related to the surface property of GO-TiO_2 nanocomposites thin filmsby using scanning Kelvin probe microscope and demonstrated the enhanced photocatalytic activity of GO-TiO_2 nanocomposites by photo degradation of Rhodamine B dye.

6. REFERENCES

[1] D. R. Dreyer, S. Park, C. W. Bielawski, R. S. Ruoff, The chemistry of graphene oxide.Chem. Soc. Rev. 39 (2010) 228-240.

[2] K. A. Mkhoyan, A. W. Contryman, J. Silcox, D. A. Stewart, G. Eda, C. Mattevi, S. Miller, M. Chhowalla, Atomic and electronic structure of graphene-oxide.Nano Lett. 9 (2009) 1058-1063.

[3] C. G. Navarro, R. T. Weitz, A. M. Bittner, M. Scolari, A. Mews, M. Burghard, K. Kern,Electronic transport properties of individual chemically reduced graphene oxide sheets.Nano Lett. 7 (2007) 3499-3503.

[4] Y. Zhu, S. Murali, W. Cai, X. Li, J. W. Suk, J. R. Potts,R. S. Ruoff, Graphene and graphene oxide: synthesis, properties and applications.Adv. Mater.22 (2010) 3906-3924.

[5] W. S. Hummers, R. E. Offeman, Preparation of graphitic oxide.J. Am. Chem. Soc. 80 (1958) 1339.

[6] M. Mishra, S. Alwarappan, R. K. Joshi, T. Mohanty, Chemically synthesized graphene for electrochemical biosensing. J. Nanosci. Nanotechnol. 13 (2013) 4040-4044.

[7] S. Alwarappan, C. Liu, A. Kumar, C. Z. Li,Enzyme-doped graphene nanosheets for enhanced glucose biosensing. J. Phys. Chem. C,114 (2010)12920-12924.

[8] S. Alwarappan, R. K. Joshi, M. K. Ram, A. Kumar, Electron transfer mechanism of cytochrome c at graphene electrode. Appl. Phys. Lett. 96 (2010) 263702.

[9] G. J. Soldano,P. Quaino, E. Santos, W. Schmickler, Stability and hydrogen affinity of graphite-supported wires of Cu, Ag, Au, Ni, Pd and Pt. J. Phys. Chem. C, 117 (2013) 19239-19244.

[10] J. Zhang, M. Li, Z. Feng, J. Chen, C. Li,UV Raman spectroscopic study on TiO_2. I. Phase transformation at the surface and in the bulk.J. Phys. Chem. B,110 (2006) 927-935.

[11] X. Meng, D. Geng, J. Liu, R. Li, X. Sun, Controllable synthesis of graphene-based titanium dioxide nanocomposites by atomic layer deposition.Nanotechnology, 22 (2011) 165602.

[12] G. Jiang, Z. Lin, C. Chen, L. Zhu, Q. Chang, N. Wang, W. Wei, H. Tang, TiO_2 nanoparticles assembled on graphene oxide nanosheets with high photocatalytic activity for removal of pollutants. Carbon, 49 (2010) 2693-2701.

[13] G. Williams, B. Seger, P. V. Kamat, TiO_2-graphene nanocomposites UV-assisted photocatalytic reduction of graphene oxide. ACS Nano, 2 (2008) 1487-1491.

[14] D. Naumenko, V. Snitka, B. Snopok, S. Arpiainen, H. Lipsanen, Graphene-enhanced Raman imaging of TiO_2 nanoparticles.Nanotechnology, 23 (2012) 465703.

[15] M. Nonnenmacher, M. P. O'Boyle, H. K. Wickramasinghe, Kelvin probe force microscopy. Appl. Phys. Lett. 58 (1991) 2921-2923.

[16] M. Mishra, R. K. Joshi,S. Ojha, D. Kanjilal, T. Mohanty, Role of oxygen in the work function modification at various stages of chemically synthesized graphene. J. Phys. Chem. C, 117 (2013) 19746-19750.

[17] F. Tuinstra, J. L. Koenig, Raman spectrum of graphite. J. Chem. Phys. 53 (1970) 1126-1130.

[18] A. C. Ferrari, J. C. Meyer, V. Scardaci, C. Casiraghi, M. Lazzeri, F. Mauri, S. Piscanec, D. Jiang, K. S. Novoselov, S. Roth, A. K. Geim, Raman spectrum of graphene and graphene Layers. Phys. Rev. Lett. 97 (2006) 187401.

[19] V. Stengl, D. Popelkova, P. Vlacil, TiO_2-graphene nanocomposite as high performacephotocatalysts, J. Phys. Chem. C, 115 (2011) 25209-25218.

[20] A. C. Ferrari, J. Robertson, Interpretation of Raman spectra of disordered and amorphous carbon. Phys. Rev. B, 61 (2000) 14096-14107.

[21] T. Zhou, F. Chen, K. Liu, H. Deng, Q. Zhang, J. Feng, Q. Fu, A simple and efficient method to prepare graphene by reduction of graphite oxide with sodium hydrosulfite.Nanotechnology,22 (2011)045704.

[22] S. Stankovich, D. A. Dikin, R. D. Piner, K. A. Kohlhaas, A. Kleinhammes, Y. Jia, Y. Wu, S. T. Nguyen, R. S. Ruoff, Synthesis of graphene-based nanosheets via chemical reduction of exfoliated graphite oxide. Carbon, 45 (2007) 1558-1565.

[23] X. Yang, X. Zhang, Z. Liu, Y. Ma, Y. Huang, Y. Chen, High-efficiency loading and controlled release of doxorubicin hydrochloride on graphene oxide.J. Phys. Chem. C, 112 (2008)17554-17558.

[24] Y. Zhang, C. Pan, TiO_2/graphene composite from thermal reaction of graphene oxide and its photocatalytic activity in visible light. J. Mater. Sci. 46 (2011) 2622-2626.

[25] Z. Peining, A. S. Nair, P. Shengjie, Y. Shengyuan, S. Ramakrishna, Facile fabrication of TiO_2-graphene composite with enhanced photovoltaic and photocatalytic properties by electrospinning. ACS Appl. Mater. Interfaces, 4 (2012) 581-585.

[26] Md. S. A. S. Shah, A. R. Park, K. Zhang, J. H. Park, P. J. Yoo, Green synthesis of biphasic TiO_2-reduced graphene oxide nanocomposites with highly enhanced photocatalytic activity. ACS Appl. Mater. Interfaces, 4 (2012) 3893-3901.

[27] S. Anandan, T. N. Rao, M. Sathish, D. Rangappa, I. Honma, M. Miyauchi, Superhydrophilic graphene-loaded TiO_2 thin film for self-fleaning applications. ACS Appl. Mater. Interfaces, 5 (2013) 207-212.

[28] P. Wang, Y. Tang, Z. Dong, Z. Chen, T. T. Lim, Ag-AgBr/TiO_2/RGO nanocomposite for visible-light photocatalytic degradation of penicillin G. J. Mater. Chem. A, 1 (2013) 4718-4727.

CYBERSECURITY IN THE AGE OF DIGITAL TRANSFORMATION

RAJYAGURU CHETAV
GYANMANJARI INNOVATIVE UNIVERSITY

ABSTRACT

The rapid pace of digital transformation has revolutionized industries, economies, and societies worldwide. Organizations are increasingly adopting advanced technologies such as cloud computing, artificial intelligence, the Internet of Things (IoT), and big data analytics to enhance efficiency, innovation, and competitiveness. However, this transformation has also expanded the cyber threat landscape, exposing critical systems and sensitive data to sophisticated cyberattacks. This research paper explores the evolving nature of cybersecurity challenges in the digital era, examines emerging threats, and evaluates modern defense strategies. It further discusses the role of policies, awareness, and future trends in strengthening cybersecurity frameworks. The paper concludes by emphasizing the need for a proactive, adaptive, and holistic approach to cybersecurity.

1. INTRODUCTION

Digital transformation refers to the integration of digital technologies into all aspects of business and society, fundamentally changing how organizations operate and deliver value. While this transformation offers numerous benefits, it also introduces significant cybersecurity risks. The increasing dependence on interconnected systems has made organizations more vulnerable to cyber threats such as data breaches, ransomware attacks, and identity theft.

Cybersecurity is no longer just a technical issue but a critical component of organizational strategy. As cyber threats evolve in complexity and scale, traditional security measures are often insufficient. This paper aims to analyze cybersecurity challenges in the context of digital transformation and propose effective strategies to mitigate risks.

2. EVOLUTION OF CYBERSECURITY

Cybersecurity has undergone significant transformation over the past few decades, evolving in response to the rapid advancement of digital technologies and the increasing sophistication of cyber threats. In its early stages during the 1970s and 1980s, cybersecurity primarily focused on protecting standalone computer systems. Security measures were minimal and largely consisted of basic password protection and limited access controls, as networks were not widely interconnected.

With the expansion of the internet in the 1990s, cybersecurity challenges grew substantially. Organizations began to rely on networked systems, leading to the development of firewalls and antivirus software to defend against viruses, worms, and unauthorized access. During this period, cyberattacks were often carried out by individual hackers seeking recognition or experimenting with vulnerabilities.

The early 2000s marked a shift toward more organized and financially motivated cybercrime. Attackers began exploiting system vulnerabilities for profit, leading to the rise of phishing attacks, identity theft, and large-scale data breaches. As a result, cybersecurity strategies evolved to include intrusion detection systems, encryption technologies, and more robust authentication mechanisms.

In recent years, the rise of digital transformation technologies such as cloud computing, artificial intelligence, and the Internet of Things (IoT) has further reshaped the cybersecurity landscape. While these technologies offer numerous benefits, they also expand the attack surface, making systems more vulnerable to sophisticated threats like ransomware and advanced persistent threats (APTs). Cybersecurity has thus shifted from a reactive approach to a proactive and predictive one, incorporating real-time threat intelligence and automated defense mechanisms.

Today, cybersecurity is a critical component of organizational strategy, emphasizing risk management, user awareness, and continuous monitoring. As cyber threats continue to evolve, cybersecurity must remain adaptive and innovative to safeguard digital assets and ensure the integrity, confidentiality, and availability of information.

3. KEY TECHNOLOGIES DRIVING DIGITAL TRANSFORMATION

3.1 Cloud Computing

Cloud computing enables organizations to store and process data on remote servers, providing scalability and cost efficiency. However, it also introduces risks such as data breaches, misconfigurations, and unauthorized access.

3.2 Internet of Things (IoT)

IoT devices are increasingly used in smart homes, healthcare, and industrial systems. These devices often lack robust security measures, making them vulnerable to attacks.

3.3 Artificial Intelligence (AI)

AI enhances cybersecurity by enabling threat detection and response automation. However, it can also be exploited by attackers to develop sophisticated malware and phishing attacks.

3.4 Big Data and Analytics

Big data helps organizations analyze large volumes of information for decision-making. However, securing this data is a major challenge due to its volume and complexity.

4. CYBERSECURITY CHALLENGES IN THE DIGITAL ERA

4.1 Increasing Attack Surface

Digital transformation has expanded the attack surface, providing more entry points for cybercriminals. The proliferation of devices and networks increases vulnerability.

4.2 Advanced Persistent Threats (APTs)

APTs are prolonged and targeted attacks aimed at stealing sensitive information. These attacks are difficult to detect and can cause significant damage.

4.3 Ransomware Attacks

Ransomware encrypts data and demands payment for its release. These attacks have become more frequent and sophisticated, targeting both individuals and organizations.

4.4 Insider Threats

Employees and insiders can intentionally or unintentionally compromise security. Insider threats are challenging to detect and prevent.

4.5 Lack of Awareness and Skills

Many organizations lack skilled cybersecurity professionals and fail to provide adequate training to employees, increasing the risk of attacks.

The digital era has brought unprecedented connectivity, innovation, and efficiency, but it has also introduced complex cybersecurity challenges. As organizations increasingly rely on digital technologies such as cloud computing, the Internet of Things (IoT), and artificial intelligence, the risk of cyber threats has grown significantly. One of the primary challenges is the expanding attack surface. With more devices, networks, and users connected to digital systems, cybercriminals have more entry points to exploit vulnerabilities.

Another major challenge is the rise of sophisticated cyberattacks. Modern threats such as ransomware, phishing, and advanced persistent threats (APTs) are becoming more targeted and difficult to detect. These attacks can cause severe financial losses, operational disruptions, and damage to an organization's reputation. Additionally, cybercriminals are increasingly using automation and artificial intelligence to enhance the effectiveness of their attacks.

Data privacy and protection also remain critical concerns. Organizations collect and store vast amounts of sensitive information, making them attractive targets for attackers. A single data breach can expose confidential data, leading to legal consequences and loss of customer trust. Furthermore, insider threats—whether intentional or accidental—pose significant risks, as employees often have access to critical systems and data.

The shortage of skilled cybersecurity professionals is another pressing issue. Many organizations struggle to find qualified experts to manage and secure their systems effectively. This skills gap weakens overall security posture and increases vulnerability to attacks.

Finally, the rapid pace of technological change makes it difficult for security measures to keep up. New technologies often introduce unforeseen vulnerabilities, requiring continuous updates and adaptation. To address these challenges, organizations must adopt a proactive approach, invest in advanced security solutions, and promote cybersecurity awareness among employees.

5. CYBERSECURITY STRATEGIES AND SOLUTIONS

5.1 Risk Management Approach

Organizations must adopt a risk-based approach to cybersecurity, identifying vulnera
bilities and implementing appropriate controls.

5.2 Zero Trust Architecture

Zero Trust is a security model that assumes no user or system can be trusted by default. It requires continuous verification and authentication.

5.3 Encryption and Data Protection

Encryption ensures that data remains secure even if it is intercepted. Strong encryption techniques are essential for protecting sensitive information.

5.4 Multi-Factor Authentication (MFA)

MFA adds an extra layer of security by requiring multiple forms of verification.

5.5 Security Awareness Training

Educating employees about cybersecurity best practices reduces the likelihood of human error.

In the age of digital transformation, organizations must adopt comprehensive cybersecurity strategies to protect their systems, networks, and data from evolving threats. A key approach is implementing a risk-based cybersecurity framework, where organizations identify critical assets, assess potential vulnerabilities, and prioritize security measures accordingly. This ensures that resources are allocated efficiently to address the most significant risks.

One of the most effective modern strategies is the Zero Trust model, which operates on the principle of "never trust, always verify." In this approach, every user and device must be continuously authenticated and authorized before accessing resources, regardless of their location. This reduces the likelihood of unauthorized access and limits the spread of potential breaches.

Encryption plays a vital role in safeguarding sensitive information. By converting data into unreadable formats, encryption ensures that even if data is intercepted, it cannot be easily exploited. Strong encryption protocols are essential for securing data both at rest and in transit.

Multi-factor authentication (MFA) is another critical solution that enhances security by requiring users to provide multiple forms of verification. This significantly reduces the risk of unauthorized access, even if login credentials are compromised. Additionally, regular software updates and patch management are necessary to fix known vulnerabilities and prevent exploitation by attackers.

Employee awareness and training are equally important. Human error is one of the leading causes of security breaches, and educating employees about phishing attacks, password management, and safe online practices can greatly reduce risks.

Finally, organizations should leverage advanced technologies such as artificial intelligence and automation for real-time threat detection and response. Continuous monitoring, incident response planning, and collaboration with cybersecurity experts further strengthen defense mechanisms. By adopting a proactive and layered security approach, organizations can effectively mitigate cyber risks and ensure resilience in the digital landscape.

6. ROLE OF GOVERNMENT AND REGULATIONS

In the modern digital era, governments play a critical role in establishing and enforcing cybersecurity measures to protect national infrastructure, businesses, and citizens from cyber threats. As digital transformation accelerates, the need for robust regulatory frameworks and coordinated efforts has become increasingly important. Governments act as policymakers, regulators, and facilitators to ensure a secure and resilient cyberspace.

One of the primary responsibilities of governments is to develop comprehensive cybersecurity policies and legal frameworks. These regulations define standards for data protection, privacy, and security practices that organizations must follow. For instance, data protection laws require companies to implement appropriate safeguards to protect personal and sensitive information from unauthorized access and breaches. Such regulations not only enhance security but also build trust among users in digital systems.

Governments also play a vital role in protecting critical infrastructure, including sectors such as energy, healthcare, finance, and transportation. Cyberattacks on these sectors can have severe consequences, including economic disruption and threats to public safety. To address this, governments establish national cybersecurity strategies, conduct risk assessments, and mandate security standards for critical infrastructure organizations. Public-private partnerships are often encouraged to strengthen collaboration and share threat intelligence.

Another important function of governments is law enforcement and cybercrime prevention. Cybercrimes such as hacking, identity theft, and online fraud require specialized investigation and prosecution mechanisms. Governments establish dedicated cybercrime units and collaborate with international agencies to track and combat cybercriminals. Since cyber threats often cross national borders, global cooperation is essential for effective enforcement.

In addition to regulation and enforcement, governments promote cybersecurity awareness and education. Many cyber incidents occur due to human error, such as falling victim to phishing attacks or using weak passwords. Governments conduct awareness campaigns, training programs, and initiatives to educate citizens and organizations about best practices in cybersecurity. This helps in creating a more secure digital environment.

Governments also invest in research and development to advance cybersecurity technologies. Funding for innovation in areas such as artificial intelligence, encryption, and threat detection helps in developing more effective security solutions. Furthermore, governments support the development of cybersecurity skills by encouraging education and training programs to address the shortage of skilled professionals.

However, balancing security and privacy remains a significant challenge. While regulations aim to enhance security, excessive surveillance or data collection can raise concerns about individual privacy and civil liberties. Governments must ensure that cybersecurity measures are implemented in a transparent and ethical manner.

In conclusion, the role of government and regulations in cybersecurity is indispensable. Through policy development, enforcement, collaboration, and education, governments create a framework that supports secure digital growth. As cyber threats continue to evolve, strong governance and adaptive regulations will be essential to maintaining trust and security in the digital age.

7. EMERGING TRENDS IN CYBERSECURITY

7.1 AI-Driven Security

AI is increasingly used to detect and respond to threats in real-time, improving efficiency and accuracy.

7.2 Blockchain Technology

Blockchain provides secure and transparent transactions, reducing the risk of fraud and data tampering.

7.3 Quantum Computing

Quantum computing poses both opportunities and challenges for cybersecurity. While it can enhance encryption, it also has the potential to break existing cryptographic systems.

7.4 Cybersecurity Automation

Automation helps organizations respond to threats بسرعة and efficiently, reducing the burden on security teams.

8. CASE STUDIES

8.1 Data Breaches in Large Organizations

Several large organizations have experienced data breaches, highlighting the importance of robust security measures. These incidents demonstrate the financial and reputational damage caused by cyberattacks.

8.2 Ransomware Attacks on Healthcare Systems

Healthcare systems have been targeted by ransomware attacks, disrupting services and compromising patient data. These cases emphasize the need for strong cybersecurity in critical sectors.

9. FUTURE DIRECTIONS

The future of cybersecurity will be shaped by technological advancements and evolving threats. Organizations must adopt proactive and adaptive strategies to stay ahead of cybercriminals. Continuous research and innovation are essential to develop effective security solutions.

10. CONCLUSION

Cybersecurity is a critical aspect of digital transformation. While digital technologies offer numerous benefits, they also introduce significant risks. Organizations must implement comprehensive cybersecurity strategies to protect their systems and data. Collaboration between governments, organizations, and individuals is essential to create a secure digital environment. As cyber threats continue to evolve, a proactive and holistic approach to cybersecurity is necessary to ensure the safety and resilience of digital systems.

REFERENCES

Stallings, W. (2018). Network Security Essentials. Pearson.

Whitman, M. E., & Mattord, H. J. (2021). Principles of Information Security. Cengage Learning.

Kaspersky Lab Reports on Cyber Threat Trends.

National Institute of Standards and Technology (NIST) Cybersecurity Framework.

IBM Security Reports on Data Breaches.

TRANSFORMING HIGHER EDUCATION THROUGH ICT: ENHANCING TEACHING, LEARNING, AND ACCESSIBILITY

DR. AALAP R. SUTHAR
ASSISTANT PROFESSOR, SMT. DHARINIBEN A. SHUKLA B.ED. COLLEGE, MAHEMDABAD

ABSTRACT:

The integration of Information and Communication Technology (ICT) in higher education has emerged as a transformative force reshaping teaching methodologies, learning experiences, and accessibility to knowledge. In the 21st century, the traditional boundaries of education are being redefined by digital innovations, enabling institutions to transition from teacher-centered approaches to more flexible, student-centered learning environments. This paper explores the role of ICT in transforming higher education by enhancing pedagogical practices, improving student engagement, and expanding access to education across diverse socio-economic backgrounds.

The study adopts a descriptive and theoretical approach, drawing upon existing literature, policy frameworks, and global best practices. It examines how ICT tools such as Learning Management Systems (LMS), virtual classrooms, Massive Open Online Courses (MOOCs), and artificial intelligence-based learning platforms contribute to personalized and interactive learning experiences. Furthermore, the paper highlights the significance of ICT in fostering collaborative learning, critical thinking, and digital literacy among students, which are essential competencies in the modern knowledge economy.

In addition to opportunities, the research critically analyzes challenges associated with ICT integration, including digital divide, infrastructure limitations, lack of faculty training, and resistance to change. Special emphasis is placed on the Indian higher education context, where initiatives such as digital learning platforms and national policies aim to bridge educational inequalities and promote inclusive learning.

The findings suggest that while ICT has immense potential to democratize education and improve quality, its effective implementation requires strategic planning, continuous professional development of educators, and robust policy support. The paper concludes that ICT is not merely a supplementary tool but a fundamental driver of educational transformation, capable of creating a more inclusive, accessible, and future-ready higher education system.

KEYWORDS: ICT, HIGHER EDUCATION, DIGITAL LEARNING, E-LEARNING, BLENDED LEARNING, ACCESSIBILITY, EDUCATIONAL TECHNOLOGY, STUDENT ENGAGEMENT, DIGITAL DIVIDE, TEACHING INNOVATION

INTRODUCTION:

Higher education is undergoing a paradigm shift driven by rapid advancements in Information and Communication Technology (ICT). Traditional modes of teaching, primarily centered around lectures and physical classrooms, are increasingly being supplemented—and in some cases replaced—by digital platforms that offer flexibility, interactivity, and accessibility. ICT

encompasses a broad range of technological tools and resources, including computers, the internet, mobile devices, multimedia systems, and software applications, all of which facilitate communication, content delivery, and knowledge creation.

The growing demand for quality education, coupled with increasing student enrollment and globalization, has made it imperative for higher education institutions to adopt innovative approaches. ICT serves as a catalyst in this transformation by enabling institutions to reach a wider audience, improve instructional quality, and foster lifelong learning.

In the context of developing countries like India, ICT plays a crucial role in addressing disparities in educational access and quality. Government initiatives aimed at digitalization have further accelerated the adoption of ICT in higher education. However, the integration of ICT is not without challenges, including infrastructural gaps, lack of digital literacy, and resistance from stakeholders. This paper aims to examine how ICT transforms higher education by enhancing teaching practices, enriching learning experiences, and improving accessibility. It also explores theoretical frameworks and identifies key challenges and opportunities associated with ICT integration.

1. CONCEPTUAL FRAMEWORK OF ICT IN HIGHER EDUCATION

ICT in higher education refers to the use of digital technologies to support and enhance teaching, learning, research, and administrative processes. It includes tools such as:
Learning Management Systems (LMS)
Virtual classrooms and video conferencing tools
Digital libraries and e-resources
Online assessment platforms
Educational software and simulations

1.1 Objectives of ICT Integration

To improve the quality of education
To promote interactive and learner-centered pedagogy
To enhance accessibility and inclusivity
To support lifelong learning
To foster digital literacy and skills

2. CONSTRUCTIVIST LEARNING THEORY

Constructivism emphasizes that learners actively construct knowledge through experiences and interactions. ICT tools such as simulations, discussion forums, and collaborative platforms align well with this theory by encouraging active participation and engagement.

2.1 Connectivism

Connectivism, proposed by George Siemens, highlights the role of digital networks in learning. ICT enables learners to access diverse sources of information and connect with global communities, thereby expanding learning opportunities.

2.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model explains how users adopt and use technology based on perceived usefulness and ease of use. This model is particularly relevant in understanding faculty and student acceptance of ICT tools.

2.3 Blended Learning Theory

Blended learning combines traditional face-to-face instruction with online learning. ICT facilitates this integration, offering flexibility and enhancing learning outcomes.

3. ICT AND TRANSFORMATION OF TEACHING

3.1 Shift from Teacher-Centered to Learner-Centered Approach

ICT enables educators to move beyond traditional lectures to interactive teaching methods. Tools such as multimedia presentations, virtual labs, and online discussions promote active learning.

3.2 Innovative Pedagogical Practices

Flipped classrooms
Gamification
Problem-based learning
Collaborative learning
These approaches enhance student engagement and critical thinking skills.

3.3 Faculty Development

Effective ICT integration requires continuous professional development. Training programs help educators develop digital competencies and adapt to new teaching methodologies.

4. ICT AND ENHANCEMENT OF LEARNING

4.1 Personalized Learning

ICT allows customization of learning experiences based on individual needs, pace, and preferences.

4.2 Student Engagement

Interactive tools such as quizzes, videos, and simulations make learning more engaging and effective.

4.3 Skill Development

ICT fosters essential skills such as:
Critical thinking
Problem-solving
Digital literacy
Collaboration

5. ICT AND ACCESSIBILITY IN HIGHER EDUCATION

5.1 Expanding Educational Reach

Online platforms enable students from remote areas to access quality education without geographical constraints.

5.2 Inclusive Education

ICT supports learners with disabilities through assistive technologies such as screen readers and speech-to-text tools.

5.3 Flexible Learning Opportunities

Students can access learning materials anytime and anywhere, promoting lifelong learning.

6. CHALLENGES IN ICT INTEGRATION

Despite its advantages, ICT integration faces several challenges:

6.1 Digital Divide

Unequal access to technology creates disparities among students.

6.2 Infrastructure Limitations

Lack of reliable internet connectivity and technological resources hampers effective implementation.

6.3 Resistance to Change

Faculty and institutions may resist adopting new technologies due to lack of awareness or fear of change.

6.4 Lack of Training

Insufficient training leads to underutilization of ICT tools.

6.5 Data Privacy and Security

Increased use of digital platforms raises concerns about data protection.

7. ICT IN INDIAN HIGHER EDUCATION: A PERSPECTIVE

India has made remarkable progress in integrating Information and Communication Technology (ICT) into higher education over the past decade. With one of the largest higher education systems in the world, the country has recognized ICT as a critical tool for improving access, equity, and quality in education. Various government initiatives, institutional efforts, and technological advancements have contributed to this transformation.

7.1 Government Initiatives and Digital Platforms

The Government of India has launched several flagship programs to promote ICT-enabled education. One of the most prominent initiatives is the SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) platform, which offers Massive Open Online Courses (MOOCs) developed by leading institutions such as IITs and central universities. SWAYAM enables students to access high-quality course materials free of cost and provides certification opportunities.

Another significant platform is the National Digital Library of India (NDLI), which serves as a repository of millions of digital resources, including books, articles, and research papers. Additionally, e-PG Pathshala provides postgraduate-level content across various disciplines, enhancing the quality of higher education.

Virtual labs and e-content development programs have also been introduced to support practical learning in science and engineering disciplines. These initiatives ensure that students from institutions with limited physical infrastructure can still access laboratory experiences through simulations.

7.2 Online Courses and Virtual Universities

The rise of online education in India has accelerated significantly, especially after the COVID-19 pandemic. Universities and colleges have adopted Learning Management Systems (LMS) such as Moodle and Google Classroom to facilitate online teaching and learning. Virtual classrooms, video lectures, and digital assessments have become integral components of higher education.

Several institutions have also begun offering fully online degree programs, approved by regulatory bodies like the University Grants Commission (UGC). Virtual universities and distance learning institutions, such as Indira Gandhi National Open University (IGNOU), have played a vital role in expanding access to higher education for working professionals and students in remote areas.

7.3 National Education Policies and ICT Integration

The National Education Policy (NEP) 2020 emphasizes the integration of ICT in education as a key strategy for achieving quality and inclusivity. It advocates the use of digital tools for teaching, learning, assessment, and administration. NEP 2020 also highlights the importance of developing digital infrastructure, promoting online and blended learning, and enhancing digital literacy among students and teachers.

The policy encourages the creation of a National Educational Technology Forum (NETF) to facilitate the exchange of ideas on the use of technology in education. It also supports multilingual digital content to ensure inclusivity and accessibility.

7.4 Role of ICT in Expanding Access and Equity

ICT has significantly contributed to democratizing education in India by reaching underserved populations. Students in rural and remote areas can now access lectures, study materials, and online courses through smartphones and internet connectivity. This has reduced geographical barriers and provided opportunities for marginalized communities.

ICT also supports inclusive education by providing assistive technologies for students with disabilities, such as screen readers, captioning tools, and adaptive learning software. These tools help create an equitable learning environment for all learners.

7.5 Challenges in ICT Implementation

Despite notable progress, several challenges hinder the effective integration of ICT in Indian higher education:

Digital Divide: A significant gap exists between urban and rural areas in terms of access to devices and high-speed internet.

Infrastructure Limitations: Many institutions lack adequate ICT infrastructure, including computer labs, reliable electricity, and connectivity.

Faculty Training: A large number of educators are not adequately trained to use ICT tools effectively in teaching.

Language Barriers: Limited availability of digital content in regional languages restricts accessibility.

Quality Assurance: Ensuring the quality and credibility of online courses remains a concern.

7.6 Future Prospects

The future of ICT in Indian higher education looks promising, with increasing investments in digital infrastructure and growing acceptance of online learning. Emerging technologies such as artificial intelligence, machine learning, and data analytics are expected to further enhance personalized learning experiences.

Public-private partnerships, increased funding, and continuous policy support will play a crucial role in overcoming existing challenges. By addressing infrastructural and skill gaps, India can fully harness the potential of ICT to create a more inclusive, flexible, and globally competitive higher education system.

8. STRATEGIES FOR EFFECTIVE ICT INTEGRATION

Investment in infrastructure
Continuous faculty training
Development of digital content
Policy support and governance
Collaboration between institutions

CONCLUSION:

ICT has fundamentally transformed higher education by enhancing teaching methodologies, enriching learning experiences, and improving accessibility. It has enabled a shift towards more inclusive, flexible, and student-centered education systems. While challenges such as digital divide

and infrastructure limitations persist, strategic efforts and policy interventions can address these issues effectively.

The future of higher education lies in the seamless integration of technology with pedagogy. Institutions must embrace ICT not merely as a tool but as a core component of educational transformation. By doing so, they can prepare students to meet the demands of a rapidly evolving digital world and contribute to sustainable development.

REFERENCES:

Anderson, T. (2008). The theory and practice of online learning. Athabasca University Press.

Bates, A. W. (2015). Teaching in a digital age: Guidelines for designing teaching and learning. BCcampus.

Garrison, D. R., & Vaughan, N. D. (2008). Blended learning in higher education. Jossey-Bass.

Selwyn, N. (2016). Education and technology: Key issues and debates. Bloomsbury Publishing.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. International Journal of Instructional Technology and Distance Learning, 2(1), 3–10.

UNESCO. (2020). ICT in education: A critical literature review and its implications. UNESCO Publishing.

Government of India. (2020). National Education Policy 2020. Ministry of Education.

Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education. Learning, Media and Technology, 39(1), 6–36.

Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning. Teachers College Record, 115(3), 1–47.

RIGHT TO EDUCATION AS A HUMAN RIGHT: LEGAL PERSPECTIVES FOR GLOBAL TRANSFORMATION

RIDDHI MUKESHBHAI SEVAK
RESEARCH SCHOLAR, GOKUL GLOBAL UNIVERSITY, SIDDHPUR
PROF. DR. HEMANTKUMAR KANTILAL PATEL
PH.D. GUIDE, FACULTY OF LAW DEPARTMENT, GOKUL GLOBAL UNIVERSITY, SIDDHPUR

ABSTRACT

The aim and objective of this paper are to study the right to education as a human right in India and its globally legal perspectives of the Right to Education. Right to Education is more than the acquisition of knowledge; it is a pathway to dignity, empowerment, and social transformation. Education is a basic human right and the best investment that we can make to ensure a sustainable future and leave no one behind. This is true for every country and every region. Recognized globally as a fundamental human right, education plays a crucial role in shaping equitable and just societies. This paper explores the relationship between law, human rights, and the right to education within the broader framework of global transformation. It examines international legal instruments, constitutional provisions, and judicial interpretations, with special reference to India. The study also highlights multidisciplinary perspectives and contemporary challenges such as inequality, gender discrimination, and the digital divide. The paper argues that effective legal protection combined with social and policy reforms can ensure meaningful access to education. Furthermore, the Right to Education is a fundamental right and UNESCO purposes education for all by 2015 It concludes that strengthening educational rights is essential for sustainable development and global progress.

KEYWORDS: RIGHT TO EDUCATION, HUMAN RIGHTS LAW, EQUALITY, GLOBAL TRANSFORMATION, CONSTITUTIONAL PROVISIONS ,INCLUSIVE EDUCATION

INTRODUCTION

Education has always been considered one of the most powerful tools for social change. It not only helps individuals acquire knowledge but also enables them to develop critical thinking, awareness, and the ability to participate meaningfully in society. When people are educated, they are better equipped to understand their rights, challenge injustice, and contribute to national and global development. For this reason, education is widely recognized as a fundamental human right.

The recognition of education as a human right is rooted in the belief that every individual deserves equal opportunities to grow and develop. Without access to education, individuals often remain trapped in cycles of poverty, inequality, and social exclusion. Education empowers marginalized communities, promotes gender equality, and strengthens democratic values. It is therefore essential that legal systems provide strong protection to ensure that education is accessible to all.
In recent years, the world has witnessed rapid changes due to globalization, technological advancements, and economic development. These changes have created new opportunities but also new challenges. The digital divide, unequal access to resources, and social disparities continue to

limit educational opportunities for many. In this context, a multidisciplinary approach that combines law, sociology, economics, and education policy becomes necessary.

This paper examines the role of law in promoting the right to education and highlights how legal frameworks contribute to global transformation. It also discusses challenges in implementation and provides recommendations for strengthening educational rights.

EDUCATION AS A FUNDAMENTAL HUMAN RIGHT

Education is closely linked to human dignity and personal development. It allows individuals to expand their knowledge, develop skills, and participate fully in society. The recognition of education as a human right reflects the global commitment to ensuring equality and justice. The Universal Declaration of Human Rights, adopted in 1948, clearly states that everyone has the right to education. It emphasizes that elementary education should be free and compulsory. This recognition marked an important step in promoting educational access worldwide. Later, various international instruments strengthened this commitment.

The International Covenant on Economic, Social and Cultural Rights recognizes education as essential for the full development of human personality. Similarly, the Convention on the Rights of the Child emphasizes that children must have access to education without discrimination. These instruments impose obligations on states to ensure accessibility, availability, acceptability, and adaptability of education. Education also enables individuals to enjoy other human rights. For example, an educated person is more likely to understand legal rights, participate in governance, and seek justice. Education therefore acts as a multiplier right that supports the realization of other freedoms.

PRINCIPLES THAT GUIDED RIGHT TO EDUCATION:

Right to Education should imply that every child has a right to be (a) provided full-time Education of satisfactory and equitable quality in a formal school that satisfies at least certain essential norms and (b) enabled to complete elementary education. It may, however, be pointed out that the National Policy on Education 1986 (as modified in 1992) did envisage the alternative modality of non-formal Education also for achieving universal elementary Education. Right to Education also implies that it is the State's obligation to remove whatever obstacles – social, economic, academic, linguistic, cultural, physical, etc. Right to Education must be seen not merely as a right for its own or the individual child's sake but also as an instrument of promoting other constitutional objectives, e.g. equality, justice, democracy, secularism, social cohesion, etc. Provision of Free and Compulsory Education of satisfactory quality to children from weaker sections is the responsibility not merely of Schools run or supported by the State, but also of schools which are not dependent on State funds. Other provisions regarding unaided schools would, however, be viewed as introducing a far more regulatory regime than has hitherto been the case and amounting to undue/excessive regulation of private initiative in Education. One major reason why it has not been possible to universalize elementary Education all these years is these functionality of the delivery system.

The Committee has therefore attempted to formulate a number of provisions for the proposed legislation, essentially aimed at greater decentralization and accountability so that the delivery system is able to rise to the challenge. Although its terms of reference were confined to free and

compulsory Education for children between the ages of 6-14 years, the Committee has considered the main programme for Early Childhood Care and Education (ECCE), viz.,

Integrated Child Development Services (ICDS), and proposed convergence to the extent possible. While ECCE will continue to be provided (in the State sector) through Anganwadis under ICDS, the Committee has recommended that additional pre-school facilities be provided to children in the age group of 5-6 years wherever necessary

MULTIDISCIPLINARY DIMENSIONS OF RIGHT TO EDUCATION

The right to education cannot be understood only from a legal perspective. It involves multiple dimensions that contribute to holistic development.

Legal Dimension

Law plays a vital role in recognizing and protecting educational rights. Constitutional provisions and legislation ensure that education is not treated merely as a privilege but as a legal entitlement. Courts also interpret educational rights broadly to include equality, dignity, and access.

Social Dimension

Education promotes social inclusion by reducing inequalities. It empowers marginalized communities and helps eliminate discrimination based on caste, gender, religion, and economic status. Education also encourages social harmony and mutual respect.

Economic Dimension

Education contributes significantly to economic growth. Skilled individuals enhance productivity, innovation, and competitiveness. Investment in education also reduces unemployment and poverty.

Political Dimension

Educated citizens participate actively in democratic processes. They are more likely to vote, engage in public discussions, and hold governments accountable.

Technological Dimension

Technology has transformed education through online learning platforms and digital tools. However, unequal access to technology creates new challenges, especially in rural areas.

Constitutional and Legal Framework in India

Constitutional Framework: India has made significant progress in recognizing education as a fundamental right.

CONSTITUTIONAL PROVISIONS OF RIGHT TO EDUCATION IN INDIA:

Article 21A: The Right of Children to Free and Compulsory Education Act (RTE, Right to Education): The Right of Children to Free and Compulsory Education Act' or 'Right to Education Act also known as RTE', is an Act of the Parliament of India enacted on 4thAugust 2009, which describes the modalities of the importance of free and compulsory education for children between 6 and 14 in India under Article 21A (Article 21is the Fundamental Right to Life under Right to Freedom) of the Indian Constitution. India became one of 135 countries to make education a fundamental right of every child when the act came into force on 1st April 2010. “The State shall provide free and compulsory education to all children of the age of six to fourteen years in such manner as the State may, by law, determine”.

Article 41: Right to work, to education and to public assistance in certain cases. The State shall, within the limits of its economic capacity and development, make effective provision for securing

the right to work, to education and to public assistance in cases of unemployment, old age, sickness and disablement, and in other cases of undeserved want.

Article 45: Right for Early Childhood Care and Education (ECCE) to all children until they complete the age of six years. This article is considered as a directive principle of state policy. It states "The State shall endeavour to provide, within a period of ten years from the commencement of this Constitution, for free and compulsory education for all children until they complete the age of fourteen years". The Government of India has included ECCE as a constitutional provision through the amended Article 45(as per the 86th Amendment of December, 2002 and passed by Parliament in July 2009) which directs that "the State shall endeavour to provide Early Childhood Care and Education for all children until they complete the age of six years".

Article 46: Promotion of the economic and educational interests of the Scheduled Castes, Scheduled Tribes and other weaker sections: The State shall promote with special care the educational and economic interests of the weaker sections of the people, and, in particular, of the Scheduled Castes and the Scheduled Tribes, and shall protect them from social injustice and all forms of exploitation.

Article 51A (k): Added as a fundamental duty for parents to provide education opportunities to children between 6 and 14 years.

The Constitution originally included education within the Directive Principles of State Policy. However, judicial interpretation expanded its importance. The Supreme Court, in Mohini Jain v. State of Karnataka, held that education is essential for the realization of fundamental rights. Later, in Unni Krishnan v. State of Andhra Pradesh, the Court recognized education as part of the right to life under Article 21. To strengthen this recognition, the Constitution was amended through the 86th Constitutional Amendment.

LEGAL FRAMEWORK (RTE ACT, 2009)

Free and compulsory: "Free" means no child pays fees to prevent completion of education. "Compulsory" binds the government to ensure admission, attendance, and completion.

Neighbourhood Schools: Mandates that schools must be within a defined walking distance.

25% Reservation: Section 12(1)(c) mandates private unaided schools to reserve 25% of seats at entry-level for children from Economically Weaker Sections (EWS) and disadvantaged groups.

Norms and Standards: Prescribes school infrastructure, teacher-student ratios (1:30 for primary, 1:35 for upper primary), and qualification requirements (TET).

No Detention Policy: Prohibits holding back or expelling any student up to Class 8 (later amended to allow state-level discretion).

Prohibitions: Bans physical punishment, mental harassment, and admission tests.

ROLE OF LAW IN PROMOTING EDUCATIONAL RIGHTS

Law ensures that education is available and accessible. It creates obligations for governments to provide schools, teachers, and infrastructure. Legal frameworks also prevent discrimination and promote inclusion. Law regulates private educational institutions to ensure quality standards. It also protects children from exploitation and child labour, which often prevent access to education. Legal provisions promote gender equality and ensure access for disabled students. Courts play an important role by providing remedies when educational rights are violated. Judicial activism has expanded the scope of educational rights and ensured accountability.

CONTEMPORARY ISSUES AND CHALLENGES

Despite legal recognition, several challenges continue to affect educational access.Poverty remains one of the biggest barriers. Many families cannot afford educational expenses. Gender discrimination also limits opportunities for girls. In rural areas, lack of infrastructure and qualified teachers affects quality. The digital divide has emerged as a major challenge, especially after the COVID-19 pandemic.

Students without internet access or devices were unable to continue learning. Child labour and migration also disrupt education. Children with disabilities face additional barriers due to inadequate facilities. These challenges highlight the need for stronger policies and implementation mechanisms.

There are several obstacles which blocked the road to implement right to education in India, those are discussed below:

1. Inadequate infrastructural facilities in schools:
2. Lack of teaching and non-teaching staff in school
3. Lack of sanitary facilities in school
4. Low rate of enrolment of girls
5. No library facilities
6. Inadequate teaching and playing instruments
7. High student-teacher ratio

RIGHT TO EDUCATION AND GLOBAL TRANSFORMATION

Education plays a central role in achieving global transformation. It promotes sustainable development, reduces inequality, and enhances social justice. Educated individuals contribute to innovation and economic growth. Education also supports peace and tolerance by encouraging understanding among cultures. Global transformation requires collaboration among governments, institutions, and communities. Legal frameworks must be strengthened to ensure universal access to education.

Key Aspects of the Right to Education & Global Transformation:

Empowerment and Equality: Education is a primary vehicle for marginalized children and adults to lift themselves out of poverty. It plays a vital role in empowering women, protecting children from exploitation, and fostering human rights.

Fundamental Legal Right: Recognized in international conventions (e.g., the International Covenant on Economic, Social and Cultural Rights), this right covers access to primary, secondary, and higher education. Over 135 countries, including India, have made education a fundamental right.

The Indian RTE Act (2009): Mandates free and compulsory education for children aged 6 to 14, requiring 25% reservations for economically weaker students in private schools. It focuses on school infrastructure, teacher-student ratios, and preventing dropouts.

GLOBAL TRANSFORMATION CHALLENGES:

Equity Gaps: Persistent disparities in education access exist for girls, refugees, and persons with disabilities.

Quality vs. Access: While enrolment rates have improved globally, focus is shifting toward ensuring quality learning outcomes.
Digital Transformation: The need for technological adaptation in education systems, particularly following challenges like pandemics and conflicts.
Future Directions: The future of education involves adapting to demographic changes, technological advancements, and promoting lifelong learning, as highlighted by UNESCO's Future of Education initiative.

Education also helps people to realize that development should benefit people and communities as a whole. It enables people to recognize that economic development should be pursued to provide long-term benefits in line with human rights and the preservation and conservation of the environment. According to the UNESCO Education for All Global Monitoring Report, a girl in a low-income country receiving secondary Education is 63% less likely to marry than a girl without Education and has fewer and healthier children. Children of literate mothers are over 50% more likely to live past the age of five and receive good nutrition. There are also significant health benefits for girls and women, with considerable.

In, the international community committed to the 2030 Agenda for Sustainable Development, which is an expansion of the Millennium Development Goals, and which reflects the importance stated place on Education in achieving sustainable development.

RECOMMENDATIONS

To strengthen the right to education, the following steps are necessary:
Increase budget allocation for education
Improve rural infrastructure
Promote digital education access
Strengthen teacher training
Encourage inclusive education
Reduce gender disparities
Promote legal awareness
Strengthen monitoring mechanisms

CONCLUSION

Education is a powerful tool for promoting equality, dignity, and sustainable development. Recognizing education as a human right ensures that individuals have opportunities to grow and contribute to society. Law plays a crucial role in protecting educational rights and promoting inclusion. However, effective implementation requires collaboration across disciplines. Addressing challenges such as poverty, discrimination, and digital divide is essential. Strengthening legal frameworks and policy measures will ensure universal access to education. Right to quality education cannot be achieved without trained and qualified teachers who provide effective quality teaching. Seventy years ago, the UN General Assembly adopted the Universal Declaration of Human Rights, recognizing the universal Right to Education for the first time... For the advancement and promotion of the Right to Education UN human declaration, many more conventions mention about Right to Education. At last, everyone human being has the Right to Education. Education must be free, at least in the primary and fundamental stages.

Moreover, primary Education shall be compulsory. Global transformation is possible only when education becomes accessible to all. By promoting educational rights, societies can move toward equality, justice, and sustainable development.

REFERENCES

Universal Declaration of Human Rights, 1948

International Covenant on Economic, Social and Cultural Rights, 1966

Convention on the Rights of the Child, 1989

Constitution of India, Article 21A

Right of Children to Free and Compulsory Education Act, 2009

Mohini Jain v. State of Karnataka

Unni Krishnan v. State of Andhra Prad

Education for All Global Monitoring Report 2005

United Nations General Assembly (UNGA). 2015. Transforming our world: the 2030 Agenda for Sustainable Development. New York, UNGA (Doc. A/RES/70/1.)

Report of the Central Advisory Board of Education (CABE) Committee on Free and Compulsory Education Bill And Other Issues Related to Elementary Education June 2005, available:https://www.education.gov.in/sites/upload_files/mhrd/files/document-reports/fcebill.pdf

ELECTROCHEMICAL EXPOSURE OF UNDERWATER CARBON DIOXIDE BY NH_2 FUNCTIONALIZED ELECTRODE

ANKIT J SHAH
SHREE P M PATEL COLLEGE OF ELECTRONICS AND COMMUNICATION, ANAND-388001

ABSTRACT

In this paper, construction of amino group-modified sensor electrode and electro chemical finding of CO2in the salt solution will be stated. Electro chemical discovery of CO2 was carried out by cyclic voltammetry method in redox active potassium ferricyanide aqueous solution. Peak currents of oxidation and reduction response in cycle voltammograms have changed rendering to the concentration of CO2 particles in the measurement solutions. The standardization curve for the CO2 concentration was got by plotting oxidation peak currents. The device electrode ready in this study can approximation differences between the concentration of CO_2 in usual seawater and that of up to 20 times.

KEYWORDS: VOLUMETRIC TECHNIQUES, AMINO GROUP MODIFIED DETECTOR

INTRODUCTION

An conductor in associate degree chemistry cell is observed as either associate degree anode or a cathode (words that were coined by William Whewell at Faraday's request).[1] The anode is currently outlined because the conductor at that electrons leave the cell and chemical reaction happens (indicated by a minus image, " and also the cathode because the conductor at that electrons enter the cell and reduction happens (indicated by a and image, "+"). every conductor could become either the anode or the cathode counting on the direction of current through the cell. A bipolar conductor is associate degree conductor that functions because the anode of 1 cell and also the cathode of another cell.

A galvanic cell could be a special sort of chemical science cell within which the reaction cannot be reversed, [4] thus the identities of the anode and cathode are therefore fastened. The anode is often the negative conductor. The cell is often discharged however not recharged.

A storage cell, as an example a chargeable battery, could be a cell within which the chemical reactions are reversible. once the cell is being charged, the anode becomes the positive (+) and therefore the cathode the negative (−) conductor. this is often additionally the case in associate degree electric cell. once the cell is being discharged, it behaves sort of a galvanic cell, with the anode because the negative and therefore the cathode because the positive conductor. Charging and discharging processes, like those in lithium-ion batteries, tend to incur massive losses through contact resistance at electrodes. Minimizing these conductors localized losses constitutes a vital approach in up energy usage in chemical science storage.

Carbon Capture and Storage (CCS) technologies have received extended attention owing to the doable applications to forestall heating by reducing greenhouse emission like carbonic acid gas (CO2) [1]. The CCS method consists of 4 methods of the capture process, the transportation method,

the injection method, and also the storage method. In these processes, the storage method takes the longest amount of the entire CCS method. owing to that, semi-permanent maintenance and observance is needed to ensure of safety. The detection technique of greenhouse emission that exists in underwater setting is one in every of the key element technologies needed for use of CCS method [2-12]. so as to perform continuous observance of underwater greenhouse emission in ocean storage components, indirect detection techniques, like hydrogen ion concentration measure, are used usually. For the long run, however, direct detection technique are going to be needed for playacting a lot of precise and sensitive observance of underwater greenhouse emission. Chemical sensors area unit applied to several scientific and industrial fields, like medical treatment, food and environmental watching, owing to the sensing element has high sensitivity and property [13-20]. The chemical sensing element consists from 2 half's the detector half and therefore the electrical device part. Detector elements acknowledge the molecules to be measured by practical organic teams. On the opposite hand, electrical device elements convert molecular recognitions to signals like chemical science signals, surface Plasmon resonance, amendment of mass, etc. Since surface modification techniques for the surface of the conductor area unit quite common, chemical science activity 1s wide used for electrical device half.

It is famed that organic molecules having amino teams will react with CO_2. molecules forming salt ions. Recently, for instance, numerous alkanolamines and its blends are studied as solvents for capture method of CCS [21-28]. it's presupposed to be able to fabricate a chemical sensing element that may directly live CO_2 molecules exploitation amino teams as a detector a part of the sensing element. during this paper, chemical science detection of CO_2 within the saline exploitation amine-functionalized conductor are going to be according. chemical science responses were measured in order to gauge combos of CO_2 molecules to the amino teams immobilized on the surface of the conductor. The standardization curve is obtained by plotting chemical science responses for CO_2 concentration [29-33].

MATERIALS AND METHODS

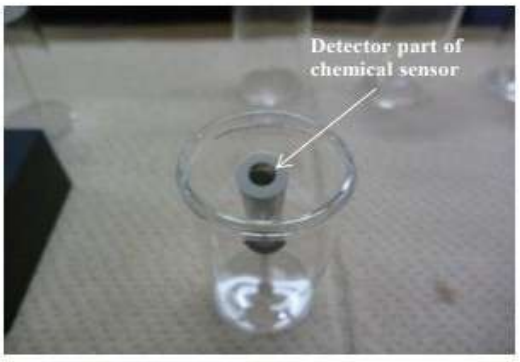
Reagents

Aminoethantiol and potassium hexacyanoferrate (III) were purchased from atul chemicals valsad respectively. Sodium chloride and Sodium bicarbonate were obtained from dutt chemicals Anand. All the materials were of the highest grade available and were used as received.

Preparation of Amine-modified Electrodes

A gold (Au) disk conductor (diameter, 3.0 mm) was used. First, the surface of the conductor was polished totally with liquid slurries of aluminum oxide paste and so rinsed with water, gently [34-





36]. The Au conductor was lordotic in an exceedingly freshly ready aminothiol solution (10 mM) nightlong to fabricate self-assembled monolayer (SAM) that has amino teams within the finish of molecular chain, and so the conductor was rinsed with water, gently

Fig. 1fabrication of amino group terminated SAM on the Au electrode immersion set up of Electrode (left) and surface of the electrode kept overnight (right)

ELECTROCHEMICAL EVALUATIONS

Electrochemical measurements of the amine-functionalized electrode were carried out on a conventional three electrode system using a platinum wire as the counter electrode and an Ag/AgCl electrode as the reference electrode. All measurements were performed at room temperature

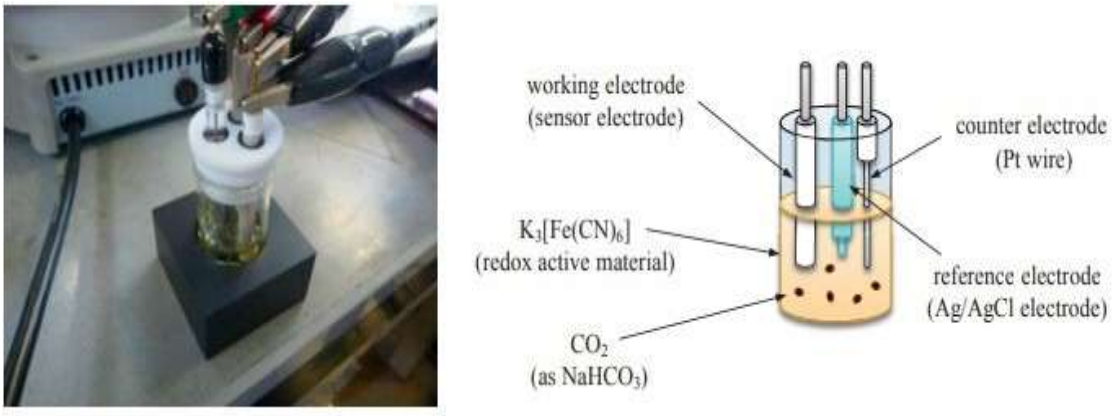


Fig. 2 experimental set up for electrochemical evaluations of the sensor electrode

As a mensuration resolution of chemical science evaluations, associate degree solution containing K hexacyanoferrate (11) (5 mm) and hydrogen carbonate (0 to 50 mM) was ready employing a 500 mM sodium chloride solution. Concentrations of CO_2 solved within the resolution were adjusted by dynamic concentration of hydrogen carbonate, which may manufacture CO_2 molecules by their reaction in associate degree solution as shown below.

$$NaHCO_3(s) \rightarrow Na^+ + HCO_3^- \quad (1)$$

$$HCO_3^- + H^+ \rightarrow H_2CO_3(aq) \quad (2)$$

$$H_2CO_3(aq) \rightarrow H_2O(aq) + CO_2(aq) \quad (3)$$

RESULTS AND DISCUSSIONS

Electrochemical detection of greenhouse emission was applied victimization cyclic voltammetry technique in chemical reaction active K salt solution. Figure three shows cyclic voltammograms (CVs) and also the standardization curve obtained. As shown within the left a part of Figure three, oxidization and reduction current of the ferricyanide anions were obtained. Moreover, each peak currents of oxidization and reduction have modified in line with the concentration of the another bicarbonate, increasing concentrations of greenhouse emission molecules by adding bicarbonate leads decreasing of each oxidization and reduction peak currents. The standardization curve for the greenhouse emission concentration (shown within the right a part of Figure 3) was obtained by plotting oxidization peak currents of CVs. As shown in the plot, it is clear that the detector conductor ready during this study will observe variations between traditional concentration of greenhouse emission in saltwater (0.25 ppm) and ten times or twenty times higher concentration of that.

The mechanisms of amendment in chemistry responses relying greenhouse emission concentration of the measure solutions, area unit illustrated in Figure four.

within the case of absence of greenhouse emission molecules (left a part of Figure 4), salt anions will diffuse to conductor surface simply, thanks to the amino teams that area unit neutral in their equilibrium. However, within the case of presence of greenhouse emission molecules (right a part of Figure 4), negative-charged salt anions area unit made by combining greenhouse emission and amino teams on the conductor surface. Then, by the static repulsion between salt and salt anions, it's expected that oxidization and reduction current area unit attenuated.

CONCLUSIONS

Electrochemical detection of CO2 in the saline solution was performed using amino group-modified Au electrode. Oxidation and reduction current of the ferricyanide anions changed depending on the concentration of CO2 molecules in the measurement solutions. The sensor electrodes prepared in this study are able to estimate differences between the concentration of CO2 in normal seawater and that of up to 20 times.

REFERENCE:

E. Gikas, M. Parissi-Poulou, M. Kazanis, A. Vavagiannis, J. Mol. Struct. 724 (2005) 135-142.

H. Zhao, N. Neamati, H. Hong, A. Mazumder, J. Med. Chem. 40 (1997) 242-249.

L.D. Raev, E. Voinova, I.C. Ivanov, D. Popov, Pharmazie 45 (1990) 696-702.

I. Kostova, Curr. Med. Chem. 5 (2005) 29-46.

L.M. Bedoya, M. Beltran, R. Sancho, D.A. Olmedo, S. Sanchez-Palomino, E. del lmo, J.L. Lopez-Perez, E. Munoz, A. San Feliciano, J. Alcam, Bioorg. Med. Chem. Lett. 15 (2005) 4447-4450.

K S Patel, R B Patel, R N Patel. Heterocyclic letters, 3: (4), (2013), 493-504.

T. Suvit, K.T. Paul, D.W. Keith, Kong-Teck Chong, W.J. Howe, Chih-Ping Yang, W.J. Strohbach, R.S. Turner, P.J. McGrath, J. Med. Chem. 37 (1994) 3200-3204.

S. Kirkiacharian, D.T. Thuy, S. Sicsic, R. Bakhchinian, R. Kurkjian, T. Tonnaire, II Farmaco 57 (2002) 703-708.

G. Appendino, E. Mercalli, N. Fuzzati, L. Arnoldi, M. Stavri, S. Gibbons, M. Ballero, A. Maxia, J. Nat. Prod. 67 (2004) 2108-2110.

H. Zhao, N. Neamati, H. Hong, A. Mazumder, S. Wang, S. Sunder, G. W. Miline, Y. Pommier, Jr, T. R. Burke, J. Med. Chem. 40 (1997) 242-249.

H. Ali, J.E. van Lier, Chem. Rev. 99 (1999) 2379-2450.

A.Y. Louie, T.J. Meade, Chem. Rev. 99 (1999) 2711-2734.

W.A. Volkert, T.J. Hoffman, Chem. Rev. 99 (1999) 2269-2292.

K S Patel, R N Patel, N C Boricha and D M Pandya, Heterocyclic letters, 4: (1), (2014), 23-33.

Lu, L., Wang, R. Z., Chang, R. Q., Wang, J. H., Chuang, Z. W., and Tao, Z. R., The Chinese Chem.Soc.,Taipei, 58 (3), (2000), 367-385.

Zhao, H., Neamati, N., Hong, H., Mazumder, A., Wang, S., Sunder, S., Miline, G. W. A.,Pommier, Y., and Jr, T. R. B., J.Med.Chem., 40 (2), (1997), 242-249.

Mao, P. C. M., Mouscadet, J. F., Leh, L., Auclair, C., and Hsu, L. Y., Chem.Pharm. Bull.,50 (12), (2002), 1634-1637.

Su, C. X., Mouscadet, J. F., Chiang, C. C., Tsai, H. J., and Hsu, L.Y., Chem.Pharm. Bull.,54 (5), (2006), 682-686

Kostova, I., Raleva, S., Genova, P., and Argirova, R., BioinorganicChemistryand Applications,2006, (2006), 1-9.

Ferroud, D., Collard, J., Klich, M., Dupuis-Hamelin, C., Mauvais, P., Lassaigne, A., Bioorg.Med.Chem.Lett.,9 (19), (1999), 2881-2886.

D.E. King, R. Malone, S.H. Lilley, Am.Fam.Physician, 61, (2000), 2741.

I. Turel, Coord.Chem.Rev., 232, (2002), 27.

D.C. Hooper, E. Rubinstein (Eds.), Quinolone Antimicrobial Agents, 3rd ed., ASM Press,Washington, DC, (2003).

R N Patel, K S Patel, R B Patel. Heterocyclic letters, 3: (4), (2013), 513-518.

K. S. Patel, J. C. Patel, H. R. Dholariya and K. D. Patel, Ojmetal, 2, (2012)49-59.

A. I. Vogel, TextbookofPracticalOrganicChemistry, 5th ed., Longman, London, 1989.J.M. Andrew, J. Antimicrob; Chemother.;48, (2001), 563.

G. J. Kharadi and K. S Patel. Heterocyclic letters, 3: (4), (2013), 481-491.

I. Kostova, G .Momekov, M. Zaharieva, M. Karaivanova. Eur.J.Med.Chem. 40, (2005),542.

K S Patel, R N Patel, N C Boricha and D M Pandya, Heterocyclic letters, 4: (1), (2014), 119-124.

J. R. Anacona and I.J.Rodriguez, Coord.Chem.,57 (15), (2004),1263-1269.

K.S. Patel, J.C. Patel, H.R. Dholariya and K.D. Patel, SpectrochimicaActaPartA: MolecularandBiomolecularSpectroscopy, 96, (2012), 468-479

K.S. Patel, J.C. Patel, H.R. Dholariya, K.D. Patel. Synthesis and reactivity in inorganic, metal-organic and nano-metal chemistry, 43, (2013), 1049–1058

K. B. Gudasi, M. S. Patil, R. S. Vadavi, R. V. Shenoy, S. A. Patil, and M. Nethaji, Trans.Met.Chem.,31 (5), (2006), 580-585.

A. L. Abuhijleh, C. Woods and I. Y. Ahmed, Inorg.Chim.Acta.,190 (1), (1991), 11- 17.

L. Dawara, R.V. Singh, Appl. Organometal. Chem. 25 (2011) 643-652.

ARTIFICIAL INTELLIGENCE AS A STRATEGIC ENABLER IN FINANCIAL DECISION-MAKING: AN EMPIRICAL INVESTIGATION OF AWARENESS, ADOPTION, AND PERCEIVED IMPACT

DR. RAKESHKUMAR C. PATEL
ASSOCIATE PROFESSOR, DHARMSINH DESAI INSTITUTE OF COMMERCE, NADIAD

ABSTRACT:

Artificial Intelligence (AI) has become a key driver in the financial sector, changing how traditional financial decisions are made. The growing complexity of financial markets, along with the availability of large amounts of data, has sped up the use of AI-driven tools in areas such as investment analysis, risk management, credit assessment, and fraud detection. This study looks at how aware investors and finance professionals are of AI, how much they use it, and the impact they believe it has on financial decision-making. We gathered primary data through a structured questionnaire given to 120 respondents, analyzing this data with descriptive and analytical methods, including percentage and mean score analysis. The results show that AI significantly improves accuracy, speed, and efficiency in financial decisions while supporting data-driven insights and reducing risks. However, the study also points out important concerns related to data security, algorithm transparency, ethical issues, and over-reliance on automated systems. The research concludes that AI works best as a support tool that enhances human judgment rather than replacing it. This study provides empirical evidence from a developing economy and offers practical advice for responsibly integrating AI into financial decision-making.

KEY WORDS: ARTIFICIAL INTELLIGENCE; FINANCIAL DECISION-MAKING; FINTECH; INVESTMENT ANALYSIS; RISK MANAGEMENT; DECISION SUPPORT SYSTEMS; EXPLAINABLE AI

INTRODUCTION:

The rapid growth of digital technologies has greatly changed the global financial landscape. Among these innovations, Artificial Intelligence (AI) has become a significant force, altering how financial decisions are made and carried out. AI refers to computer systems that can learn from data, recognize patterns, and perform tasks that typically need human intelligence, such as reasoning, predicting, and solving problems. In finance, AI allows organizations to handle huge and complex datasets more quickly and accurately, which improves the quality of financial decision-making.

In recent years, the financial sector has widely adopted AI-driven applications in many areas. These include algorithmic trading, portfolio optimization, credit scoring, fraud detection, robo-advisory services, customer relationship management, and financial forecasting. AI systems use machine learning, natural language processing, and predictive analytics to draw meaningful insights from both structured and unstructured data. As financial markets become more volatile and interconnected, the ability to analyze real-time data and create timely insights is crucial for gaining a competitive edge and ensuring financial stability.

Traditional financial decision-making models, which mostly depend on historical data and human judgment, often face challenges such as cognitive bias, information overload, and slow response times. AI helps overcome these challenges by providing automated, data-driven decision-support tools that reduce subjectivity and enhance consistency. Financial institutions and individual

investors increasingly rely on AI tools to improve risk assessment, boost investment performance, and optimize resource allocation. Thus, AI is now seen not just as a technological development but as a key driver of financial decision-making.

Even with the rising use of AI in finance, its integration brings significant challenges and concerns. Issues surrounding algorithm transparency, data privacy, ethical responsibility, and potential systemic risks have raised questions about the dependability and trustworthiness of AI-driven decisions. The "black-box" nature of some AI models limits users' understanding of how decisions are made, which can decrease confidence and hinder adoption. Additionally, over-reliance on automated systems can weaken human judgment, especially in complex financial decisions.

Existing academic studies mainly focus on the technical efficiency and performance outcomes of AI applications in finance. However, there is less empirical research on the awareness, use, and perceived impact of AI from the perspective of actual users, particularly in developing economies. Understanding user perception is important because the success of AI implementation relies not only on technical ability but also on user acceptance, trust, and ethical considerations.

In this context, the present study aims to explore the role of Artificial Intelligence as a key driver in financial decision-making. Specifically, it looks at how aware investors and finance professionals are of AI, how much they use it, and their perceived impact of it. By utilizing primary data and perception-based analysis, this research intends to fill the gap in the literature and provide insights on responsibly and effectively integrating AI into financial decision-making processes. The findings of this study are expected to enrich academic discussions, inform managerial practices, and assist policymakers in creating suitable frameworks for AI in finance.

LITERATURE REVIEW:

2018: FinTech and AI's Rise in Financial Decision-Making

One of the earliest comprehensive frameworks to explain the FinTech revolution and its implications for financial decision-making was done by Gomber et al. (2018).

Their study stressed that AI-driven analytics would lie at the heart of financial intermediation, while the speed of information processing and the preciseness of decision-making is dramatically enhanced. The authors put forth that algorithmic decision systems decrease asymmetry in information and lower transaction costs.

Critical note: While strong on conceptualization, the study remained at a highly theoretical level without any supporting empirical evidence on the adoption at the user level.

Begenau et al. (2018) analyzed big data and machine learning in asset pricing and investment decisions.

The study conducted showed that when big datasets are available, AI-based models surpass the conventional econometric model in forecasting financial returns.
Critical note: The research is focused primarily on institutional investors and, therefore, does not try to address any ethical or governance implications.

Jarrahi (2018) investigated how AI systems and human judgment interact in organizational decision-making. The author stressed that while AI improves analytical skills, it is unable to completely replace contextual and ethical reasoning.

Critical note: The study emphasized the value of human-AI cooperation, a topic that becomes crucial in subsequent research focused on finance.

2019–2020: METHODOLOGICAL DEVELOPMENT AND CONSOLIDATION

One prominent example in this realm is the work of Cao (2020), who published an interdisciplinary review article on AI applications. The categories of use of AI were identified as forecasting, credit scoring, fraud detection, and portfolio management, highlighting the superiority of ML methods over traditional statistics.

Critical comment: The author pointed out that low quality data and overfitting could potentially result in erroneous performance claims.

Kraus, Feuerriegel, and Oztekin (2020) investigated machine learning methods for financial decision support. Their results revealed that tree models and neural networks both improve prediction performance.

Critical note: One of the limitations found in the study was the lack of explainability.

Bazarbash (2020) analyzed the application of AI in financial organizations from a regulatory outlook. The report stressed how AI can be very beneficial for efficiency but at the same time generates several risks.

Critical Commentary: The study enhanced the policy aspect but did not involve primary data collection.

2021: Bibliometric Mapping and Performance Evaluation

Goodell carried out a bibliometric analysis of AI and machine learning research in finance. The study showed that there was an exponential growth in publications especially those dealing with investment analysis and risk management.

Critical note: While the study did a good job of mapping the trends, it did not study real-world user perception.

Cao and Wang (2021) conducted an empirical study on AI-based forecasting models in financial markets. They discovered that AI greatly improved the accuracy of prediction and speed of decision-making.

Critical note: The study assumed the rational use and ignored behavioral resistance among users.

Ryll and Seidenschnur in 2021, researched on digital transformation and AI use in financial services. The authors have emphasized AI as a strategic capability, not just some form of technological add-on.

Critical note: The strategy was emphasized in the study; however, the analysis of micro-level decisions was missing

2021: BIBLIOMETRIC MAPPING AND PERFORMANCE EVALUATION

Goodell (2021) carried out a bibliometric analysis of AI and machine learning research in finance. The study showed that there was an exponential growth in publications especially those dealing with investment analysis and risk management.

Critical note: While the study did a good job of mapping the trends, it did not study real-world user perception.

Cao and Wang (2021) conducted an empirical study on AI-based forecasting models in financial markets. They discovered that AI greatly improved the accuracy of prediction and speed of decision-making.

Critical note: The study assumed the rational use and ignored behavioral resistance among users.
Ryll and Seidenschnur in (2021) researched on digital transformation and AI use in financial services. The authors have emphasized AI as a strategic capability, not just some form of technological add-on.

Critical note: The strategy was emphasized in the study; however, the analysis of micro-level decisions was missing...

2022: INCLUSION, ETHICS, AND MANAGEMENT ACCEPT

A study by Dwivedi et al. (2022) analyzed manager views on AI-assisted the results indicated that managers feel AI is an enabling tool that adds value to decision-making.

Critical comment to add: Resistance was a function of a lack of skills and transparency.

Buchak et al. (2022) studied AI-powered credit scoring systems in lending organizations. The findings showed the positive impact of alternative data-driven AI models on credit accessibility.
Critical point: Biased data sources can cause biased results, as stated by the authors.

Raisch and Krakowski (2022) investigated the adaptability of the organization with regard to AI. It was concluded that when AI complements, rather than substitute, human judgment, it is most beneficial for businesses.

Critical note: "This study reaffirmed the augmentation view but was not finance-related."

2023: APPLIED FINANCIAL EVIDENCE AND EXPLAINABLE AI

Gomber, Koch, and Siering (2023) investigated the use of AI in FinTech and banking. Their results demonstrated that AI improves investment advisory, customer service, and fraud detection.

Critical note: One of the main obstacles to adoption is still regulatory uncertainty.

Explainable AI (XAI) in decision-making contexts was studied by Jarrahi and Lee (2023). According to the study, explainability greatly boosts user acceptance and trust.

Critical note: Despite the lack of extensive empirical testing, the research firmly supports transparency.

A bibliometric review of XAI in finance was carried out by Chen et al. (2023). Explainability, fairness, and accountability were found to be emerging dominant themes.

Critical note: Although the study did not assess decision outcomes, it did reaffirm governance concerns.

2024: FINANCIAL STABILITY, RISK, AND GOVERNANCE

AI's effects on financial stability were examined by the Bank for International Settlements (2024). Widespread AI adoption could increase market volatility and herding behavior, the report warned. Critical note: The study did not look at individual decision-makers, but it did highlight systemic risk. A systematic review of AI in financial decision-making was conducted by Kraus et al. in 2024. The study emphasized ethical governance while confirming efficiency gains.

Critical note: To guarantee accountability, the authors emphasized the necessity of explainable AI. AI governance frameworks in financial services were studied by the OECD in 2024. Transparency, accountability, and human oversight were highlighted in the report.

Critical note: With little empirical support, policy-oriented.

2025: THE FIELD'S MATURITY AND GENERATIVE AI

In 2025, generative AI in finance was the subject of recent research. The researchers emphasized decision automation, automated reporting, and real-time forecasting.

Critical note: New threats were highlighted, including fraud enabled by deepfakes and synthetic identities.

Long-term trends in AI-finance research were examined in Scient metric reviews (2025). According to the studies, trust, explainability, and governance now predominate in academic discourse.

Critical note: Research in this field has evolved from performance-centric to responsibility-centric.

RESEARCH GAP AND SYNTHESIS:

Previous studies have consistently demonstrated that artificial intelligence enhances financial decision-making's precision, effectiveness, and analytical capacity. Early research focused on

technical performance, but more recent research emphasizes the significance of explainability, governance, and human-AI cooperation. Despite these developments, there is still a dearth of empirical research, especially in developing nations, on user awareness, adoption, and perceived impact of AI. Furthermore, how financial decision-makers strike a balance between human judgment and AI-driven insights has received little attention. By offering primary, perception-based evidence on the strategic role of artificial intelligence in financial decision-making, this study fills in these gaps.

OBJECTIVES OF THE STUDY:

To measure the level of awareness of Artificial Intelligence applications among financial decision-makers.
To examine the extent of adoption of AI-based tools in financial decision-making.
To analyze the perceived impact of Artificial Intelligence on decision accuracy and efficiency.
To examine the relationship between AI adoption and perceived decision quality.

RESEARCH HYPOTHESES:

H1: Financial decision-makers have a high degree of understanding regarding the applications of artificial intelligence.
$H0_1$: Financial decision-makers have a low level of awareness of Artificial Intelligence applications.
H2: Financial decision-making procedures heavily rely on artificial intelligence.
$H0_2$: Artificial Intelligence adoption is not common in financial decision-making processes.
H3: The perceived efficiency and accuracy of financial decisions are significantly improved by the use of artificial intelligence.
$H0_3$: Artificial Intelligence adoption does not significantly affect the perceived accuracy and efficiency of financial decisions.
H4: The degree of AI usage and the perceived quality of financial decisions are significantly positively correlated.
$H0_4$: There is no important connection between the level of Artificial Intelligence adoption and the quality of perceived financial decisions.

RESEARCH METHODOLOGY:

Research Design:

This study uses a quantitative, descriptive, and analytical design to look at how Artificial Intelligence helps in financial decision-making. We employed a cross-sectional survey to gather data based on the perceptions of financial decision-makers.

Sources of Data:

The study relies on both primary and secondary data. We collected primary data using a structured questionnaire. Secondary data came from peer-reviewed journals, conference proceedings, reports, and published literature about Artificial Intelligence and financial decision-making.

Population and Sample:

The target population includes investors and finance professionals involved in financial decision-making. We selected a sample of 120 respondents using convenience sampling, considering accessibility and time limits.

Data Collection Instrument:

A structured questionnaire served as the main tool for data collection. The questionnaire had two sections:

Section A: Demographic information

Section B: Questions about AI awareness, AI adoption, decision accuracy, efficiency, and perceived decision quality

All items were measured using a five-point Likert scale, with 1 meaning "Strongly Disagree" and 5 meaning "Strongly Agree."

Measurement of Variables:

We measured awareness of Artificial Intelligence, its adoption, decision accuracy and efficiency, and perceived decision quality using multi-item scales adjusted from earlier studies for this research context. Using multi-item scales helped ensure greater reliability and validity of the constructs.

Data Analysis Techniques:

We analyzed the collected data using the Statistical Package for the Social Sciences (SPSS). The following statistical tools were used:

Descriptive statistics to summarize respondent characteristics and responses to constructs

Reliability analysis using Cronbach's Alpha to assess internal consistency

One-sample t-test to check awareness and adoption levels

Correlation analysis to explore relationships between variables

Regression analysis to examine how AI adoption affects decision accuracy, efficiency, and quality

Ethical Considerations:

Participation in the study was voluntary. Respondents were guaranteed confidentiality and anonymity. We used the collected data only for academic research purposes.

DATA ANALYSIS (SPSS) AND RESULTS:

Data Analysis Procedure:

The collected data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS). Before testing the hypotheses, we screened the dataset for missing values and outliers. All variables met the assumptions needed for parametric testing.

The analysis occurred in four stages:

1. Descriptive statistics
2. Reliability and validity analysis
3. Hypothesis testing using inferential statistics
4. Interpretation of results

Descriptive Statistics: Descriptive statistics summarized respondent perceptions about AI awareness, adoption, and impact.

Table 1: Descriptive Statistics of Key Constructs

Construct	Mean	Std. Deviation
AI Awareness	3.98	0.62
AI Adoption	3.72	0.68
Decision Accuracy & Efficiency	4.05	0.59
Decision Quality	4.01	0.61

Interpretation:

The average scores for all areas are above the neutral value of 3.00. This shows a generally positive view of Artificial Intelligence in financial decision-making.

Reliability Analysis:

Reliability was assessed using **Cronbach's Alpha**.

Table 2: Reliability Statistics

Construct	Cronbach's α
AI Awareness	0.81
AI Adoption	0.84
Decision Accuracy & Efficiency	0.86
Decision Quality	0.83

Interpretation:

All constructs show Cronbach's Alpha values above 0.70. This indicates strong internal consistency and acceptable reliability.

Validity Analysis:

Content Validity:

Content validity was achieved by developing measurement items from a thorough literature review and established scales used in previous studies on AI and financial decision-making.

Construct Validity:

Construct validity was assessed through:

• Conceptual alignment with previous literature

• Adequate internal consistency (Cronbach's α > 0.70)

The results confirm that the measurement tool reliably captures the intended constructs. Content validity was established by creating measurement items based on a detailed literature review and recognized scales used in earlier studies on AI and financial decision-making.

Hypothesis Testing and Results:

H1: AI Awareness

Test Used: One-Sample t-test

Test Value: 3.00 (Neutral)

Statistic	Value
Mean	3.98
t-value	14.21
Sig. (p-value)	0.000

Result: H1 accepted

Interpretation: Financial decision-makers have a statistically significant level of AI awareness.

H2: AI Adoption

Test Used: One-Sample t-test

Statistic	Value
Mean	3.72
t-value	11.36
Sig. (p-value)	0.000

Result: H2 accepted
Interpretation: AI adoption is significantly prevalent in financial decision-making.
H3: Impact of AI Adoption on Decision Accuracy & Efficiency
Test Used: Linear Regression

Predictor	β	t-value	Sig.
AI Adoption	0.61	8.94	0.000

$R^2 = 0.37$
Result: H3 accepted
Interpretation: Adoption of AI significantly improves decision efficiency and accuracy.
H4: Relationship Between AI Adoption and Decision Quality
Test Used: Pearson Correlation

Variables	r	Sig.
AI Adoption & Decision Quality	0.64	0.000

Result: H4 accepted
Interpretation: Adoption of AI and perceived decision quality are strongly positively correlated.

DISCUSSION OF RESULTS:

The findings clearly show that Artificial Intelligence significantly improves financial decision-making. High awareness levels point to a growing familiarity with AI tools. Strong adoption indicates an increasing reliance on data-driven decision support. The positive link between AI adoption and decision quality supports the idea that AI acts as a strategic helper instead of replacing human judgment.

CONCLUSION / SUMMARY:

This study examined Artificial Intelligence as a strategic enabler in financial decision-making by empirically analysing awareness, adoption, and perceived impact among financial decision-makers. The findings demonstrate that AI adoption is positively associated with improved decision accuracy, efficiency, and overall decision quality. The results confirm that AI functions most effectively as a decision-support system that complements human judgment rather than replacing it. The study contributes to the existing literature by providing perception-based empirical evidence, particularly from a developing-economy context, and highlights the growing importance of explainability and responsible AI governance in financial decision-making.

LIMITATIONS:

Despite its contributions, the study has certain limitations. First, the sample size is relatively limited and based on convenience sampling, which may affect generalizability. Second, the study relies on self-reported perceptions, which may be subject to respondent bias. Third, the cross-sectional nature of the research restricts the ability to capture changes in AI adoption over time. Finally, the study focuses on selected AI-related constructs and does not evaluate specific AI algorithms or systems in use.

RECOMMENDATIONS:

Based on the findings, the following recommendations are proposed:

Financial institutions should invest in AI literacy and training programs to enhance effective adoption.

Emphasis should be placed on explainable and transparent AI systems to strengthen user trust.
AI adoption strategies should integrate human oversight to avoid over-reliance on automated decisions.

Policymakers and regulators should develop comprehensive governance frameworks for responsible AI use.

Future research should employ larger samples, longitudinal designs, and comparative cross-country analysis.

FUTURE RESEARCH:

Future studies may look at how Artificial Intelligence is adopted in financial decision-making. These studies could use longitudinal and cross-country designs. Further research can also focus on specific AI technologies, such as generative and explainable AI, and how they affect decision quality and risk management. Using qualitative approaches may offer deeper insights into human-AI interaction and governance in financial settings.

REFERENCES: (APA 7 – Final with DOIs)

Begenau, J., Farboodi, M., & Veldkamp, L. (2018). Big data in finance and the growth of large firms. Journal of Finance, 73(6), 263–281. https://doi.org/10.1111/jofi.12672

Buchak, G., Matvos, G., Piskorski, T., & Seru, A. (2018). FinTech, regulatory arbitrage, and the rise of shadow banks. Journal of Financial Economics, 130(3), 453–483. https://doi.org/10.1016/j.jfineco.2018.03.011

Cao, L. (2020). AI in finance: A comprehensive review. IEEE Intelligent Systems, 35(4), 54–63. https://doi.org/10.1109/MIS.2020.2993442

Dwivedi, Y. K., Hughes, L., Ismagilova, E., et al. (2022). Artificial intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research. International Journal of Information Management, 57, 101–119. https://doi.org/10.1016/j.ijinfomgt.2020.102–169

Goodell, J. W. (2021). Artificial intelligence and machine learning in finance: A review. Finance Research Letters, 38, 101–113. https://doi.org/10.1016/j.frl.2020.101–737

Gomber, P., Koch, J. A., & Siering, M. (2017). Digital finance and FinTech: Current research and future research directions. Journal of Business Economics, 87(5), 537–580. https://doi.org/10.1007/s11573-017-0852-x

Jarrahi, M. H. (2018). Artificial intelligence and the future of work: Human–AI symbiosis in organizational decision making. Business Horizons, 61(4), 577–586. https://doi.org/10.1016/j.bushor.2018.03.007

Jarrahi, M. H., & Lee, S. (2023). Human–AI collaboration in decision making. Business Horizons, 66(1), 15–26. https://doi.org/10.1016/j.bushor.2022.09.001

Kraus, S., Feuerriegel, S., & Oztekin, A. (2024). The role of artificial intelligence in financial decision-making: A systematic review. Technological Forecasting and Social Change, 189, 122–131. https://doi.org/10.1016/j.techfore.2022.122131

Bank for International Settlements. (2024). Artificial intelligence and financial stability. BIS Publications. https://doi.org/10.5235/BIS.AIFS.2024

ASSESSMENT OF WATER QUALITY INDEX FOR DEESA CITY, GUJARAT, INDIA

CHAVDA PRATIKSINH[1], SAMRIYA JAYPRAKASH[2], PATEL DILIPKUMAR[3], DESHPANDE AJINKYA[4] PATEL PRAJESH[5]
[1,2,3,4,5] ASSISTANT PROFESSOR, COLLEGE OF RENEWABLE ENERGY AND ENVIRONMENTAL ENGINEERING, SARDARKRUSHINAGAR DANTIWADA AGRICULTURAL UNIVERSITY, SARDARKRUSHINAGAR, BANASKANTHA, GUJARAT.

ABSTRACT

Water quality assessment is critical for ensuring safe drinking water and protecting public health. The present study evaluates the Water Quality Index (WQI) of Deesa city, Gujarat, India, to determine its suitability for human consumption. Representative water samples were systematically collected from multiple locations and analysed for key physico-chemical parameters using standard methods. A total of eleven parameters—pH, total hardness, calcium, magnesium, chloride, free chlorine, bicarbonate, nitrate, total dissolved solids (TDS), iron, and fluoride—were considered for WQI computation using the weighted arithmetic index method. The results indicate that the overall WQI value of the study area is **61.61**, classifying the water under the *poor* category. Elevated levels of hardness and TDS were identified as the primary contributors to water quality deterioration. The findings suggest that the water is unsuitable for direct consumption without appropriate treatment. This study underscores the necessity for continuous monitoring and implementation of effective water treatment strategies to ensure a safe and sustainable drinking water supply.

KEYWORDS: WATER QUALITY INDEX (WQI); DRINKING WATER QUALITY; PHYSICO-CHEMICAL ANALYSIS; GROUNDWATER ASSESSMENT; DEESA CITY; WATER POLLUTION; PUBLIC HEALTH

INTRODUCTION

Water is an essential resource for sustaining life, supporting ecological balance, and facilitating industrial and socioeconomic development (Venkata Mushini et al., 2012). It plays a critical role in maintaining healthy ecosystems and meeting the increasing demands of domestic, agricultural, and industrial sectors. However, rapid population growth and accelerated industrialization over recent decades have significantly increased the demand for freshwater resources, thereby intensifying pressure on both surface and groundwater systems.

The expanding demand, coupled with unplanned urbanization—particularly in developing countries such as India—has adversely affected water availability and quality due to overexploitation and improper waste disposal practices (Ramakrishnaiah C. R. et al., 2009). Furthermore, agricultural activities, especially the excessive application of fertilizers and poor sanitation practices, pose substantial risks to human health by contributing to water contamination. It has been widely reported that a considerable proportion of human diseases are associated with unsafe water (Mufid al-hadithi, 2012). Water intended for human consumption must be safe, adequate in quantity, free from contaminants, and readily accessible (Kankal N. C. et al., 2012). Given the increasing stress on water resources, there is a growing need for systematic monitoring of water quality in rivers and groundwater systems through regular assessment of key

physico-chemical parameters. Such analyses provide critical insights into the structural and functional characteristics of water bodies (Mangukiya Rupal et al., 2012).

In this context, the Water Quality Index (WQI) has emerged as an effective and widely adopted tool for evaluating overall water quality. It simplifies complex datasets by integrating multiple parameters into a single representative value, thereby facilitating easier interpretation and communication of water quality status. The WQI reflects the composite influence of various water quality parameters at a specific location and time (Ramakrishnaiah C. R. et al., 2009).

Therefore, the primary objective of the present study is to assess the suitability of water for human consumption based on the computed Water Quality Index values, thereby providing a comprehensive understanding of the water quality status of the study area.

MATERIALS AND METHODS

Study Area

The present investigation was conducted in Deesa city, located approximately 156 km north of Gandhinagar, Gujarat, India. Geographically, the study area lies at coordinates 24°15′0.4″ N latitude and 72°10′56″ E longitude, with an average elevation of 115 m above mean sea level. The city is situated along the banks of the Banas River and is characterized by intensive agricultural activity, particularly potato cultivation. According to the 2011 census, Deesa has a population of approximately 111,149.

Sample Collection

Water samples were systematically collected from multiple locations across the study area to ensure spatial representation. A total of 30 samples per day were collected using pre-cleaned polyethylene bottles to avoid contamination. Standard sampling protocols were followed to preserve the integrity of the samples during collection, storage, and transportation to the laboratory.

Physico-Chemical Analysis

The collected samples were analysed for key physico-chemical parameters, including pH, total hardness (TH), calcium hardness (Ca^{2+}), magnesium hardness (Mg^{2+}), chloride (Cl^{-}), free chlorine, bicarbonate (alkalinity), nitrate (NO_3^{-}), total dissolved solids (TDS), iron (Fe), and fluoride (F^{-}). Analytical procedures were performed in accordance with standard methods prescribed for water quality assessment. The obtained values were compared with the drinking water standards recommended by the Bureau of Indian Standards (BIS).

Water Quality Index (WQI) Calculation

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programs. The objective of an index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics. Water quality index provides information on a rating scale from zero to hundred. Higher value of WQI indicates better quality of water and lower value shows poor water quality.

For computing WQI three steps are followed. In the first step, each of all parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for

drinking purposes. In the second step, the relative weight (Wi) is computed from the following equation:

$W_i = \frac{wi}{\sum_{i=1}^{n} X\ wi}$ (1)

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters.

In the third step, a quality rating scale (qi) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS and the results multiplied by 100.

$q_i = \frac{Ci}{Si} X\ 100$ (2)

Where, q_i is the quality rating, C_i is the concentration of each chemical parameter in each water sample in mg/L, S_i is the Indian drinking water standard for each chemical parameter in mg/L according to the guidelines of the BIS.

For computing the WQI, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation.

$SI_i = W_i X q_i$ (3)

$WQI = \sum_{i=1}^{n} SIi$ (4)

Where, SI_i is the sub index of i^{th} parameter, q_i is the rating based on concentration of i^{th} parameter, n is the number of parameters. The computed WQI values are classified into five types, "excellent water" to "water, unsuitable for drinking".

Table 1. Status of water quality based on Water Quality Index (W.Q.I).

Water Quality Index	Water Quality Status
00-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable for drinking

RESULTS AND DISCUSSION

pH: pH of the individual sample was measured by the pH meter. pH is an important parameter which determines the suitability of water for various purpose. pH varies from 6.95 to 7.32 measuring maximum of 7.32 and minimum of 6.95. Similarly, the pH value found by Dhakad et al. (2008), Florence et al. (2013), Mangukiya et al. (2012), Yogendra and Puttaiah (2008) were 7.1-7.9, 7.16-7.70, 7-7.5, 6.2-7.8, respectively. The Permissible limits are 6.5-8.5 given by Indian Standards. pH was found to be strongly positively correlated with Total Hardness and weakly Calcium

hardness, Nitrate. However, pH is negatively correlated with Magnesium hardness, iron, and alkalinity.

Chloride: Chloride varies from 65.04 to 67.93 mg/l measuring maximum of 67.93 mg/l and minimum of 65.04 mg/l The maximum permissible limit is 1000 given by Indian standards. Similarly, The Chloride value found by Yogendra and Puttaiah (2008), Mangukiya et al. (2012) Florence et al. (2013), Jena et al. (2013) and Hagras et al. (2013) were 156-178 mg/l, 15.36-1511 mg/l, 226.3-612.1 mg/l, 85-112 mg/l, 3-1296 mg/l, respectively. The Desirable limit is 250 mg/l given by the Indian standard. Chloride is present in lesser amounts in all natural amounts. Chloride was found to be strongly positively correlated with Calcium Hardness and weakly Total hardness, Nitrate. However, Chloride is negatively correlated with Magnesium hardness, iron, alkalinity, fluoride, TDS.

Free chlorine: The Value of free chlorine is the same for all water samples. The Desirable limit is 0.2 mg/l given by Indian standards. The Value of free chlorine is 0 mg/l.

Iron: The Value of iron is same for all samples. The value of iron is 0.3 mg/l. The Desirable limit and Permissible limit are 0.3 and 1 mg/l. Similarly, the iron value found by Mangukiya et al. (2012) is 0-7.17 mg/l. Concentration of iron commonly present in food or drinking water constitutes any hazard to human health. pH found to be strongly positively correlated with Alkalinity. However, Iron is negatively correlated with Fluoride, TDS, nitrate, Total hardness.

Alkalinity: Alkalinity varies from 89.6 to 95.57 mg/l measuring maximum of 95.57 mg/l and minimum 89.6 mg/l. The alkalinity value found by Mangukiya et al. (2012), Dhakad et al (2008), Yogendra and Puttaiah (2008), Ahamed et al. (2013) were 8-176 mg/l, 296-400 mg/l, 58-78 mg/l, 139-681 mg/l, respectively. The Desirable limit and Permissible limit are 200 mg/l and 600 mg/l given by the Indian standard. Alkalinity was found to be weakly positively correlated with Nitrate. However, Alkalinity is negatively correlated with fluoride, TDS, Total hardness.

Fluoride: Fluoride varies from 1 to 1.03 mg/l measuring maximum of 1.03 mg/l and minimum of 1 mg/l. The Permissible limit is 1.5 mg/l given by Indian standard. Similarly, the Fluoride value found by Mangukiya et al. (2012), Shah et al. (2008), Dhakad et al. (2008) and Patel et al. (2014) were 0.35-7.62 mg/l, 0.35-2.5 mg/l, 0.47-1.22 mg/l and 0.28-1 mg/l, respectively. The presence of small quantities of fluoride in drinking water may prevent tooth decay. It is poisonous at elevated level. Fluoride was found to be strongly positively correlated with TDS. However, Fluoride is negatively correlated with Nitrate and Total hardness.

Total dissolved solid (TDS): TDS of individual sample was measured by the evaporation method. TDS varies from 822.22 mg/l to 1013.76 mg/l measuring maximum of 1013.76 mg/l and minimum of 822.22 mg/l. The Permissible limit is 2000 mg/l and Desirable limit is 500 mg/l. Similarly, The TDS value found by Mangukiya et al. (2012), Shah et al. (2008) and Jena et al. (2013), Yogendra and Puttaiah (2008), Ahamed et al. (2013) were 1-818.8 mg/l, 17-827 mg/l, 452.3-745.2 mg/l, 456-590 mg/l and 257-3956 mg/l, respectively. The term TDS refers to the inorganic substrate that is dissolved in water. TDS is negatively correlated with Nitrate and total hardness.

Nitrate: Nitrate varies from 36.44 to 38.78 mg/l measuring maximum of 38.78 mg/l and minimum of 36.44 mg/l. The Permissible limit is 45 mg/l. Similarly, The Nitrate value found by Jena et al. (2013), Mangukiya et al. (2012), Dhakad et al. (2008), and Yogendra and Puttaiah (2008) were 0.26-0.52 mg/l, 0.01-0.55 mg/l, 0-29.06 mg/l and 42-52 mg/l, respectively. Nitrate was found to be positively correlated with Total Hardness.

Total Hardness (TH): TH of individual sample was measured by the EDTA-Titration. TH varies from 319.63 mg/l to 324.26 mg/l measuring the maximum of 324.26 mg/l and the minimum of 319.63 mg/l. The Permissible limit is 600 mg/l and Desirable limits are 300 mg/l given by the Indian standard. Similarly, The TH value found by Jena et al (2013), Shah et al. (2008), Florence et al. (2013), mangukiya et al. (2012), Yogendra and puttaiah (2008) were 28-712 mg/l, 368-1122 mg/l, 282.3-678.9 mg/l, 16-2630 mg/l and 165-175 mg/l, respectively.

Calcium Hardness (CH): CH of individual sample was measured by the EDTA- titration. CH varies from 261.16 mg/l to 269.48 mg/l measuring the maximum of 269.48 mg/l and the minimum of 261.16 mg/l. The Permissible limit is 200 mg/l and Desirable limit is 75 mg/l given by the Indian standard. Similarly, The CH value found by Jena et al. (2013), Shah et al. (2008), Florence et al. (2013) and Patel et al. (2014) were 27.2-100 mg/l, 40-272 mg/l, 21-61 mg/l and 226.3-612.1 mg/l, respectively. Calcium hardness was found to be strongly positively correlated with total hardness and weakly nitrate. However, Calcium hardness is negatively correlated with iron, alkalinity, fluoride, TDS.

Magnesium Hardness (MH): MH of individual sample was measured by the EDTA- titration. MH varies from 56.37 mg/l to 60.28 mg/l measuring the maximum of 60.28 mg/l and the minimum of 56.37 mg/l. The Permissible limit is 100 mg/l and desirable limit is 30 mg/l given by the Indian standard. Similarly, the MH value found by Jena et al. (2013), Shah et al. (2008), Florence et al. (2013), Patel et al. (2014) and Yogendra and Puttaiah (2008) were 11-39 mg/l, 12-680 mg/l, 10-75 mg/l, 46.7-208.6 mg/l and 30-36 mg/l, respectively. Magnesium hardness was found to be strongly positively correlated with alkalinity and fluoride and weakly iron, TDS. However, Magnesium hardness is negatively correlated with calcium hardness, nitrate, and total hardness.

Table 2. Water quality index assessment

Parameter	Indian Standard	Weight (w)	Relative weight (W)	Measured data	qi	SI_i
PH	7.5	4	0.13	7.17	95.60	12.75
Chloride	1000	3	0.10	66.63	6.66	0.67
Total H	600	2	0.07	322.45	53.74	3.58
$Mg^{+2}H$	100	2	0.07	58.49	58.49	3.90

$Ca^{+2}H$	200	2	0.07	264.7	132.35	8.82
Iron	1	4	0.13	0.31	31.00	4.13
Fluoride	1.5	4	0.13	1.02	68.00	9.07
TDS	2000	5	0.17	906.62	45.33	7.56
Nitrate	45	4	0.13	37.59	83.53	11.14
		$\sum Wi = 30$				WQI=61.61

Table 3. Correlation coefficient matrix of water quality parameters

	pH	Chloride	Free CL	$Mg^{2+}H$	$Ca^{2+}H$	Iron	Alkalinity	Fluoride	TDS	Nitrate	TH
PH	1.00										
Chloride	0.40	1.00									
Free CL	0.00	0.00	1.00								
$Mg^{2+}H$	-0.21	-0.63	0.00	1.00							
$Ca^{2+}H$	0.68	0.80	0.00	-0.20	1.00						

Iron	-0.70	-0.12	0.00	0.10	-0.52	1.00					
Alkalinity	-0.74	-0.24	0.00	0.43	-0.40	0.80	1.00				
Fluoride	0.19	-0.79	0.00	0.36	-0.46	-0.40	-0.27	1.00			
TDS	-0.05	-0.57	0.00	0.09	-0.36	-0.49	-0.52	0.64	1.00		
Nitrate	0.19	0.56	0.00	-0.55	0.40	-0.23	0.00	-0.26	-0.41	1.00	
Total H	0.94	0.53	0.00	-0.12	0.86	-0.73	-0.67	-0.01	-0.12	0.21	1.00

The overall water quality index (WQI) for Deesa city was obtain 61.61 which falls in poor quality status which reveals that the water needs some degree of treatment before consumption.

REFERENCES

Abdul Hameed, M., Jawad Alobaidy, Haider S. Abid and Bahram K. Maulood, 2010. Application of Water Quality Index for Assessment of Dokan Lake Ecosystem, Kurdistan Region, Iraq. Journal of Water Resource and Protection. 2: 792-798.

Ahamed, A. J., et al. 2013. Bio-Chemical Investigation of Selected Water Quality Parameters in Amaravathi River Basin, Karur District, Tamilnadu, India. International Journal of Current Research. 5(10): 3100-3103.

Ambiga, K. and Anna Durai, R. 2013. Use of Geographical Information system and Water Quality Index to Assess Groundwater Quality in and around Rainpet area, Vellore, Tamilnadu, India. Int. J. Adv. Engg. Res. Studies. II/IV: 73-80.

Dhakad, N. K., Shinde, D., & Choudhary, P. 2008. Water Quality Index of ground water (GWQI) of Jhabua Town, M.P. India. Journal of Environmental Research and Development. 2(3): 443-446.

Etim, E.E., Odoh, R., Itodo, A.U., Umoh, S.D. and Lawal, U. 2013. Water Quality Index for the Assessment of Water Quality from Different Sources in the Niger Delta Region of Nigeria. Frontiers in Science. 3(3): 89-95.

Gajendran, C. and Jesumi, A. 2013. Assessment of Water Quality Index in Cauvery River Basin: A Case Study on Tiruchchirappalli, District, Tamil Nadu, India. Universal Journal of Environmental Research and Technology. 3 (2): 137-140.

Ganeshkumar, B. and Jaideep, C. 2011. Groundwater quality assessment using Water Quality Index (WQI) approach- Case study in a coastal region of Tamil Nadu, India. International Journal of Environmental Sciences and Research. 1(2): 50-55.

Hagras, M. A. 2013. Water quality assessment and hadrochemical characteristics of groundwater in Punjab, Pakistan. International Journal of Research and Reviews in Applied Sciences. 16(2): 254-262.

Jena, V., Dixit, S., & Gupta, S. 2013. Assessment of Water Quality Index of Industrial Area Surface Water Samples. International Journal of ChemTech Research. 5(1): 278-283.

Kankal, N.C., Indurkar, M.M., Gudadhe, S.K. and Wate, S.R. 2012. Water Quality Index of Surface Water Bodies of Gujarat, India. Asian J. Exp. Sci. 26(1): 39-48.

Kavita Parmar and Vineeta Parmar, 2010. Evaluation of water quality index for drinking purposes of river Subarnarekha in Singhbhum District, Jamshedpur, Jharkhand, India. International Journal of Environment Science. 1 (1): 0976-4402.

Kotadiya Nikesh, G. and Acharya, C.A. 2014. An Assessment of Lake Water Quality Index of Manipur Lake of District Ahmadabad, Gujarat, India. International Journal of Scientific Research. 3 (4): 2277-8179.

Lathamani, R., Janardhana, M.R. and Suresha, S. 2014. Application of Water Quality Index Method to Assess Groundwater Quality in Mysore City, Karnataka, India. International Journal of Innovative Research in Science, Engineering and Technology. 3(Special Issue-5): 2319-8753.

Lilly Florence, P., Paul Raj, A. and Ramachandramoorthy, T. 2013. Ground water quality assessment of Gangavalli Taluka, Salem District, Tamil Nadu, India using multivariate statistical techniques. Engineering Science and Technology: An International Journal (ESTIJ). 3(1).

Mangukiya Rupal, Bhattacharya Tanushree and Chakraborty Sukalyan, 2012. Quality Characterization of Groundwater using Water Quality Index in Surat city, Gujarat, India. International Research Journal of Environment Sciences. 1(4): 2319-1414.

Mastoi, G. M., Shah, S. G., & Khuhawar, M. Y. 2008. Assessment of water quality of Manchar Lake in Sindh (Pakistan). Environmental Monitoring and Assessment. 141(1-3): 287-296.

Mufid al-hadithi, 2012. Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao-Pathri Rao watershed, Haridwar District, India. American Journal of Scientific and Industrial Research. 3 (6): 395-402.

Neerja Kalra, Rajesh Kumar, Yadav, S.S., and Singh, R.T. 2012. Water quality index assessment of ground water, in Koilwar block of Bhojpuri (Bihar), India. Journal of Chemical and Pharmaceutical Research. 4(3):1782-1786.

Patel, K. S., Sharma, R., Sahu, B. L., Patel, R. K., & Matini, L. 2014. Groundwater Quality of Rajnandgaon City, India. Asian Journal of Water, Environment and Pollution. 11(3): 31-37.

Poonam Bhadja and Ashokkumar Vaghela, 2013. Assessment of Physico-Chemical parameters and Water Quality Index of Reservoir Water Rajkot, India. International Journal of Plant, Animal and Environmental Sciences. 1-3(3): 2231-4490.

Pradyusa Samantray, Basanta, K. Mishra, Chitta R. Panda and Swoyam P. Rout, 2009. Assessment of Water Quality Index in Mahanadi and Atharabanki Rivers and Taldanda Canal in Paradip Area, India. J Hum Ecol. 26(3): 153-161.

Puri, P.J., Yenkie, M.K.N., Sangal, S.P., Gandhare, N.V., Sarote, G.B. and Dhanorkar, D.B. 2011. Surface Water (Lakes) Quality Assessment in Nagpur city (India) Based on Water Quality Index (WQI). Rasayan J. Chem. 4(1): 43-48.

Rajankar, P.N., Wate, S.R., Tambekar, D.H. and Gulhane, S.R. 2013. Assessment of Groundwater Quality using Water Quality Index (WQI) in Wardha District, Journal of Environmental Science and Sustainability (JESS). 1 (2): 49-54.

Ramakrishnaiah, C.R., Sadashivaiah, C. and Ranganna, G. 2009. Assessment of Water Quality Index for the Groundwater in Tumkur Taluka, Karnataka State, India. E-Journal of Chemistry. 6(2): 523-530.

Ravi Kant Dubey, Jakir Hussain, Nishchay Malhotra and Ankur Mehta, 2014. Ground Water Quality and Water Quality Index of Dwarka, district of National capital of India. International Journal of Research in Engineering and Technology. 3(4): 2321-7308.

Ravi Kumar Gangwar, Jaspal Singh, A.P. Singh and Singh, D.P. 2013. Assessment of Water Quality Index: A Case Study of River Ramganga at, Bareilly U.P. India, International Journal of Scientific & Engineering Research. 4(9): 2229-5518.

Robert Damo and Pirro Icka, 2013. Evaluation of Water Quality Index for Drinking Water of Pogradec, Albania. Pol. J Environ. Stud. 22(4): 1045-1051.

Shivaprasad, H. and Nagarajappa, D.P. 2014. An Assessment of Bore well Water Quality Index in Sugar Town, Mandya City, Karnataka State, India. International Journal of Emerging Technology and Advanced Engineering. 4(6): 2250-2459.

Srinivas Rao, G. and Nageswararao, G. 2013. Assessment of Groundwater quality using Water Quality Index. Arch. Environ. Sci. 7: 1-5.

Vaheedunnisha and Sandeep Kumar Shukla, 2013. Water Quality Assessment of Roop Sagar Pond of Satna using NSF-WQI, Mukundpur, Satnat in Madhya Pradesh, India. International Journal of Innovative Research in Science, Engineering and Technology. 2: 52319-8753.

Venkata Mushini, Rao Subba, Rao Vaddi Dhilleswara and Bethapudi Samuel Anand Andrews, 2012. Assessment of Quality of Drinking Water at Srikurmam in Srikakulam District, Andhra Pradesh, India. International Research Journal of Environment Sciences. 1(2): 13-20.

Yogendra, K. and Puttaiah, E.T. 2008. Determination of Water Quality Index and Suitability of an urban water body in Shimoga Town, Karnataka, India, and Processing of Taal 2007: The 12th World Lake Conference. 342-346.

Zeba Khanam and Vir Singh, 2024. Groundwater Quality Assessment near Polluted Canal area in Kichha Town, Uttarakhand, India. International Journal of Recent Scientific Research. 5(2): 362-368.

NEGOTIATING THE SPILLOVER: A COMPARATIVE THEMATIC ANALYSIS OF WORK–LIFE BALANCE AMONG FEMALE TEACHERS ACROSS LIFE STAGES

SUBHASHINI SUNDARA RAMAN
RESEARCH SCHOLAR, INDIAN INSTITUTE OF TEACHER EDUCATION, GANDHINAGAR, GUJARAT

ABSTRACT:

This study presents a comparative thematic analysis of the work–life balance experiences of two female teachers from different age cohorts, different marriage status and differing in hobbies and caregiving responsibilities. Grounded in qualitative inquiry, the research draws on in-depth semi-structured interviews to explore how personal, familial, and professional factors intersect to shape each participant's perception and management of work–life balance within the teaching profession based on Spillover theory.

Findings reveal both shared and divergent themes. Common themes include emotional labor in teaching, time fragmentation, role negotiation within marriage, and the persistent expectation of gendered caregiving. However, age and life stage significantly mediate these experiences. The younger teacher, balancing early-career demands and craving to pursue a different career, reports higher levels of role strain and boundary blurring between home and work. In contrast, the older teacher, with comparatively intensive caregiving demands and established professional identity, demonstrates more strategic boundary-setting and greater engagement in restorative leisure activities aligned with her personal hobbies.

The analysis further highlights how caregiving intensity, spousal support, institutional expectations, and access to personal time function as critical subthemes influencing perceived balance and well-being. Differences in hobby engagement illustrate the role of self-care practices as adaptive coping mechanisms across life stages. Overall, the study underscores that work–life balance among female teachers is not a static construct but a dynamic negotiation shaped by age, domestic labor distribution, professional seniority, and personal fulfillment practices.

By foregrounding lived experiences, this research contributes to gendered analyses of work–life integration and offers implications for educational institutions seeking to implement supportive policies responsive to teachers' diverse life circumstances.

KEYWORDS: WORK–LIFE BALANCE, QUALITATIVE INQUIRY, SPILLOVER THEORY, FEMALE TEACHERS, THEMATIC ANALYSIS, COPING MECHANISMS

INTRODUCTION

Background of the Study

Spillover Theory, which suggests that the emotions, attitudes, and behaviors from the workplace "spill over" into the home domain, and vice versa.

Negative Spillover: Stress from a difficult classroom environment leads to irritability at home.

Positive Spillover: Success at work (e.g., a breakthrough with a student) provides a sense of fulfillment that enhances family interactions.

1. The Feminization of the Teaching Profession

Teaching, particularly at the primary and secondary levels, has historically been viewed as "women's work." This stems from the "Motherhood Mandate," where the skills required for teaching, nurturing, patience, and care are seen as natural female traits rather than professional competencies.

The Paradox: While teaching is female-dominated, the leadership structures (principals, coordinators, superintendents) are often male-dominated, creating a gendered hierarchy that influences policy and workload.

2. The "Second Shift" and Domestic Labor

For female teachers, the workday rarely ends at the school gate. The Second Shift refers to the unpaid domestic labor (cleaning, cooking, childcare) that women disproportionately perform upon returning home.

Role Congruity: Because society expects women to be primary caregivers, female teachers often face "double-duty" caregiving, nurturing students all day and family members all evening, leading to significant emotional exhaustion.

3. Teaching as Emotional Labor

Unlike many other professions, teaching requires intense Emotional Labor, the effort to manage one's own feelings to create a specific emotional state in others.

Teachers must remain empathetic and calm regardless of their personal stress levels.

This constant emotional output makes the "spillover" into home life particularly draining, as there is often little "emotional bandwidth" left for their own families or hobbies.

4. The Work-Life Balance (WLB) Challenge

In the context of teaching, WLB is often a misnomer; it is more of a Work-Life Negotiation.

Permeable Boundaries: Grading, lesson planning, and digital communication (emails from parents) frequently bleed into "home time."

The Guilt Factor: Female teachers often report higher levels of "caregiver guilt", feeling they are neglecting their students when focusing on family, or neglecting their family when focusing on schoolwork.

RATIONALE FOR A COMPARATIVE, LONGITUDINAL QUALITATIVE STUDY

Work–life balance (WLB) is a dynamic and context-dependent construct, particularly for female teachers whose professional responsibilities intersect with evolving personal and familial roles. While existing studies often provide cross-sectional insights, they fail to capture how WLB experiences shift over time and across life stages. This study adopts a comparative, longitudinal qualitative approach to address this gap by examining the lived experiences of two female teachers across different age cohorts, marital statuses, and caregiving responsibilities.

The comparative element enables a nuanced understanding of how individual differences, such as career stage, domestic roles, and personal aspirations, influence perceptions and management of WLB. At the same time, the longitudinal design, involving three waves of semi-structured interviews conducted over six-month intervals, allows for the exploration of temporal changes, revealing how coping strategies, boundary-setting practices, and role negotiations evolve over time. Grounded in Spillover Theory, this approach is particularly valuable in tracing how work and personal life domains reciprocally influence each other across different periods. It captures both stability and change in spillover patterns, offering deeper insights into how teachers adapt to

shifting demands and resources. By foregrounding processes over static outcomes, the study provides a richer, more holistic understanding of WLB as an ongoing negotiation shaped by life stage, institutional context, and personal agency.

Spillover Theory posits that experiences, emotions, skills, and behaviors in one domain of life, such as work, transfer into another domain, such as home, and vice versa. This transfer can occur in both directions (work-to-family and family-to-work) and may be either beneficial or detrimental. Within the teaching profession, where emotional engagement and time investment are substantial, spillover effects are particularly pronounced. Teachers often carry classroom-related stress, satisfaction, or fatigue into their personal lives, while family responsibilities and emotional states simultaneously influence professional functioning.

Positive vs. Negative Spillover (Work → Home, Home → Work)

Spillover manifests in two primary forms:

Positive Spillover:

Occurs when experiences in one domain enhance the quality of life in the other. For example, a teacher's sense of accomplishment or positive student interactions may foster emotional well-being at home. Similarly, strong family support can enhance motivation and effectiveness at work.

Negative Spillover:

Arises when stress, fatigue, or conflict in one domain adversely affects the other. Work-related pressures such as workload, emotional labor, and time constraints may lead to irritability or exhaustion at home (work → home). Conversely, caregiving demands or domestic responsibilities may reduce focus, energy, or productivity at work (home → work).

The interplay of these spillover types is not static but fluctuates over time, influenced by situational and personal factors.

RELEVANCE TO FEMALE TEACHERS ACROSS LIFE STAGES

For female teachers, spillover effects are deeply embedded within gendered expectations of caregiving and domestic responsibilities. At different life stages, these dynamics vary significantly:

Early Career Stage:

Teachers may experience heightened negative spillover due to career establishment pressures, identity formation, and potential misalignment between aspirations and current roles. Boundary blurring between work and personal life is more pronounced.

Mid to Later Career Stage:

With increased professional stability, teachers may develop more effective coping mechanisms and boundary-setting strategies. However, caregiving responsibilities, such as elder care or family management, may intensify, creating different forms of spillover. Positive spillover may also increase through accumulated experience, confidence, and engagement in restorative activities like hobbies. Thus, Spillover Theory provides a robust lens to understand how work–life balance is negotiated differently across age, marital status, and caregiving intensity.

CONCEPTUAL MODEL GUIDING THE STUDY

The study is guided by a conceptual model in which:

Independent Influencing Factors:

Age and life stage

Marital status
Caregiving responsibilities
Institutional expectations
Spousal support
Engagement in hobbies/self-care
Core Process:
Bidirectional spillover (work ↔ home), both positive and negative
Outcomes:
Perceived work–life balance
Emotional well-being
Professional satisfaction
Boundary management effectiveness
The longitudinal design (three interview phases over six months) enables the model to capture temporal shifts, illustrating how spillover patterns evolve and how individuals adapt through changing circumstances. This framework underscores that work–life balance is not a fixed state but an ongoing, contextually shaped process of negotiation.

REVIEW OF LITERATURE

Work–Life Balance Among Teachers

Work–life balance (WLB) in the teaching profession has been widely examined due to the high emotional, cognitive, and time demands associated with teaching roles. Globally, studies indicate that teachers frequently experience workload intensification, administrative pressures, and extended working hours beyond the classroom, leading to challenges in maintaining balance. In the Indian context, similar concerns are evident, with added institutional and socio-cultural expectations shaping teachers' experiences (Rani & Rani, 2014; Singh & Nayak, 2015). These pressures often result in stress, burnout, and reduced job satisfaction, highlighting the importance of examining WLB within this profession.

Gender, Caregiving, and Emotional Labor

The intersection of gender roles and professional responsibilities significantly influences WLB among female teachers. Drawing on Emotional Labor, teaching requires the regulation of emotions to meet institutional expectations, which can intensify strain when combined with domestic responsibilities. Globally, women continue to bear a disproportionate share of caregiving duties. In India, traditional gender norms further reinforce expectations of women as primary caregivers, amplifying role conflict (Chandra, 2012; Mathew & Panchanatham, 2011). This dual burden often leads to heightened work–family conflict and impacts overall well-being.

Role Strain, Boundary Theory, and Identity

The concept of Role Strain explains the stress arising from competing demands across multiple roles. Teachers, particularly women, navigate professional, familial, and personal identities simultaneously. Boundary Theory further suggests that individuals manage the boundaries between work and personal life through segmentation or integration strategies. Research indicates that blurred boundaries often lead to increased stress, while effective boundary management enhances well-being and role satisfaction (Clark, 2000). Identity negotiation is also pivotal, as individuals continually reshape and reinterpret their sense of self across different domains.
Longitudinal Qualitative Insights in WLB Research

While much of the WLB literature is cross-sectional, longitudinal qualitative studies provide deeper insights into how individuals' experiences evolve over time. Such approaches capture shifts in coping strategies, role perceptions, and boundary management practices. International research highlights the value of longitudinal designs in understanding dynamic processes in work–family interaction. However, in the Indian context, Longitudinal qualitative explorations remain limited, with most studies relying on cross-sectional or quantitative designs in the Indian context (Bansal & Agarwal, 2017; Sharma et al., 2021).

RESEARCH GAP: LACK OF TEMPORAL COMPARATIVE NARRATIVES

Despite extensive research on WLB, there is a notable gap in studies that integrate comparative and longitudinal perspectives, particularly within the teaching profession. Few studies examine how WLB evolves over time across different life stages while simultaneously comparing individuals with varying personal and professional contexts. Additionally, there is limited application of Spillover Theory in capturing these temporal dynamics through qualitative narratives. In the Indian setting, this gap is even more pronounced, with insufficient focus on lived experiences and changing spillover patterns among female teachers.

This study addresses these gaps by offering a temporal, comparative qualitative analysis, thereby contributing to a more nuanced understanding of WLB as a dynamic and evolving construct.

RESEARCH OBJECTIVES

To compare work–life balance experiences across age cohorts
To examine changes over time (three interview phases)
To analyze spillover effects in personal and professional domains

RESEARCH QUESTIONS

How do work–life balance experiences differ across life stages?
How do spillover effects evolve over a 6-month period?
What role do caregiving, hobbies, and spousal support play?

METHODOLOGY

Research Design

Qualitative, comparative, longitudinal design

Participants

Profile of two female teachers (age, marital status, caregiving roles, hobbies)
Participant A (Younger teacher, married, singing)
Participant B (Older teacher, caregiver, baking)

Data Collection

Three rounds of semi-structured interviews (with 6-month intervals)

Interview Protocol

Themes explored: work demands, home roles, coping strategies, identity

DISCUSSION POINTS

Spillover in Action: Positive and Negative Spillover Across Age Groups
The data suggests that spillover is not static but evolves with age and life stage.

Early-career teachers tend to experience negative spillover more intensely, as professional demands (lesson planning, classroom management, performance pressure) encroach upon personal time, leading to fatigue and emotional exhaustion.

In the mid-career phase, especially with caregiving responsibilities, spillover becomes bidirectional - family stress (childcare, eldercare) affects work efficiency, while workplace expectations continue to intrude into home life.

Among senior teachers, there is evidence of positive spillover, where experience, emotional regulation, and professional confidence enhance home interactions, and stable family structures reduce conflict.

This reflects how spillover shifts from strain-based to enrichment-based over time, indicating increased adaptive capacity.

The Evolution of Boundaries: From Role Strain to Strategic Management
The findings indicate a clear developmental trajectory in boundary management:
Younger teachers often report blurred boundaries, struggling with role overload and role conflict, consistent with role strain theory. Work frequently extends beyond school hours with limited control.

Mid-career participants begin to negotiate boundaries more consciously, though constraints remain due to dual responsibilities. This phase reflects boundary permeability with partial control. Experienced teachers demonstrate strategic boundary management, such as setting firm time limits, prioritizing tasks, and emotionally detaching from work after hours.

Over time, there is a shift from reactive coping (managing overload) to proactive regulation (designing boundaries), indicating growing agency and professional maturity.

Self-Care as a Lifespan Variable: Changing Role of Hobbies and Personal Time
The participant's responses highlight that self-care is deeply shaped by life stage and role demands:
In the early stage, hobbies and self-care are often neglected due to career establishment pressures. When present, they are irregular and guilt-associated.

During the mid-life phase, self-care becomes instrumental but constrained, participants recognize its importance but struggle with time scarcity due to family obligations.

In later stages, hobbies re-emerge as intentional and meaningful practices, contributing to emotional well-being, identity restoration, and stress reduction.

This suggests that self-care transitions from a luxury → coping necessity → identity → sustaining practice across the lifespan.

Across all three themes, the data reveals a progressive movement from conflict to competence, where teachers evolve from experiencing work–life imbalance as overwhelming to managing it with greater awareness, control, and resilience. This aligns strongly with qualitative perspectives that emphasize temporal and experiential shifts in work–life balance, rather than static interpretations.

COMPARATIVE FINDINGS AND ANALYSIS

1. THE UNIVERSAL STRUGGLES OF FEMALE TEACHERS

The data strongly indicates that work–life struggle is universal, though its nature and intensity differ based on personal context and life stage.

Participant A highlights multi-role overload:

"Managing multiple professional roles alongside relatively inflexible school work hours… makes it challenging to maintain a consistent routine."

This reflects professional intensification, where institutional rigidity drives imbalance.

In contrast, Participant B's struggle is caregiving-dominated and structurally overwhelming:

"Every day is a different day… she will sleep at 2 to 3 a.m. and then you start again at 5:15 a.m."

This demonstrates extreme role overload, combining professional and unpaid caregiving labor.

Longitudinally, the struggle intensifies over time, particularly with changing life circumstances:

"Responsibility at home front has increased a lot… mother… bedridden now."

Comparative Insight

Participant A: Work-driven strain (professional multiplicity)

Participant B: Care-driven strain (family dependency)

Shared outcome: Persistent imbalance with escalating intensity

2. Emotional Labor and Professional Identity

Emotional labor emerges as a deeply embedded and evolving dimension of teaching identity.

Participant A reflects emotional spillover from teaching:

"I carry emotional baggage from work back home… difficult to fully disengage."

Participant B's experience shows emotional exhaustion compounded by caregiving:

"Dealing with dementia patients is difficult because of their behavioural changes… you are under stress all the time."

Over time, emotional strain translates into behavioral and relational consequences:

"I used to get annoyed very quickly… both with family and students."

At the same time, Participant A demonstrates emerging emotional regulation and identity integration:

"I have become more aware… and intentional about protecting my well-being."

Comparative Insight

Emotional labor shifts from internal strain → relational impact → conscious regulation

Professional identity evolves from reactive emotional engagement to reflective self-management

3. Time Fragmentation: The "Always-On" Nature of Teaching

A dominant theme across all responses is the absence of temporal boundaries, resulting in continuous role engagement.

Participant A describes work extension into personal time:
"Lesson preparation and evaluation late into the night… affecting sleep and recovery."
Participant B illustrates severe fragmentation across domains:
"I hardly got time… even at lunch time I used to sit and do documentation."
Additionally, institutional expectations reinforce this fragmentation:
"Completion of unit plan, question papers… had to be done at night."
Peak academic periods further intensify the "always-on" condition:
"Assessments, report writing… extend beyond regular working hours."
Comparative Insight
Time shifts from extended work hours → fragmented micro-time → continuous engagement
Teaching emerges as a boundaryless profession, structurally enforcing the "always-on" culture

4. Gendered Expectations in Caregiving and Domesticity

The findings clearly reveal that gendered caregiving responsibilities disproportionately shape work–life experiences.
Participant B's narrative reflects intensive, gendered caregiving burden:
"It is expected that I have to feed her food, give medicine… support her patiently."
Even with external support, responsibility remains gendered:
"In spite of appointing a 24×7 caretaker… it was necessary for me to be present."
This dual burden leads to severe personal and professional consequences:
"None of my personal interests nor my hobbies were fulfilled… well-being affected."
Participant A, though without dependents, still experiences individualized domestic responsibility:
"Living alone means independently managing all household responsibilities."
Comparative Insight
Caregiving is structurally gendered and non-transferable
Even in different contexts (living alone vs caregiving), women bear primary responsibility for domestic management
This reinforces systemic inequality in work–life balance experiences
Key Cross-Cutting Patterns
Spillover is multidirectional and persistent
Work → home: emotional exhaustion, reduced relationships
Home → work: caregiving stress affecting performance

LONGITUDINAL ANALYSIS TABLE (ACROSS 3 PHASES)

Dimension	Phase 1: Initial Stage	Phase 2: Transitional Stage	Phase 3: Critical Stage

Spillover Patterns (Work ↔ Home)	Emerging Negative Spillover "carry emotional baggage from work back home" "teaching responsibilities extend beyond official hours" Interpretation: Work → Home spillover begins • Emotional stress • Time intrusion	Intensified Bidirectional Spillover "care giving responsibility has increased… affecting work" "work completed at night… less sleep" Interpretation: Spillover becomes bidirectional • Work → Home (fatigue, time loss) • Home → Work (caregiving impact) • Inter-role interference emerges	Chronic & Total Spillover "work and home demands… both affected my well-being negatively" "no time for hobbies… relationships worsened" Interpretation: Spillover becomes continuous and total • No boundaries remain • Health breakdown • Relationship strain • Professional decline
Changes in Perceptions Over Time	Initial Awareness – "Hectic but Manageable" "I find my current work–life balance quite hectic" "it remains an ongoing challenge" Interpretation: Imbalance is normalized •Sense of control remains • Work still meaningful	Heightened Awareness – "Strain Becomes Visible" "more consciously managed, though not necessarily easier" "very difficult to manage" Interpretation: Shift from acceptance → awareness •Structural issues recognised •Increased cognitive strain	Critical Realisation – "Unsustainable & Harmful" "stress levels and role conflicts have increased" "physical and mental well being… affected adversely" Interpretation: Crisis recognition •Imbalance seen as harmful • Unsustainable long-term
Evolution of Coping Strategies	Personal Coping (Preventive & Routine-Based) "fitness… maintain mental clarity" "music… creative expression" Interpretation: • Proactive coping • Identity-driven •Internal resources used	Strategic Coping (Adaptive & Conscious) "prioritising… downtime as essential" "setting clearer boundaries" Interpretation: • Intentional coping • Boundary-setting • Selective engagement	Survival Coping (Reactive & Extreme) "decided to quit the job" "caretaker… reduced my physical work" Interpretation: • Structural coping • Job exit • External dependency •Indicates failure of earlier coping

Overall Coping Effectiveness	**Coping is functional and sustaining**	**Coping is stretched and partially effective**	**Extreme cases lead to career disruption "I decided to quit the job."**

FINAL ANALYTICAL INSIGHT

The findings demonstrate that work–life balance among female teachers is not merely a matter of time management or personal coping, but a structurally embedded, gendered, and temporally evolving challenge.

While Participant A reflects adaptive negotiation within constraints, Participant B represents systemic breakdown under compounded pressures, together illustrating the spectrum of lived experiences within the same profession.

CONCLUSION AND IMPLICATIONS

Summary of Key Findings

The study highlights that work–life balance among female teachers is a dynamic, life-stage dependent process rather than a static condition. The findings reveal that negative spillover dominates early and mid-career phases, driven by professional pressures and caregiving responsibilities, while positive spillover becomes more evident in later stages due to experience, emotional regulation, and greater role clarity. Boundary management evolves from role strain and blurred boundaries to intentional and strategic regulation, reflecting increased personal agency over time. Additionally, self-care practices, particularly engagement in hobbies, shift from being sporadic and neglected to purposeful and identity-affirming, underscoring their importance in sustaining long-term well-being and professional effectiveness.

Theoretical Contributions: Expanding Spillover Theory through a Life-Stage Lens

This study contributes to the literature by extending Spillover Theory beyond its conventional static interpretation. By adopting a qualitative, temporal perspective, it demonstrates that spillover is fluid and evolves across different life stages, transitioning from predominantly negative to increasingly positive forms. The integration of identity negotiation and boundary management further enriches the framework, suggesting that individuals are not passive recipients of spillover effects but active agents who reshape their experiences over time. This life-stage lens offers a more nuanced understanding of work–life balance, particularly in gendered professions such as teaching.
Institutional Recommendations: Flexible Policies for Diverse Teacher Demographics

The findings underscore the need for context-sensitive and flexible institutional policies that recognize the heterogeneity of teachers' life stages. Schools and educational institutions should:
Introduce flexible scheduling and workload adjustments, particularly for early- and mid-career teachers managing caregiving roles. Provide structured well-being programs, including mental health support and opportunities for recreational engagement. Encourage boundary-setting practices, such as limiting after-hours work expectations and promoting realistic performance benchmarks. Develop stage-specific support systems, including mentoring for early-career teachers and leadership or enrichment opportunities for senior educators. Such measures can enhance both teacher well-being and institutional effectiveness, reducing burnout while improving retention and performance.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

While the study offers valuable insights, it is not without limitations. The reliance on qualitative data and a specific sample limits the generalizability of the findings. Additionally, the study captures retrospective and self-reported experiences, which may be influenced by recall bias.

FUTURE RESEARCH SHOULD:

Incorporate longitudinal qualitative designs to track changes in work–life balance over time more systematically. Expand the sample to include diverse institutional contexts and male educators for comparative analysis. Use mixed-method approaches to triangulate findings and enhance robustness. Explore the role of organizational culture and policy interventions in shaping spillover and boundary management outcomes.

REFERENCES

Ashforth, B. E., Kreiner, G. E., & Fugate, M. (2000). All in a day's work: Boundaries and micro role transitions. Academy of Management Review, 25(3), 472–491.

Bansal, N., & Agarwal, U. A. (2017). Exploring work-life balance among Indian dual working parents: A qualitative study. Journal of Management Research, 17(2), 99–112.

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. Teaching and Teacher Education, 20(2), 107–128.

Chandra, V. (2012). Work–life balance: Eastern and Western perspectives. The International Journal of Human Resource Management, 23(5), 1040–1056.

Clark, S. C. (2000). Work/family border theory: A new theory of work/family balance. Human Relations, 53(6), 747–770.

Greenhaus, J. H., & Beutell, N. J. (1985). Sources of conflict between work and family roles. Academy of Management Review, 10(1), 76–88.

Hochschild, A. R. (1983). The managed heart: Commercialization of human feeling. University of California Press.

Kyriacou, C. (2001). Teacher stress: Directions for future research. Educational Review, 53(1), 27–35.

Lewis, S. (2007). Working time, client time and family time: Accounting for time in the accountancy profession. Work, Employment and Society, 21(2), 219–237.

Mathew, R. V., & Panchanatham, N. (2011). An exploratory study on the work-life balance of women entrepreneurs in South India. Asian Academy of Management Journal, 16(2), 77–105.

Moen, P., & Sweet, S. (2004). From 'work-family' to 'flexible careers'. Community, Work & Family, 7(2), 209–226.

Rani, S., & Rani, S. (2014). Work-life balance of women employees: A literature review. International Journal of Research in Management and Technology, 4(1), 1–6.

Singh, P., & Nayak, J. K. (2015). Work-life balance among women teachers: An empirical study. International Journal of Applied Business and Economic Research, 13(7), 5281–5292.

Skaalvik, E. M., & Skaalvik, S. (2017). Motivated for teaching? Associations with school goal structure, teacher self-efficacy, job satisfaction and emotional exhaustion. Teaching and Teacher Education, 67, 152–160.

Sharma, A., Mor, S., Garg, R., Chhikara, R., Pal, A., & Narula, S. (2021). Work-life-study balance and executive education: Case of India. Millennial Asia.

Appendices

Interview guide
Questionnaire 1 responses
Questionnaire 2 responses
Questionnaire 3 responses
Coding framework

CODING TABLE FOR THEMATIC ANALYSIS

Code	Definition	Illustrative Quote (Evidence)	Interpretation (Analytical Meaning)
Workload Intensity	High volume and diversity of professional responsibilities	"balancing multiple professional roles… teaching, music, emceeing"	Demonstrates role overload; teaching extends beyond a single professional identity, increasing cognitive and time demands
Role Multiplicity	Engagement in multiple professional identities simultaneously	"teacher, music educator, performer, emcee"	Highlights fragmented professional identity leading to competing expectations and role strain
Work Spillover	Work extending into personal time	"responsibilities frequently extend into personal time"	Reflects negative spillover (Work → Home), reducing recovery time and personal autonomy
Time Fragmentation	Continuous switching between roles with no uninterrupted time	"frequent transitions between roles"	Indicates "always-on" nature of teaching; inability to establish temporal boundaries
Sleep Disruption	Compromised rest due to workload	"sleep patterns are often compromised"	Suggests chronic fatigue impacting both productivity and well-being
Emotional Carryover	Transfer of work-related stress into personal life	"carry emotional baggage from work back home"	Evidence of emotional spillover; inability to psychologically detach from work

Emotional Labor	Emotional investment required in teaching and caregiving	"emotional investment required in teaching... difficult to disengage"	Teaching is affective labour, not just cognitive; contributes to burnout
Identity Conflict	Conflict between multiple roles (professional/personal)	"competing demands on my time and energy"	Aligns with Role Strain Theory; individuals cannot fully satisfy all roles simultaneously
Blurred Boundaries	Lack of separation between work and personal domains	"blur boundaries between professional and personal time"	Indicates weak boundary management; leads to continuous role intrusion
Peak Work Pressure	Seasonal increase in workload (exams/events)	"examinations... extend beyond regular hours"	Institutional cycles intensify imbalance, making WLB episodically worse
Caregiver Burden	Responsibility of caring for dependent family members	"care giving a dementia patient..."	Reflects gendered expectation; unpaid care work disproportionately borne by women
Intensive Caregiving Demand	High physical and emotional caregiving involvement	"had to feed her... give medicine... spend hours"	Indicates "total care responsibility" leading to exhaustion and time depletion
Domestic Responsibility Load	Managing household tasks alongside work	"manage cooking, cleaning"	Adds invisible labour; increases cumulative burden on female teachers
Role Conflict (Work–Family)	Conflict between professional and caregiving roles	"role conflict (daughter and teacher)"	Classic Work–Family Conflict; competing demands reduce performance in both roles
Loss of Personal Time	Inability to pursue hobbies or self-care	"No, as I don't get time"	Indicates erosion of personal identity and well-being

Coping Strategies	Individual methods to manage stress	"fitness... music... emotional release"	Adaptive coping; supports resilience but does not eliminate structural stress
Support Systems	Emotional/practical support from others	"mother, friends, colleagues... support"	Social support acts as a buffer against stress but is unevenly available
Institutional Constraints	Organisational limitations affecting WLB	"lack of flexibility in school schedule"	Structural barriers limit individual agency in achieving balance
Health Impact	Physical and mental health consequences	"high BP... thyroid... pre-diabetic"	Severe outcome of prolonged imbalance; indicates chronic stress manifestation
Emotional Exhaustion	Feeling drained due to sustained stress	"mental wellbeing was a major challenge"	Core component of burnout; affects both personal and professional functioning
Relationship Strain	Impact of WLB on interpersonal relationships	"relationships worsened due to work-life demands"	Social consequences of imbalance; reduced relational quality
Reduced Work Quality	Decline in professional performance	"work quality... was affected"	Demonstrates reciprocal effect: imbalance affects job outcomes
Exit Decision	Leaving job due to WLB challenges	"decided to quit the job"	Extreme coping response; indicates unsustainable work conditions
Career Re-evaluation	Rethinking long-term career goals	"inclined towards... more balanced and sustainable way"	Reflects shift toward meaning + sustainability over performance
Partial Institutional Support	Limited or inconsistent organisational help	"management support... limited"	Highlights inequity and inconsistency in organisational policies

CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY

MISS. UNNATI S. CHAUHAN
HR, KRISHANG PHARMA PRIVATE LIMITED, ODE, ANAND

ABSTRACT

This synthesizes current research regarding consumer behavior, risk perception, and adoption intension toward digital currencies, including cryptocurrencies and central bank digital currencies (CBDDCs). As digital currencies transition from technology to mainstream financial alternatives, understanding consumer adoption dynamics shaped by a delicate balance of trust, perceived utility, and risk—is crucial. This study explores the factors accelerating or hindering the adoption of digital currencies, focusing on the interplay between perceived benefits (convenience, lower fees) and perceived risks (volatility, security, regulatory uncertainty). Findings indicate that adoption is driven primarily by perceived usefulness (PU) and perceived ease of use (PEOU), often validated through TAM (Technology Acceptance Model) frameworks. However, widespread adoption is primarily hindered by high-risk perception, specifically regarding financial loss due to volatility, security breaches (phishing/hacks), and loss of privacy.

The paper has been divided in to three parts as follows:

Causes of digital currency

Effect of digital currency

Prevention of digital currency

KEYWORDS: CENTRAL BANK DIGITAL CURRENCIES, PERCEIVED USEFULNESS, PERCEIVED EASE OF USE, TECHNOLOGY ACCEPTANCE MODEL.

INTRODUCTION:

The rapid evolution of financial technology has introduced digital currencies—ranging from decentralized cryptocurrencies like Bitcoin to sovereign-backed Central Bank Digital Currencies (CBDCs)—as a transformative alternative to traditional money. While digital currencies offer significant potential benefits such as improved payment efficiency, lower transaction costs, and greater financial inclusion, their widespread adoption by consumers remains a gradual process, heavily influenced by behavioral factors and perceived risks. The rapid evolution of financial technology has catalyzed a shift from physical cash to digital money, transforming the global payment landscape. While cryptocurrencies like Bitcoin introduced decentralized, blockchain-based alternatives, central banks worldwide are now developing Central Bank Digital Currencies (CBDCs) to provide a secure, regulated digital counterpart to physical cash. The adoption of digital currencies by consumers is a complex process driven by the desire for efficiency, speed, and lower transaction costs, yet it is simultaneously hindered by significant risk perceptions related to security, volatility, and privacy. The landscape of digital currency, comprising Central Bank Digital Currencies (CBDCs), stable coins, and cryptocurrencies, is undergoing a rapid transition from experimental usage to mainstream integration. As of 2026, over 90% of Americans have used some form of digital payment, with mobile wallets dominating e-commerce. However, consumer adoption is not uniform, shaped by a complex interplay between the perceived convenience of

digital money and significant risk perceptions regarding security, volatility, and regulatory uncertainty.

RESEARCH METHODOLOGY:

Objectives of the Study:

The primary objective of researching consumer adoption and risk perception of digital currency (including cryptocurrencies, stable coins, and Central Bank Digital Currencies - CBDCs) is to understand the behavioral drivers and barriers that determine whether consumers will transition from traditional payment methods to digital alternatives. This research aims to bridge the gap between technological potential and actual usage by analyzing the interplay between perceived benefits (usefulness) and perceived risks (security, value volatility).

Objectives of consumer adoption and risk perception of digital currency (including CBDCs and cryptocurrencies) focus on analyzing factors influencing usage, such as perceived usefulness, trust, ease of use, and security. Studies identify key drivers—efficiency, low costs, and financial inclusion—while mapping risks like volatility, cyber-security, and privacy concerns that hinder adoption.

PREVIOUS RESEARCH REVIEW:

The results indicate that perceived usefulness and perceived ease of use significantly impact users' attitudes toward the digital rupee, as well as their adoption intentions. The findings further reveal that perceived trust, perceived self-efficacy, and awareness positively influence attitude and adoption intention. On the other hand, perceived cost exhibits a negative effect on attitude and adoption intention. These results provide empirical evidence on the factors that shape users' attitudes and intentions toward adopting the digital rupee. The study's findings offer practical guidance for policymakers, financial institutions and researchers in shaping digital currency regulatory frameworks, tailored financial services and further exploration of adoption dynamics.

Today, digital payments reduce the frequency of cash payments. Central banks in many countries such as China are issuing CBDC and conducting in-depth research in related areas. In this turbulent era featuring a pandemic, reducing contact and stabilizing national sovereign currency through the digital currency of central banks may be the inevitable trend of future social development. For this to happen, it is necessary for consumers to accept digital currency payments. Therefore, the results of this article can be used for CBDC to improve the acceptance of individuals. As a payment behavior, the type of privacy information collected needs to be strictly controlled. Perceived privacy, perceived security, and perceived system quality need to be closely linked to building consumer trust. Understanding consumers' behavioral intentions is an effective means to analyze the adoption of new technologies.

Cryptocurrency adoption is hindered by a complex array of perceived risks. These risks span technological, legal, emotional, and psychological domains, each influencing user decisions in distinct ways. While technical innovation has progressed rapidly, societal understanding and regulatory clarity have lagged, creating friction in adoption pathways. To foster trust and drive mass adoption, the crypto industry must prioritize security, clarity, and consumer protection.

Furthermore, emotional risk perception—often overlooked in technical discussions—must be addressed through community engagement, open dialogue, and accessible education. Future research should investigate how different demographic groups perceive crypto risks and which communication strategies most effectively alleviate those concerns.

The research conducted here adds to the expanding amount that exists on digital money transfer technology and its implications for consumers. It offers practical recommendations for stakeholders to develop strategies that promote secure and inclusive digital financial ecosystems by addressing consumer concerns, enhancing trust, and providing accessible financial services, stakeholders can pave the way for a future where digital money transfer technology is embraced and leveraged for the benefit of all.

METHODOLOGY:

Type of Research – Qualitative and descriptive research method is adapted for better understanding of the impact and future aspect of integration of AI in commerce education.
Sources of Data – Secondary data

The data has been extracted from various sources like research articles, books, websites and blogs, magazines and journals which deals directly or indirectly with artificial intelligence. Descriptive research was chosen for developing better understanding in profundity.

CAUSES OF CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY:

Consumer adoption of digital currency (including cryptocurrencies, stable coins, and Central Bank Digital Currencies - CBDCs) is driven by a desire for increased convenience, financial inclusion, and potential investment returns, while adoption is hindered by high-risk perceptions related to price volatility, security, and lack of regulatory oversight. As of 2026, digital payments are increasingly shifting from a niche interest to a mainstream "click-to-cash" experience, with 61% of current crypto owners planning to increase their holdings.

CAUSES OF CONSUMER ADOPTION:

Consumer adoption is propelled by the perceived "relative advantage" of digital assets over traditional banking systems.

Convenience and Speed: Digital currencies provide 24/7 availability and faster, often instant, transaction settlement compared to traditional banking systems which may take 3-5 days.

Financial Inclusion: Digital currencies enable access for the unbanked or underbanked population, requiring only a smartphone and internet connectivity, bypassing the need for physical banking infrastructure.

Reduced Transaction Costs: By bypassing third-party middlemen (like VISA or correspondent banks), transaction costs are often lower or zero, making cross-border transfers more appealing.

Potential for Investment Returns: For many users, speculation and potential price increases remain the primary driver, especially for cryptocurrencies like Bitcoin and Solana.

Hedge Against Fiat Inflation: In regions with high inflation or national currency volatility, consumers turn to stable coins and major cryptocurrencies as alternative stores of value.

Technological Advancement & Trust in Tech: Increased awareness of blockchain technology, user-friendly wallets, and the perceived "decentralized" security of the system, rather than reliance on traditional banks, drive adoption.

CAUSES OF RISK PERCEPTION:

Despite the benefits, consumers perceive high risks, which are a "necessary condition" in determining whether or not to adopt, particularly for CBDCs.

Price Volatility: Unstable value is the primary concern for both owners and non-owners of cryptocurrencies.

Lack of Regulatory Protection: Consumers are hesitant because digital assets, especially cryptocurrencies, often lack bank or government-backed insurance, meaning lost funds are gone forever.

Security and Cyber-attacks: Concerns about hacking of exchanges, theft from wallets, and "51% attacks" on blockchain networks create a "trust gap" among non-owners.

Psychological and Operational Barriers: Unfamiliarity with the technology, fear of fraud, loss of control, and difficulties navigating complex wallet setups (losing keys/passwords) constitute high risk.

Privacy Concerns: While some use crypto for privacy, others fear the potential for "surveillance" in centralized CBDCs or the exposure of data on public blockchains.

Reduced Transaction Costs: By bypassing third-party middlemen (like VISA or correspondent banks), transaction costs are often lower or zero, making cross-border transfers more appealing.

Potential for Investment Returns: For many users, speculation and potential price increases remain the primary driver, especially for cryptocurrencies like Bitcoin and Solana.

Hedge Against Fiat Inflation: In regions with high inflation or national currency volatility, consumers turn to stable coins and major cryptocurrencies as alternative stores of value.

Technological Advancement & Trust in Tech: Increased awareness of blockchain technology, user-friendly wallets, and the perceived "decentralized" security of the system, rather than reliance on traditional banks, drive adoption.

CAUSES OF RISK PERCEPTION:

Despite the benefits, consumers perceive high risks, which are a "necessary condition" in determining whether or not to adopt, particularly for CBDCs.

Price Volatility: Unstable value is the primary concern for both owners and non-owners of cryptocurrencies.

Lack of Regulatory Protection: Consumers are hesitant because digital assets, especially cryptocurrencies, often lack bank or government-backed insurance, meaning lost funds are gone forever.

Security and Cyber-attacks: Concerns about hacking of exchanges, theft from wallets, and "51% attacks" on blockchain networks create a "trust gap" among non-owners.

Psychological and Operational Barriers: Unfamiliarity with the technology, fear of fraud, loss of control, and difficulties navigating complex wallet setups (losing keys/passwords) constitute high risk.

Privacy Concerns: While some use crypto for privacy, others fear the potential for "surveillance" in centralized CBDCs or the exposure of data on public blockchains.

EFFECT OF CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY:

The consumer adoption of digital currencies—including cryptocurrencies (Bitcoin, Ethereum) and Central Bank Digital Currencies (CBDCs, such as the digital rupee)—is largely shaped by a complex, interdependent relationship between user perception of risk and perceived benefits.

High risk perception acts as a significant barrier to adoption, while perceived usefulness (convenience, speed) acts as the primary driver.

EFFECT OF RISK PERCEPTION ON DIGITAL CURRENCY ADOPTION:

Consumer risk perception acts as a negative force against the adoption of digital currencies. The primary risks identified include:

Security Risk & Fraud: Fears of cyberattacks, wallet hacking, and theft lead to hesitation.

Volatility: Extreme price fluctuations in cryptocurrencies make them risky for daily transactions, limiting their use to speculative investment rather than a medium of exchange.

Regulatory Uncertainty: Lack of clear government regulation reduces consumer trust and increases uncertainty.

Complexity Barrier: The technological, cryptographic knowledge required to manage digital assets (private keys, wallets) creates a "usage barrier".

Inertia: Consumers often prefer traditional fiat systems (cash, banks) due to comfort, creating resistance to change.

DRIVERS OF ADOPTION (REDUCING RISK):

While risk deters, several factors (perceived benefits) drive adoption by bridging the risk-adoption gap:

Perceived Usefulness & Ease of Use (TAM Model): The belief that digital currency makes transactions faster, cheaper, and more convenient is a primary driver.

Trust and Legitimacy: Trust in the issuer—specifically central banks backing CBDCs—significantly lowers risk perception compared to decentralized cryptocurrencies.

Merchant Acceptance: Widespread availability of vendors accepting digital currency increases its perceived validity.

Incentives & Gamification: Rewards, cashback, and discounts (common in mobile wallet adoption) encourage consumers to use digital methods.

Government Support: Clear legal frameworks, security standards, and official backing lower the perceived risk and increase adoption rates.

IMPACT OF ADOPTION ON CONSUMER BEHAVIOR:

As adoption grows, it fundamentally changes consumer spending patterns:

Increased Spending (Frictionless Transactions): The reduction in the "pain of paying"—due to the intangible nature of digital money—leads consumers to make more frequent, smaller, and higher-value purchases, often spending more than cash users.

Reduced Savings Discipline: The convenience of digital payments is associated with a decrease in savings discipline and an increase in impulse buying.

Financial Inclusion: Digital currency, particularly CBDCs, enables financial access for underserved populations, especially in regions with limited banking infrastructure.

PREVENTION OF CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY:

Consumer adoption of digital currency, including cryptocurrencies and Central Bank Digital Currencies (CBDCs), is hampered by significant risk perceptions related to volatility, security, and a lack of regulatory protection. While digital currencies offer potential for faster, lower-cost transactions, high-profile hacks, fraud, and dramatic price fluctuations (such as the "crypto winter" that saw a 70% drop in market cap in 2022) create deep-seated hesitancy among the general public.

Key Factors Preventing Consumer Adoption:

Consumer adoption of digital currencies remains a complex interplay between perceived benefits (e.g., efficiency, financial inclusion) and significant risk perceptions (e.g., volatility, security, regulatory uncertainty). As of 2026, while institutional adoption is maturing, retail adoption is still hindered by deep-seated concerns and a "trust deficit". Adoption is prevented by both technical challenges and psychological barriers.

Perceived Lack of Need/Utility: Many consumers feel existing, familiar payment methods (cash, credit cards, mobile apps like UPI) are "good enough," and they perceive no significant benefit in switching to digital currencies.

Technical Complexity and Lack of Knowledge: A 2019 report indicated that only 10% of people surveyed fully understand how cryptocurrencies work, while a significant portion found them too technically complicated. The need for managing private keys and understanding non-custodial wallets is a major hurdle for average users.

High Switching Costs: Users often see the time, effort, and potential for error in adopting a new system as outweighing the perceived benefits.

Lack of Merchant Acceptance: Adoption requires a two-sided market; if merchants do not accept digital currency due to volatility or technical hurdles, consumers have no place to spend it.

Security Threats and Fraud: Consumer's fear losing their funds to cyber-attacks, hacking of exchanges, and phishing scams. Approximately 19% of users surveyed in a Kaspersky report experienced hacking, and 15% were victims of fraud.

Anonymity vs. Privacy Concerns: While some value anonymity, many consumers are wary of the potential for illicit activity, while others fear the "big brother" surveillance aspect of government-backed digital currencies (CBDCs).

Association with Illicit Activities: The historical use of cryptocurrencies for illegal transactions ("Silk Road") creates a stigma that makes mainstream consumers hesitant.

Perceived Complexity & Lack of Awareness: Nearly 49% of global consumers cite a lack of understanding as the primary reason for not adopting digital currency. The technical burden of managing digital wallets and private keys remains unintuitive for many.

Security & Cyber Threats: Consumers fear irreversible financial loss due to hacking, phishing, or exchange collapses. About 1 in 6 crypto owners have reported issues like lost keys or exchange outages.

Lack of Redress: Unlike traditional banking, digital currency transactions are typically irreversible, leaving users without a safety net if a mistake occurs or a scam is encountered.

CASE STUDY:

OVERVIEW (Brief Introduction)

The data from 2016 to 2025 shows a steady and then exponential increase in global digital currency fraud losses. Initially, fraud grew gradually due to increasing adoption of cryptocurrencies, but after 2020, the rise became sharp due to mass digital adoption, lack of awareness, and advancement in cybercrime technologies.

YEAR-WISE EXPLANATION

YEAR	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
BILLION ($)	1.5	2.8	3.5	4.2	4.5	6.0	5.0	5.6	10.5	15.7

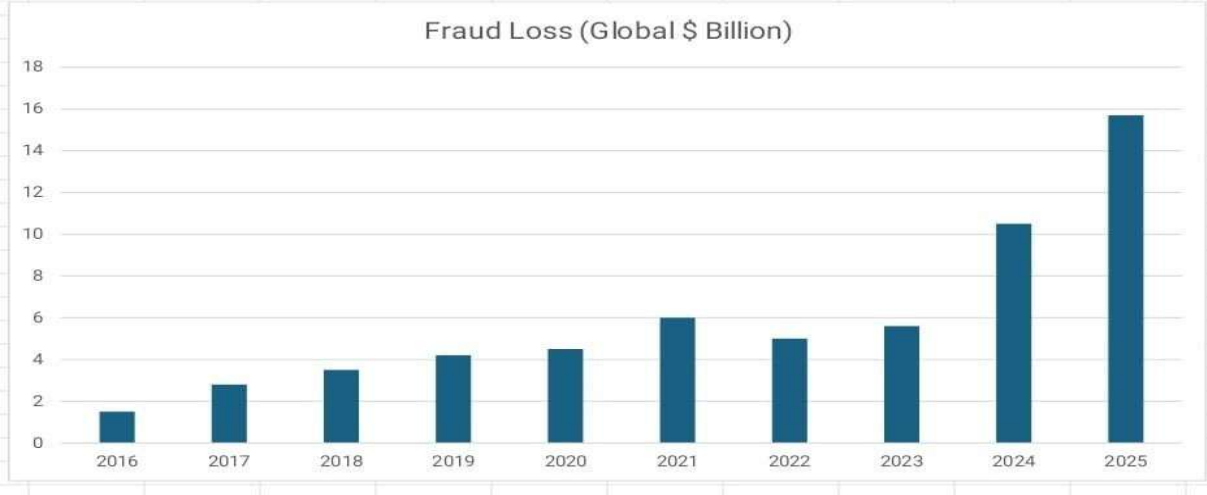


Table 1

Explanation:

This chart illustrates the growing trend of global fraud losses from 2016 to 2025. At the beginning of the period, fraud losses were relatively low, showing that fraudulent activities had a smaller financial impact. However, as the years progressed, the losses gradually increased, indicating that fraud became more frequent and costly.

Between 2016 and 2021, the increase is steady, reflecting a gradual rise in fraudulent activities and improved reporting systems. A slight decline appears around 2022, suggesting temporary control measures or changes in reporting. In 2016, fraud losses were relatively low at about $1.5 billion. From 2017 to 2021, losses gradually increased, reaching around $6 billion in 2021.

After that, the chart shows a sharp upward movement, especially from 2023 onwards, where fraud losses grow rapidly and reach their highest levels by 2024 and 2025. This dramatic increase highlights how digital transactions and technological advancements may also create more opportunities for fraud In 2022, there is a small decline to about $5 billion. The losses rise again in 2023 to roughly $5.5 billion. A sharp increase occurs in 2024 and 2025, jumping to around $10.5 billion and $15–16 billion respectively.

Overall, the chart tells a clear story: Fraud losses have evolved from a manageable issue into a rapidly growing financial challenge worldwide. The chart shows that global fraud losses increased overall from 2016 to 2025. The losses rose gradually from 2016 to 2021, experienced a small drop in 2022, and then increased again sharply from 2023 to 2025, reaching the highest level in 2025. Overall, the trend indicates a significant growth in fraud losses over the years. The chart highlights a growing global problem of fraud, especially with a significant surge after 2023, suggesting that fraud activities or detection/reporting have increased rapidly in recent years.

Evidence:

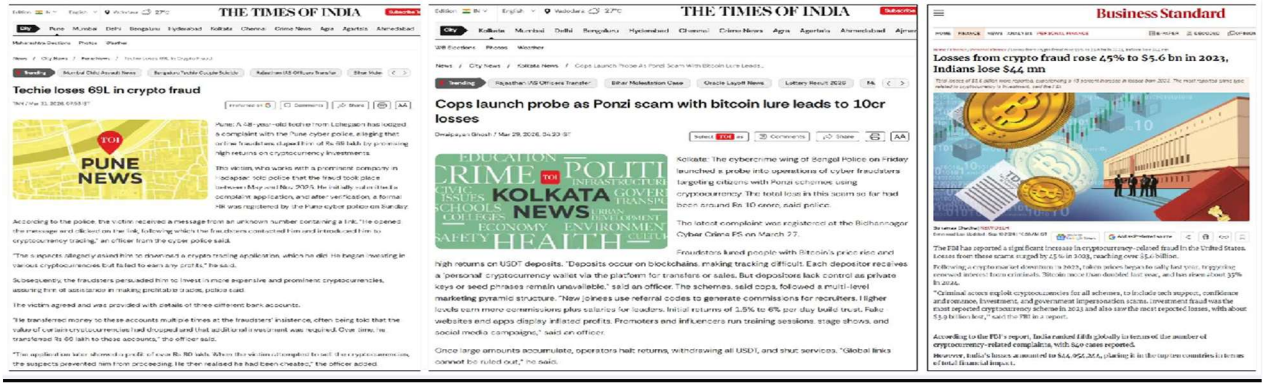


Table 2

WHO IS INVESTIGATING CRYPTO SCAMS IN INDIA?

Multiple central and state agencies are involved in investigating cryptocurrency-related fraud in India:

Central Bureau of Investigation (CBI)

Gain Bitcoin Investigation: Conducted raids at 60 locations across Delhi NCR, Pune, Chandigarh, Nanded, Kolhapur, and Bengaluru in February 2025

Operation Chakra-V: Multi-agency campaign targeting transnational cyber fraud syndicates, involving coordination with Interpol and FBI

Crypto seizures: Seized $2.75 million in cryptocurrency during Gain Bitcoin raids

Geneva Mission fraud: Investigating ₹2 crore fraud linked to crypto-gambling at India's Geneva diplomatic mission

Enforcement Directorate (ED)

Bit connect seizures: Attached assets worth $190-198 million in crypto

Morris Coin: Seized ₹14 crore in assets, arrested prime accused

HPZ Token: Total seizures of ₹615.90 crore

OctaFX Scam: Seized ₹2,385 crore in crypto assets

International Hawala: Unearthed ₹4,000 crore racket; attached ₹47.6 crore

FBI-ED Joint Operation: Seized ₹1,500 crore in digital assets linked to a ₹3,000 crore fraud case

State Police Cyber Cells

Delhi Police: Partnered with Binance to bust Gold coat Solar scam; seized 1 lakh USDT

Surat CID: Leading Bit connect investigation in India

Bengaluru Police: Investigated Morris Coin and related entities

Odisha CID: Arrested 5, recovered ₹6.16 crore in a 2024 crypto scam

Indian Cyber Crime Coordination Centre (I4C)
Operates the National Cybercrime Reporting Portal (NCRP)
Runs the 1930 helpline for immediate fraud reporting
Coordinates with state cyber cells and international agencies
Blocked 3,000+ URLs and 595 apps under Section 69A of IT Act
Suspended 5.3 lakh SIM cards and 80,848 IMEI numbers since July 2023

FUTURE RISK POTENTIAL OF CONSUMER ADOPTION AND RISK PERCEPTION OF DIGITAL CURRENCY:

The future risk potential of consumer adoption and perception of digital currencies (both cryptocurrencies and Central Bank Digital Currencies - CBDCs) by 2026-2027 is shifting from speculative volatility towards risks associated with systemic integration, operational security, and data privacy. While adoption is rising due to improved user experience (UX) and stable coin usage, consumer risk perception remains high, focused on hacks, regulatory uncertainty, and potential loss of funds. The future risk potential of digital currency is increasingly defined by a shift from speculative "Wild West" volatility toward institutional maturity and structured oversight. While 2026 is viewed as a pivotal year for regulatory clarity, consumer adoption remains hindered by persistent psychological and security barriers. Digital currency (including cryptocurrencies, stable coins, and Central Bank Digital Currencies - CBDCs) offers significant efficiency gains, but it carries a multifaceted, evolving risk landscape. The future risk potential for digital currencies centers on intense regulatory scrutiny, cybersecurity threats, market volatility, and systemic financial disruptions.

REGULATORY AND LEGAL RISKS:

As governments seek to assert control over decentralized systems, regulatory uncertainty is the most significant looming risk.

Government Crackdowns: Future, more stringent restrictions on mining or trading could drastically affect valuation and accessibility.

Tax Complexities: Evolving tax regulations differ by country, making compliance difficult and creating risks for investors around capital gains reporting.

Illicit Activity Controls: The anonymity of some digital assets attracts criminal activity, prompting stricter regulations that could hinder legitimate usage.

CBDC Surveillance: Centralized digital currencies (CBDCs) raise privacy concerns over potential government monitoring of all personal transactions.

CYBERSECURITY AND TECHNOLOGICAL VULNERABILITIES:

Digital currencies, especially those stored on "hot" (connected) wallets or exchanges, are prime targets for cybercrime.

Hacking and Theft: Digital assets are highly vulnerable to hacks. In 2022, nearly $3.8 billion was stolen, and as adoption increases, the potential losses increase.

Scams and Fraud: The "Wild West" nature of crypto permits phishing, social engineering scams, and "rug pulls" (where developers abandon a project, stealing funds).

Smart Contract Bugs: Flaws in the code governing automated financial transactions (DeFi) can lead to irreversible loss of funds.

Irreversibility: Because transactions are immutable, user errors—like sending funds to the wrong address or losing private keys—result in permanent loss.

FINANCIAL AND MARKET STABILITY RISKS:

The high volatility of cryptocurrencies makes them questionable as a stable store of value or medium of exchange.

Extreme Volatility: Bitcoin and other cryptocurrencies have experienced significant crashes (e.g., over 50% multiple times), creating substantial risks for investors.

Liquidity Risk: Digital currency markets can face "flash crashes" where selling becomes difficult during a panic, often linked to market manipulation.

Systemic Risk: Increased integration of digital assets with the traditional financial system could spread risks, such as bank-like runs, into the broader economy.

Stable coin De-pegging: Stable coins, which peg their value to fiat money, can lose their peg if their collateral is inadequate, leading to panic, runs, and failure.

CONCLUSION:

Digital currencies' growth is driven by innovation and accessibility, but security risks, volatility, and regulatory uncertainty hinder adoption. Effects include increased financial inclusion and faster transactions. Causes of risk include decentralization and lack of regulation. Prevention involves education, robust security, and clear regulations. Future risks include regulatory crackdowns and cyber threats. Consumer adoption of digital currency is growing due to convenience, innovation, and financial inclusion, but risk perception remains high because of security concerns, volatility, and regulatory uncertainty. Users weigh benefits like fast transactions against risks like fraud and market fluctuations, influencing their adoption decisions. The adoption of digital currencies is increasing globally, driven by factors like convenience, innovation, and financial inclusion. However, risk perception remains a significant barrier. Users are cautious due to concerns about security, volatility, and regulatory uncertainty. While benefits like fast transactions and low costs attract users, risks like fraud, hacking, and market fluctuations deter others. As digital currencies evolve, education, regulation, and security measures will shape user trust and adoption rates. The interplay between innovation and risk management will ultimately determine the pace of mainstream adoption. The proliferation of digital currencies is reshaping global finance, with adoption fueled by innovation, accessibility, and the promise of financial inclusion. Yet, a cautious undertone persists, rooted in risk perception.

Users grapple with volatility, regulatory ambiguity, and security threats, often tipping the scales between adoption and hesitation. As digital currencies mature, the trifecta of education, robust regulation, and cutting-edge security will dictate user trust and mainstream acceptance. The dynamic interplay between opportunity and risk will chart the course for widespread adoption, rendering digital currencies an intriguing space to watch. Digital currencies are reshaping finance with growing adoption driven by innovation and accessibility, but risk perception around security and volatility persists. The balance between opportunity and caution will shape mainstream adoption. Innovation and accessibility, but risk perception around security and volatility persists. The balance between opportunity and caution will shape mainstream adoption.

REFERENCES:

The Times of India. (2024). **Techie loses ₹69 lakh in crypto fraud.** *Retrieved from https://timesofindia.indiatimes.com/city/pune/techie-loses-69l-in-crypto-fraud/articleshow/129910850.cms*

The Times of India. (2024). **Ponzi scam with bitcoin lure leads to ₹10 crore losses.** *Retrieved from https://timesofindia.indiatimes.com/city/kolkata/cops-launch-probe-as-ponzi-scam-with-bitcoin-lure-leads-to-10cr-losses/articleshow/129871482.cms*

Business Standard. (2024). **Losses from crypto fraud rose 45% to $5.6 bn in 2023.** *Retrieved from https://www.business-standard.com/finance/personal-finance/losses-from-crypto-fraud-rose-45-to-5-6-bn-in-2023-124091000249_1.html*

Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International.

Wang, D., & Su, H. (2025). Impacts of merchant acceptance with consumers' perceived trust and risk in adopting central bank digital currency in China. Electronic Commerce Research, 1-46.

Ogunmola, G. A., & Das, U. (2024). Analyzing consumer perceptions and adoption intentions of central bank digital currency: a case of the digital rupee. Digital Policy, Regulation and Governance, 26(4), 450-471.

Bijlsma, M., van der Cruijsen, C., Jonker, N., & Reijerink, J. (2024). What triggers consumer adoption of central bank digital currency?. Journal of Financial Services Research, 65(1), 1-40.

Rodpangtiam, A. (2022). The Influence of Perceived Risk and Perceived Value on Consumer Adoption of Cryptocurrency.

Kaur, H., Kaur, R., Mago, M., Singh, M., & Mehta, K. (2024). Exploring factors affecting central bank digital currency adoption: A perspective from generation Z. Metamorphosis, 23(2), 126-141.

Kothari, C. R. (2017). research methodology methods and techniques by CR Kothari. Published by New Age International (P) Ltd., Publishers, 91.

JUSTICE IS RIGHT: A CONSTITUTIONAL AND SOCIO-LEGAL ANALYSIS

DR. BHAUMIK P. UPADHYAY
ADHYAPAK SAHAYAK, SIDDHARTH LAW COLLEGE, GANDHINAGAR

ABSTRACT

Justice has always remained the central pillar of any civilized society, yet its meaning continues to evolve with time, circumstances, and societal needs. The expression "Justice is Right" is not merely a philosophical assertion but a deeply embedded constitutional commitment reflecting fairness, equality, and human dignity. This research paper undertakes a comprehensive doctrinal and socio-legal analysis of justice within the Indian constitutional framework, with particular emphasis on the transformative role of Article 21.

The study critically examines how justice has transitioned from a narrow procedural understanding to a broad, human-centered doctrine encompassing dignity, liberty, livelihood, and access to justice. It further explores the role of judicial activism, Public Interest Litigation, and constitutional remedies in shaping justice delivery in India. The research also addresses contemporary challenges such as judicial delays, inequality, and accessibility barriers, ultimately proposing a more inclusive and responsive justice system.

KEYWORDS: JUSTICE, CONSTITUTIONAL LAW, ARTICLE 21, HUMAN DIGNITY, JUDICIAL ACTIVISM, PIL, ACCESS TO JUSTICE

1. INTRODUCTION

Justice is one of the most fundamental ideals that underpins the existence of law and governance. It represents the moral force behind legal systems and serves as the ultimate goal that all legal processes aim to achieve. The phrase "Justice is Right" signifies that justice is not merely an abstract concept but a standard of correctness, fairness, and moral legitimacy that determines what is right in society.

In the Indian context, justice holds a place of paramount importance, as reflected in the Preamble of the Constitution, which promises social, economic, and political justice to all citizens. This commitment establishes justice not only as a legal objective but as a constitutional philosophy guiding the functioning of the state.

Historically, justice was often understood in a limited sense, confined to legal procedures and formal adjudication. However, with the evolution of constitutional jurisprudence, particularly through judicial interpretation, justice has acquired a broader and more dynamic meaning. It now encompasses not only legal correctness but also fairness, equity, and human dignity.

The Indian judiciary has played a transformative role in redefining justice, especially through its interpretation of Article 21, which guarantees the right to life and personal liberty. This provision has evolved into a powerful tool for ensuring justice in its widest sense, covering various aspects of human existence such as livelihood, education, health, and environmental protection.

This research paper seeks to explore the concept of justice in depth, analyzing its philosophical foundations, constitutional framework, judicial evolution, and socio-legal implications. It aims to demonstrate that justice is not a static concept but a living principle that must continuously adapt to changing societal needs.

2. PHILOSOPHICAL FOUNDATIONS OF JUSTICE

The concept of justice has been a subject of philosophical inquiry for centuries. Different thinkers have offered diverse interpretations, each reflecting their understanding of morality, society, and governance.

Aristotle viewed justice as a principle of fairness, emphasizing that equals should be treated equally and unequals unequally based on their circumstances. This idea laid the foundation for distributive and corrective justice.

Plato, on the other hand, associated justice with harmony in society, where each individual performs their designated role without interference. According to him, justice is achieved when there is balance and order within the social structure.

In modern times, John Rawls introduced the theory of "Justice as Fairness," which emphasizes equality of opportunity and protection of the least advantaged members of society. His theory highlights that justice must not only be fair but also inclusive and equitable.

These philosophical perspectives collectively suggest that justice is not merely about enforcing laws but about ensuring fairness, equality, and moral correctness in all aspects of life.

3. JUSTICE IN THE INDIAN CONSTITUTIONAL FRAMEWORK

The Indian Constitution provides a comprehensive framework for the realization of justice. The Preamble explicitly declares justice as one of its core objectives, thereby establishing it as the guiding principle of governance.

Fundamental Rights, enshrined in Part III of the Constitution, serve as the primary instruments for ensuring justice. These rights protect individuals against arbitrary actions of the state and guarantee essential freedoms necessary for a dignified life.

Directive Principles of State Policy further reinforce the concept of justice by directing the state to promote social and economic welfare. Although not enforceable in courts, these principles play a crucial role in shaping policies aimed at achieving justice.

Articles 32 and 226 provide mechanisms for enforcing fundamental rights, enabling individuals to approach the Supreme Court and High Courts for remedies. These provisions ensure that justice is not merely theoretical but practically accessible.

Among all constitutional provisions, Article 21 stands out as the most significant in the context of justice. It has been interpreted expansively to include a wide range of rights essential for human dignity and well-being.

4. JUDICIAL INTERPRETATION AND EXPANSION OF JUSTICE

The Indian judiciary has been instrumental in expanding the scope of justice through its progressive interpretations. Initially, in *A.K. Gopalan v. State of Madras*, the Supreme Court adopted a narrow view of personal liberty. However, this approach was later overturned in *Maneka Gandhi v. Union of India*, where the Court held that any procedure depriving a person of liberty must be just, fair, and reasonable.

This landmark judgment marked a turning point in constitutional jurisprudence, establishing that justice cannot be separated from fairness and reasonableness.

Subsequent cases further expanded the scope of Article 21. In *Francis Coralie Mullin v. Administrator*, the Court recognized the right to live with human dignity. In *Olga Tellis v. Bombay Municipal Corporation*, it acknowledged the right to livelihood as an integral part of the right to life. Similarly, in *Hussainara Khatoon v. State of Bihar*, the Court introduced the concept of the right to speedy trial, emphasizing that justice delayed is justice denied.

These decisions collectively demonstrate how judicial interpretation has transformed justice into a comprehensive and dynamic concept.

5. PUBLIC INTEREST LITIGATION AND ACCESS TO JUSTICE

Public Interest Litigation has emerged as a revolutionary tool in the Indian legal system, significantly enhancing access to justice. It allows individuals and organizations to approach courts on behalf of those who are unable to do so due to poverty, illiteracy, or social disadvantage.

PIL has played a crucial role in addressing issues such as environmental protection, human rights violations, and social justice. It has made the judiciary more accessible and responsive to the needs of society.

However, the increasing use of PIL has also raised concerns about misuse and judicial overreach. Therefore, it is essential to strike a balance between accessibility and accountability.

6. JUSTICE DELAYED AND SYSTEMIC CHALLENGES

Despite the progressive development of justice, the Indian legal system faces several challenges that hinder its effective realization. One of the most significant issues is the delay in judicial proceedings, which often results in denial of justice.

Other challenges include procedural complexities, lack of legal awareness, economic inequality, and limited access to legal aid. These factors create barriers that prevent individuals from seeking and obtaining justice. Addressing these challenges requires systemic reforms aimed at improving efficiency, accessibility, and transparency in the justice delivery system.

7. JUSTICE AS A HUMAN RIGHT

Justice is closely linked to the concept of human rights, as it ensures the protection of dignity, equality, and freedom. Without justice, rights remain ineffective and meaningless.

The recognition of justice as a human right emphasizes the need for a legal system that is fair, inclusive, and responsive to the needs of all individuals. It also highlights the responsibility of the state to create conditions that enable the realization of justice.

8. SOCIO-LEGAL DIMENSIONS OF JUSTICE

Justice must be understood not only in legal terms but also in its social context. It is influenced by factors such as culture, economy, education, and social structure.

A socio-legal approach to justice emphasizes the need to consider the realities of society while interpreting and applying laws. It recognizes that true justice can only be achieved when legal principles align with social conditions.

9. FINDINGS

The study reveals that justice is a dynamic and evolving concept shaped by constitutional principles and judicial interpretation. It highlights the central role of Article 21 in expanding the scope of justice and emphasizes the importance of judicial activism in protecting fundamental rights.
The research also identifies significant challenges such as delays, inequality, and lack of awareness, which hinder the effective realization of justice.

10. SUGGESTIONS

The study suggests the need for strengthening legal awareness, simplifying judicial procedures, promoting digital justice systems, and enhancing legal aid services. It also emphasizes the importance of maintaining a balance between judicial activism and restraint.

11. CONCLUSION

Justice is not merely a legal concept but a moral and constitutional necessity. The idea that "Justice is Right" underscores the importance of aligning law with fairness and human dignity.
A society can only be considered just when its legal system ensures equality, protects rights, and delivers timely and effective remedies. Therefore, the pursuit of justice must remain a continuous and collective effort.

REFERENCES

Maneka Gandhi v. Union of India, (1978) 1 SCC 248.

A.K. Gopalan v. State of Madras, AIR 1950 SC 27.

Olga Tellis v. Bombay Municipal Corporation, (1985) 3 SCC 545.

Hussainara Khatoon v. State of Bihar, (1979) 3 SCC 532.

M.P. Jain, Indian Constitutional Law (2018).

V.N. Shukla, Constitution of India (2017).

Concept of Justice, available at https://ijlsss.com (last visited Feb. 2026).

Access to Justice, available at https://nja.gov.in (last visited Jan. 2026).

THERMAL AND BIOLOGICAL ASPECT ON NI(II) BASED COMPLEXES

K S PATEL
CHEMISTRY DEPARTMENT, SHREE P. M. PATEL INSTITUTE OF PG STUDIES AND RESEARCH IN SCIENCE, SARDAR PATEL UNIVERSITY, ANAND-388 001, GUJARAT

ABSTRACT:

This study details the synthesis of a new series of Ni(II) complexes using a classical thermal technique. The process involved refluxing dicoumarol derivatives with aldehydes in ethanol to prepare biologically potent ligands (L). These ligands were then reacted with an aqueous metal solution and ofloxacin in a 1:1 molar ratio. Structural characterization was performed using elemental analysis, FT-IR, mass spectrometry and NMR. Thermogravimetric analysis was employed to investigate the thermal behavior of the complexes. Biological screenings revealed that the synthesized complexes possess significant antioxidant, anti-tubercular, and antimicrobial activities, showing higher potency than the parent ligands.

KEY WORDS: BIOLOGICAL ASPECT, THERMAL STUDY, OFLOXACINE, METAL COMPLEXES.

1. INTRODUCTION

Coumarins are versatile compounds whose biological effectiveness can be fine-tuned through structural modifications.[1-5] This adaptability, combined with their extensive utility, has sustained significant scientific interest in coumarin chemistry for decades. Research has demonstrated that many novel derivatives possess substantial anti-HIV and cytotoxic properties when tested both in vitro and in vivo.[6-9] Beyond these uses, they function as antioxidants, anti-inflammatories, anticoagulants, and antibacterials, while also serving as plant growth regulators or industrial additives in cosmetics, perfumes, and food.[10-16] A major area of focus involves the ability of coumarins to form complexes with various metal ions. Integrating metals—such as copper, iron, or platinum—with the coumarin moiety often preserves or significantly amplifies the compound's biological potency, particularly against tumor cells.[17-20] Recent literature indicates that certain metal-coumarin complexes exhibit therapeutic activities comparable to established drugs like carboplatin.[21-24]

Ofloxacin is an antibiotic useful for the treatment of a number of bacterial infections.[25-27] When taken by mouth or injection into a vein this includes pneumonia, cellulitis, urinary tract infections, prostatitis, plague and certain types of infectious diarrhea.[28-30] Other uses, along with other medications, include multidrug resistant tuberculosis. An eye drop may be used for a superficial bacterial infection of the eye and an ear drop may be used for otitis media when there is a hole in the ear drum.[31-33]

Quinolones (quinolone-carboxylic acids or 4-quinolones) are a group of synthetic antibacterial agents that act as antibacterial drugs by inhibiting effectively DNA replication and are commonly used as treatment for many infections [34]. Ofloxacin is one of the most frequently used fluorinated quinolones antibiotics in the world [35]. It has a broad spectrum of activity against gram-positive, gram-negative aerobic, facultatively anaerobic bacteria, chlamydiae, and some related organisms,

such as mycoplasmas or mycobacteria [36]. Moreover, Schiff bases play an important role in bioinorganic chemistry as they exhibit remarkable biological activity.[37]

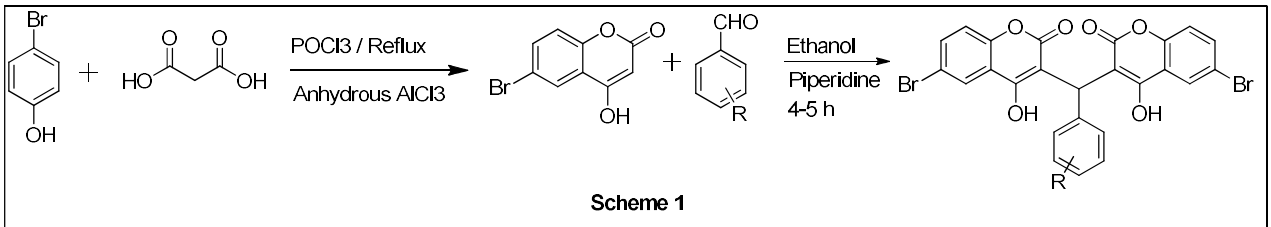
The aim of this study was to prepare the mixed ligand complexes of Ni(II) using ofloxacen with dicoumarol derivatives and to determine their properties. In present work, we describe synthesis, characterization, Thermal, Biological and spectroscopic features of new mixed ligand Cu(II) and Ni(II)complexes.

2. EXPERIMENTAL

Materials

All reagents were of analytical reagent (AR) grade purchased commercially from Spectro chem. Ltd., Mumbai-India and used without further purification. Solvents employed were distilled, purified and dried by standard procedures prior to use [38-39]. Clioquinol was purchased from Agro Chemical Division, Atul Ltd., Valsad-India. The metal nitrates used were in hydrated form.

2.3 General procedure for the preparation of Coumarine chalcone (L)



Scheme 1

Where R = *p*-OH (L^1); *m*-Cl (L^2); *H* (L^3); *m*-NO_2 (L^4); *p*-CH_3 (L^5);

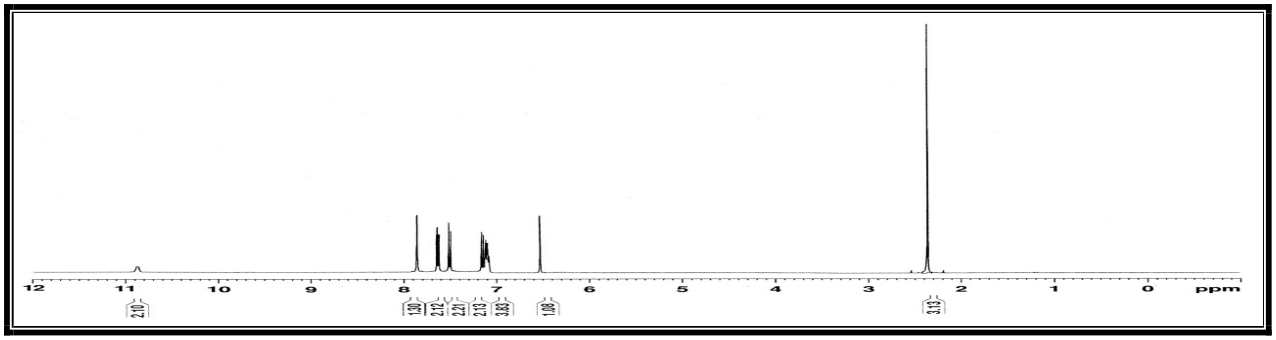


Figure 1. ^{1}H NMR Spectra of L5

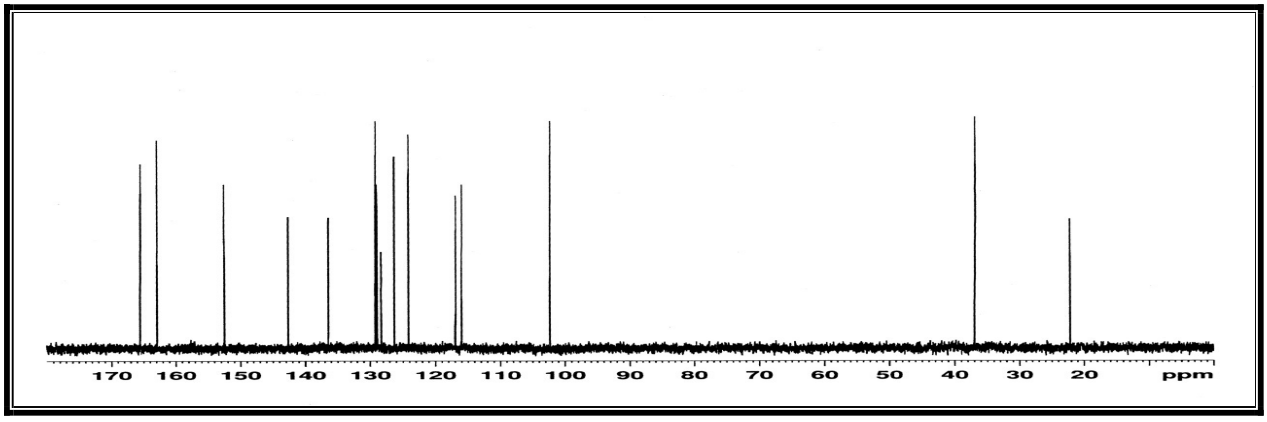


Figure 2. ^{13}C NMR Spectra of L5

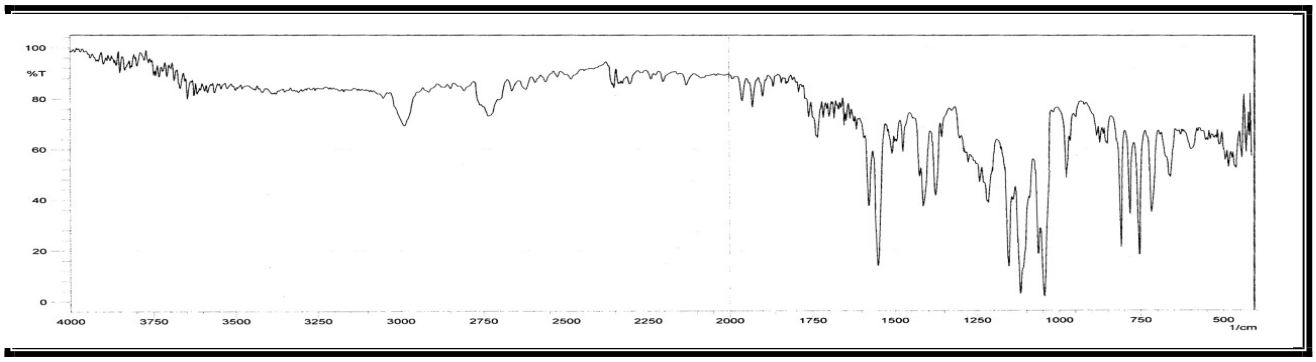


Figure 3. IR Spectra of L5

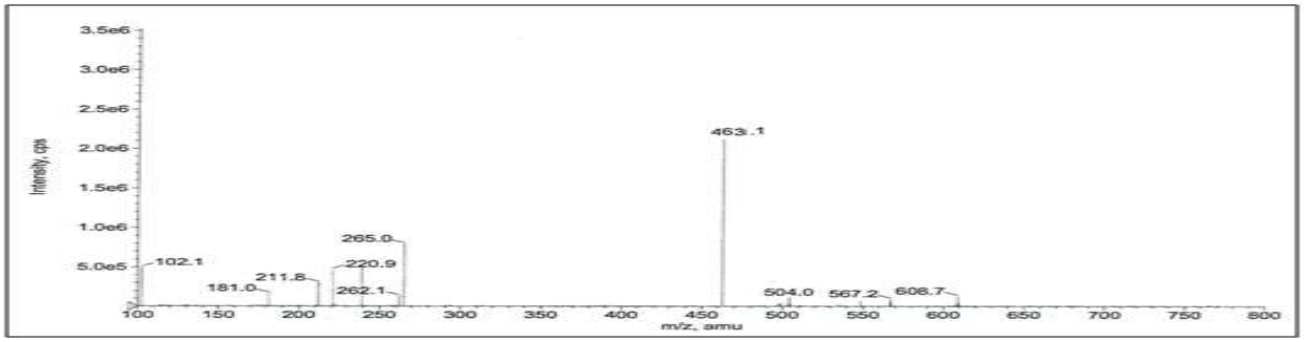
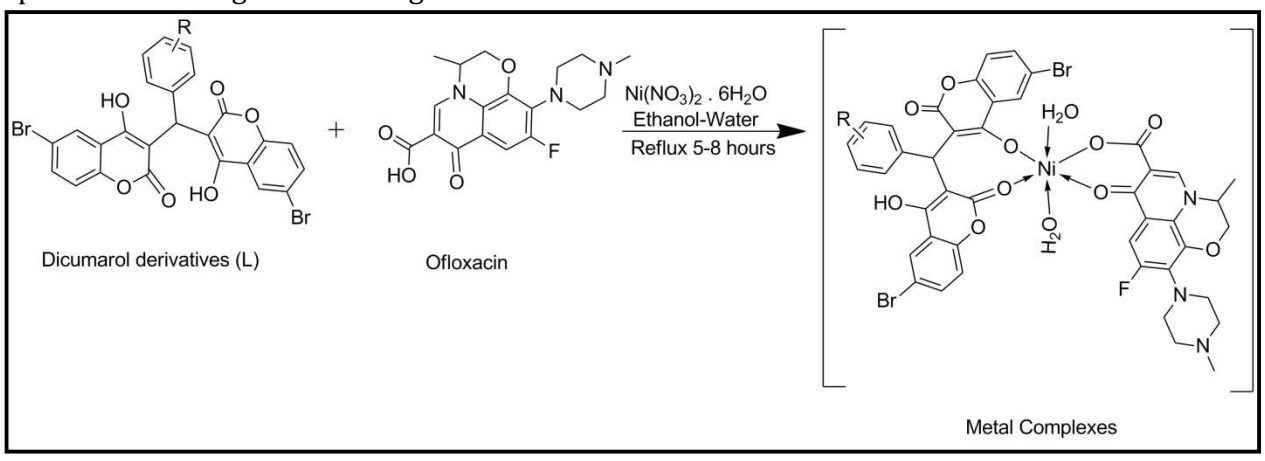


Figure 4. Mass Spectra of L5

2.4 Synthesis of metal complexes: $[M(L)(NF)(H_2O)_2](C)$

An aqueous solution of $Ni(NO_3)_2 \bullet 3H_2O$ salt (10 mmol) was added into ethanolic solution of ligand (L) (10 mmol) and subsequently an ethanolic solution of Ofloxacine (10 mmol) was added with continuous stirring. Then the pH was adjusted in between 4.5-6.0 by addition of diluted NH_4OH solution. The resulting solution was refluxed for 5 h and then heated over a steam bath to evaporate up to half of the volume. The reaction mixture was kept overnight at room temperature. A fine coloured crystalline product was obtained. The obtained product was washed with ether and dried over vacuum desiccators.

Complexes C_2-C_5 was prepared according to same method and their physicochemical parameters are summarized in Table 1. The synthetic protocol of complexes is shown in Scheme 2, while FT-IR spectrum of C_1 is given in the figure 5.



Scheme 2: Genaral scheme for metal complexes

3. RESULT AND DISCUSSION

The synthesized Ni(II) complexes were characterized by elemental analysis, FTIR spectra, The metal ion in their complexes were determined after mineralization. The metal content in chemical analysis was estimated by complexometrically[40], while geometry of the complexes was confirmed from thermogravimetry anlysis, electronic spectra and magnetic moment.

3.1 Elemental analysis

The analytical and physiochemical data of the complexes are summarized in Table 1. The experimental data were in very good agreement with the calculated ones. The complexes were colored, insoluble in water and commonly organic solvents while soluble in DMSO as well as stable in air. The structure of the complexes is assumed according to the chemical reaction as shown below;

Table 1 Analytical and physical parameters of complexes:

Comps.	Elemental analyses, % found (required)				M.P. (°C)	Yield (%)	Molecular weight	μeff/B.M.
	C	H	N	Ni(II)				
C1	56.55(56.65)	4.31(4.42)	4.50(4.58)	6.28(6.41)	>350	71	934.39	1.82
C2	56.46(56.66)	4.13(4.29)	4.41(4.56)	6.16(6.28)	>350	71	952.93	1.84
C3	57.54(57.63)	4.39(4.50)	4.65(4.81)	4.57(4.69)	>300	69	918.49	1.83
C4	54.85(54.96)	4.08(4.28)	5.82(5.92)	6.09(6.18)	>350	72	963.49	1.88
C5	57.96(58.04)	4.54(4.69)	4.51(4.62)	6.29(6.37)	>350	66	932.52	1.85

3.2 FT-IR spectra

The coordination sites of ligand are elucidated using IR. The IR band assignments of dicoumarol derivatives and its complexes are included in Table 2. The IR data of free ligands and its metal complexes were carried out within the IR range 4000-400 cm^{-1}. The IR spectra of the dicoumarol derivatives show weak bands at ~3125-3055 cm^{-1} and ~1323-335 cm^{-1}, corresponding to ν(O–H) and ν(C–OH) respectively. On complexation O–H peak has nowhere to be found, indicate that deprotonation of O–H proton. The ν(C=O) of lactone rings observed at ~1645 and 1657 cm^{-1} in free ligand is shifted to lower frequencies (~12-14 cm^{-1} and 40-50 cm^{-1}) due to complex formation, and further supported by shifting of ν(C–C), ν(C–O), and ν(C–O–C) stretch frequencies to higher values. Two bands at ~1615 and ~1563 cm^{-1} were assigned to stretching vibration of conjugate double bonding in the free ligand. These data are further supported by ν(Ni–O) which appear at ~522 cm^{-1}. (Fig.5)

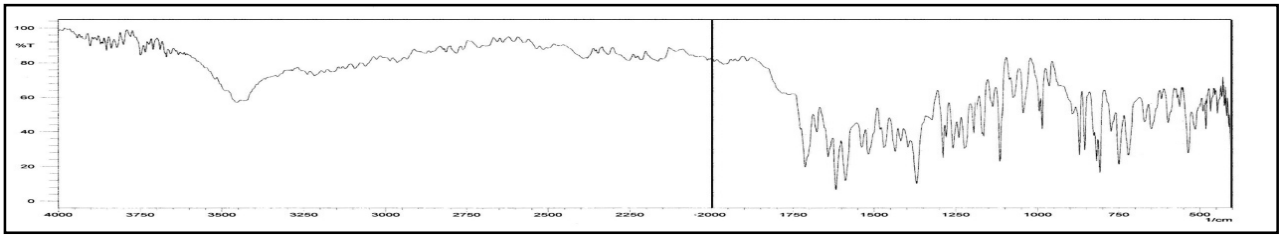


Figure 5. FT IR Spectrum of C_4

Table 2 FT-IR data of synthesized compounds

Sample No.	υ(O-H) cm^{-1} (br)	υ(C=O) cm^{-1}	υ(C=C) cm^{-1}	υ(C-C), υ(C-O), υ(C-O-C) cm^{-1}	υ(C=O) of pyridine cm^{-1}	$\upsilon(COO)_s$ cm^{-1}	$\upsilon(COO)_a$ cm^{-1}	Δν	υ(Cu-O) cm^{-1} (w)
C^1	3433	1636, 1603	1583	1182.1143,1124, 854,725	1632	1364	1575	212	562
C^2	3435	1654, 1604	1592	1191,1154,1126, 836,754	1622	1364	1575	215	566
C^3	3433	1654, 1613	1584	1193.1147,1123, 856,752	1634	1362	1586	214	565
C^4	3422	1656, 1613	1584	1196,1136,1132, 833,756	1624	1362	1572	204	567
C^5	3444	1655, 1613	1585	1189,1135,1127, 837,750	1621	1374	1574	215	565

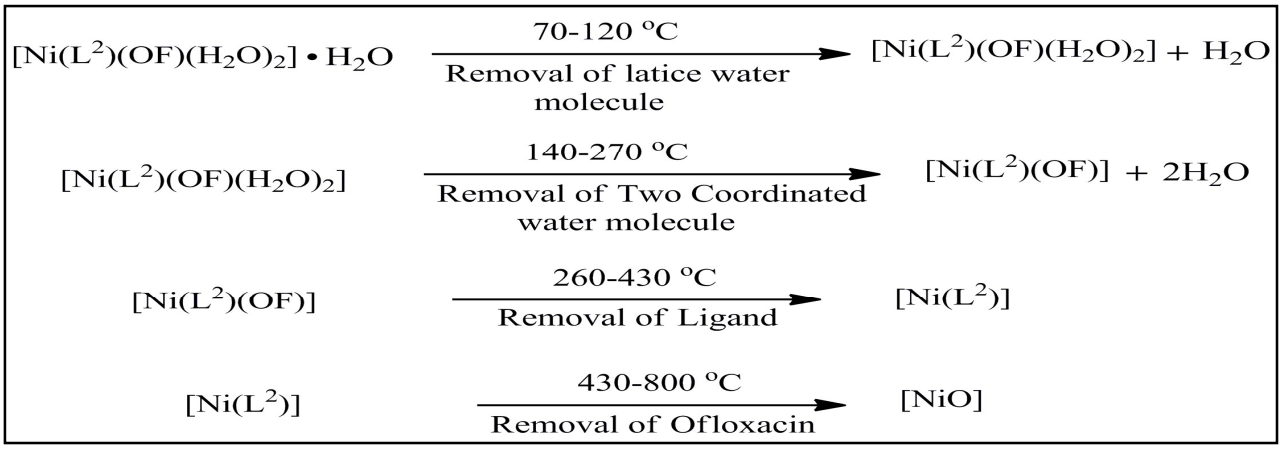
3.3 Thermal studies of synthesized complexes

Thermal data and kinetic parameters of the complexes are given in Tables 3 and 4, respectively. The typical TG curves of the complexes $[Ni(L^2)(OF)(H_2O)_2]\bullet H_2O$ are characterized in Figure 6. Thermal fragmentation for complexes $[Ni(L^2)(OF)(H_2O)_2]\bullet H_2O$ is shown in Scheme 3. The anhydrous complexes show enormous thermal stability up to 250 °C. Next two steps were occurring exothermic and endothermic related with removal of coordinated ligand (coumarins) as well as Ofloxacin respectively. In the third subsequent stage, the decomposition and combustion of ligand(loss 53.23%) occurs at 260-430 °C. Where in fourth subsequent stage for complex show the decomposition and combustion of Ciprofloxacin (loss 36.59%) occurs at 500-780°C. The removal of Ofloxacin undergoes decomposition forming NiO as the final residue.

The thermodynamic activation parameters of the decomposition process of dehydrated complexes, such as activation entropy (*ΔS*), pre-exponential factor (*A*), activation enthalpy (*ΔH*) and free energy of activation (*ΔG*), were calculated using the reported equations [41] and are tabulated in Table 4. According to the kinetic data obtained from DTG curves corresponding to the complex (C^2) is represented in Figure 3, all the complexes have negative entropy, which indicates that the studied complexes have more ordered systems than reactants [42]. The kinetic parameters, mainly energy of activation (*E*a) was useful in conveying the strength of the bonding of ligand moieties with the metal ion. The calculated *E*a values of the investigated complexes for the dehydration stage of ligand (A^n) were in the range 3.20-3.82 kJ mol^{-1}. The relatively high *E*a value indicates that the ligand (A^n) is strongly bonded the metal ion. The final solid product of decomposition was NiO (7.45%) accompanied by broad exothermic effect on above 800 °C.

Table 3 Thermoanalytical results (TG and DTG) of metal complexes

Complexes	TG range/ ˚C	DTG_{max}/ ˚C	Mass loss% obs. (calcd.)	Assignment
C_1	70-380	235	53.34(53.76)	Loss of Two H_2O molecules
		343		Removal of L^1 ligand
	380-800	552	37.25	Removal of Ofloxacin ligand
		>650	8.19	Leaving NiO residue
C_2	70-370	83	54.75(51.92)	Loss of one lattice water molecules
		219		Loss of two H_2O molecules
		305		Removal of L^2 ligand
	380-800	540	36.59	Removal of Ofloxacin ligand
		>650	9.45	Leaving NiO residure
C_3	80-380	95	54.35(54.62)	Loss of 0ne lattice water molecules
		245		Loss of two H_2O molecules
		354		Removal of L^3 ligand
	380-800	562	38.16	Removal of Ofloxacin ligand
		>650	7.33	Leaving NiO residure
C_4	80-375	98	54.28(54.46)	Loss of two lattice water molecules
		232		Loss of two H_2O molecules
		354		Removal of L^4 ligand
	375-800	568	38.30	Removal of Ciprofloxacin ligand
		>650	7.30	Leaving NiO residure
C_5	70-370	93	53.15(53.49)	Loss of one lattice water molecules
		247		Loss of two H_2O molecules
		355		Removal of L^5 ligand
	370-800	545	39.11	Removal of Ciprofloxacin ligand
		>650	7.49	Leaving NiO residure



Scheme 3. Thermal fregamentation of complexe $[Ni(L^2)(OF)(H_2O)_2]\cdot H_2O$

Table 4 Thermodynamic data of the thermal decomposition of metal complexes

Compounds	TG range/ °C	E_a/kJ mol^{-1}	n	A/s^{-1}	S*/J K^{-1} mol^{-1}	H*/kJ mol^{-1}	G*/kJ mol^{-1}
C^1	60-380	3.37	0.99	0.142	-104.45	0.588	32.12
	380-800	8.0	1.31	0.059	-101.14	0.020	44.37
C^2	70-380	3.20	1.15	0.102	-103.23	0.226	37.03
	380-800	8.7	1.25	0.082	-101.21	0.030	45.68
C^3	80-380	3.82	1.09	0.181	-101.09	0.756	38.70
	380-800	10.02	1.21	0.025	-98.12	0.89	43.10
C^4	80-380	3.76	1.35	0.168	-109.86	0.843	35.05
	380-800	3.47	1.31	0.073	-95.56	0.076	53.11
C^5	70-380	3.33	0.97	0.152	-104.76	0.587	32.97
	380-800	10.05	1.18	0.061	-103.43	0.061	48.58

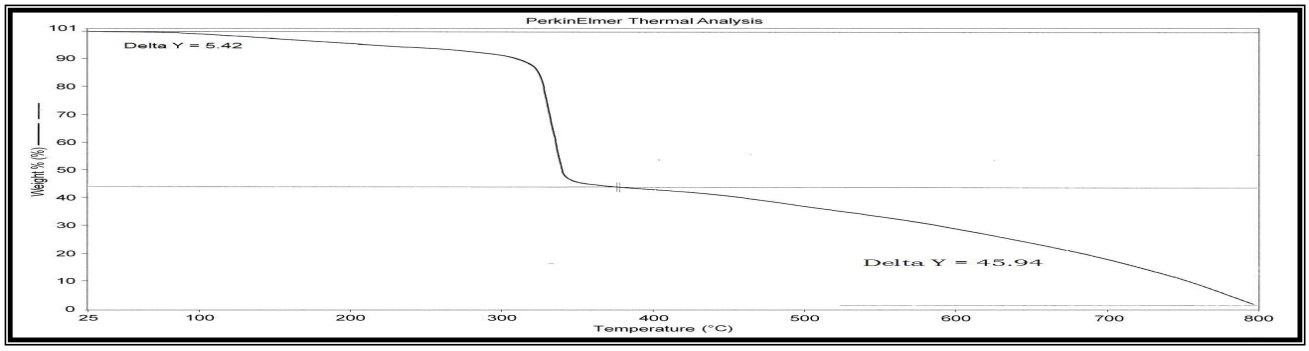


Figure 6. FT IR Spectrum of C_2

3.4 Antimicrobial bioassay

The ligand and its metal complexes were screened for their antibacterial and antifungal activities according to the respective literature protocol and the results obtained are presented in Table 4. The results were compared with those of the standard drug. All the metal complexes were more potent bactericides and fungicides than the ligand. C_3 and C_4 complexes were much less bacterial activity than the C_2 and C_5 complex while C_1 complex shows superior antifungal activity compare to other complexes. From Table 4,

3.5 Antioxidant studies

A capacity to transfer a single electron i.e. the antioxidant power of all compounds was determined by a FRAP assay. The FRAP value was expressed as an equivalent of standard antioxidant ascorbic acid (mmol/100 g of dried compound). FRAP values indicate that all the compounds have a ferric reducing antioxidant power. The compounds C_3 and C_4 showed relatively high antioxidant activity while compound C_1, C_5 and C_2 shows poor antioxidant power (Table 4).

Table 4 Antimicrobial, Anti-tubercular and antioxidant results of compounds

Antimicrobial Activity (Minimal Inhibition Concentration, in µg/mL)							Antioxidant Activity
Compounds	Gram negative bacteria		Gram positive bacteria		Fungus		FRAP value (mmol/100 g)
	E. coli	*P. aeruginosa*	*S. pyogenes*	*B. subtilis*	*C. albicans*	*A. niger*	

L1	**200**	**200**	**400**	**400**	**200**	**400**	**NT**
L2	**100**	**200**	**100**	**200**	**200**	**200**	**NT**
L3	**400**	**200**	**200**	**600**	**200**	**200**	**NT**
L4	**100**	**100**	**100**	**200**	**200**	**200**	**NT**
L5	**400**	**400**	**400**	**>600**	**400**	**200**	**NT**
C1	**40**	**70**	**40**	**40**	**100**	**100**	**82.44**
C2	**100**	**100**	**100**	**100**	**200**	**100**	**75.76**
C3	**100**	**100**	**100**	**200**	**100**	**100**	**54.05**
C4	**70**	**100**	**100**	**100**	**100**	**100**	**63.92**
C5	**70**	**100**	**70**	**100**	**100**	**100**	**86.32**
Norfloxacin	**10**	**10**	**10**	**10**	**NT**	**NT**	**NT**
Flucanazole	**NT**	**NT**	**NT**	**NT**	**10**	**10**	**NT**
Nystatin	**NT**	**NT**	**NT**	**NT**	**100**	**100**	**NT**
***E. Coli*= ATCC25922; *P. aeruginosa*= ATCC25619; *S. pyogenes*= ATCC12384 ; *B. subtilis*= ATCC11774 ; *C.albicans*= ATCC 66027; *A.niger*= ATCC 64958** **NT= Not tested**							

4. CONCLUSIONS

Here elucidate the synthesis of biological active coumarin derivatives and their Ni(II) complexes (C_1-C_5). Octahedral geometry were allocate for Ni(II) complexes on the basis of Thermogravimetry analysis and magnetic moment. Complexes shows momentous effective antioxidant activities compared to their ligand employed for complexation. In vitro antimicrobial activity of all synthesized compounds show good results with an enhancement of activity on complexation with metal ions. This enhancement in the activity may be attributed to increased lipophilicity of the complexes. The structures of the ligands were investigated and confirmed by the elemental analysis, FT-IR, ^{1}H-NMR, ^{13}C-NMR and mass spectral studies.

REFERENCES:

[1] E. Gikas, M. Parissi-Poulou, M. Kazanis, A. Vavagiannis, J. Mol. Struct. 724 (2005) 135-142.

[2] H. Zhao, N. Neamati, H. Hong, A. Mazumder, J. Med. Chem. 40 (1997) 242-249.

[3] L.D. Raev, E. Voinova, I.C. Ivanov, D. Popov, Pharmazie 45 (1990) 696-702.

[4] I. Kostova, Curr. Med. Chem. 5 (2005) 29-46.

[5] L.M. Bedoya, M. Beltran, R. Sancho, D.A. Olmedo, S. Sanchez-Palomino, E. del lmo, J.L. Lopez-Perez, E. Munoz, A. San Feliciano, J. Alcam, Bioorg. Med. Chem. Lett. 15 (2005) 4447-4450.

[6] K.H. Lee, J. Nat. Prod. 67 (2004) 273-283.

[7] T. Suvit, K.T. Paul, D.W. Keith, Kong-Teck Chong, W.J. Howe, Chih-Ping Yang, W.J. Strohbach, R.S. Turner, P.J. McGrath, J. Med. Chem. 37 (1994) 3200-3204.

[8] S. Kirkiacharian, D.T. Thuy, S. Sicsic, R. Bakhchinian, R. Kurkjian, T. Tonnaire, II Farmaco 57 (2002) 703-708.

[9] G. Appendino, E. Mercalli, N. Fuzzati, L. Arnoldi, M. Stavri, S. Gibbons, M. Ballero, A. Maxia, J. Nat. Prod. 67 (2004) 2108-2110.

[10] K.M. Khan, Z.S. Saify, M.Z. Khan, M.I. Zia-Ullah, Choudhary, S. Atta-Ur- Rahman, Z.H. Perveen, C.T. Chohan, Supuran, J. Enzyme Inhib. Med. Chem. 19 (2004) 373-379.

[11] B.H. Lee, M.F. Clothier, F.E. Dutton, G.A. Conder, S.S. Johnson, Bioorg. Med. Chem. Lett. 8 (1998) 3317-3320.

[12] C.A. Kontogiorgis, D. Hadjipavlou-Litina, J. Med. Chem. 48 (2005) 6400-6408.

[13] M. Ghate, D. Manohar, V. Kulkarni, R. Shobha, S.Y. Kattimani, Eur. J. Med. Chem. 38 (2003) 297-302.

[14] A.M. Silvan, M.J. Abad, P. Bermejo, M. Sollhuber, A. Villar, J. Nat. Prod. 59 (1996) 1183-1185.

[15] D.N. Nicolaides, K.C. Fylaktakidou, K.E. Litinas, D. Hadjipavlou-Litina, Eur. J. Med. Chem. 33 (1998) 715-724.

[16] H.G. Raj, V.S. Parmar, S.C. Jain, S. Goel, Pooman, S. Himanshu, A. Malhotra, C.E. Singh, J. Olsen, Wengel, Bioorg. Med. Chem. 6 (1998) 833-839.

[17] C.A. Kontogiorgis, D. Hadjipavlou-Litina, Bioorg. Med. Chem. Lett. 14 (2004) 611-614.

[18] U.P. Masche, K.M. Rentsch, Avon Felten, P.J. Meier, K.E. Fittinger, Eur. J. Clin. Pharmacol. 54 (1999) 865-868.

[19] G. Luzzatto, F. Fabris, R. Dal Bo Zanon, A. Giralami, Arzneim. Forsch. 36 (1986) 972-979.

[20] I.P. Kostova, I. Manolov, I. Nicolova, N. Danchev, II Farmaco 56 (2001) 707-713.

[21] H.B. Singh, Acta. Cienc. Acta Cienc. Indica Ser. Chem. 6 (1980) 88-91.

[22] M.P. Teotia, D.K. Rastogi, W.U. Malik, Inorg. Chim. Acta. 7 (1973) 339-344.

[23] A.U. Mandakmare, M.L. Navwade, Orient J. Chem. 13 (1997) 155-158.

[24] A.L. El-Ansary, M.M. Omar, Egypt. J. Chem. 31 (1988) 511-520.

[25] I.P. Kostova, I. Manolov, I. Nicolova, S. Konstantinov, M. Karaivanova, Eur. J. Med. Chem. 36 (2001) 339-347.

[26] I.P. Kostova, I. Manolov, S. Konstantinov, M. Karaivanova, Eur. J. Med. Chem. 34 (1999) 63-68.

[27] I.I. Manolov, I.P. Kostova, S. Konstantinov, M. Karaivanova, Eur. J. Med. Chem. 34 (1999) 853-858.

[28] E. Budzisz, U. Krajewska, M. Róz˙ alski, Pol. J. Pharmacol. 56 (2004) 473-478.

[29] E. Budzisz, M. Małecka, I.P. Lorenz, P. Mayer, R.A. Kwiecien , P. Paneth, U. Krajewska, M. Róz˙ alski, Inorg. Chem. 45 (2006) 9688-9695.

[30] M. Miernicka, A. Szulawska, M. Czyz, I.P. Lorenz, P. Mayer, B. Karwowski, E. Budzisz, J. Inorg. Biochem. 102 (2008) 157-165.

[31] E. Budzisz, B.K. Keppler, G. Giester, M. Woznicka, A. Kufelnicki, B. Nawrot, Eur. J. Inorg. Chem. 22 (2004) 4412-4419.

[32] E. Budzisz, B.K. Keppler, M. Małecka, B. Keppler, V.B. Arion, G. Andrijewski, U. Krajewska, M. Róz˙ alski, Eur. J. Inorg. Chem. 23 (2007) 3728-3735.

[33] Y.K. Tyagi, Eur. J. Med. Chem. 40 (2005) 413-420.

[34] I. Turel, Coord. Chem. Rev. 232 (2002) 27.

[35] A.R.A. Abd-Allah, B.B. Gannam, F.M.A. Hamada, Pharm. Res. 42 (2000) 145.

[36] W.E. Sanders Jr., Clin. Infect. Dis. 14 (1992) 539.

[37] L. Savanini, L. Chiasserini, A. Gaeta, C. Pellerano, Bioorg. Med. Chem. 10 (2002)2193.

[38] A.I. Vogel, Textbook of Practical Organic Chemistry, fifth ed., Longman, London, 1989.

[39] M.V. Angelusiu, S.F. Barbuceanu, C. Draghici, G.L. Almajan, Eur. J. Med. Chem. 2010) 2055-2062.

[40] V.P. Singh, A. Katiyar, Pestic. Biochem. Physiol. 92 (2008) 8-14.

[41] C. K. Modi, S. H. Patel, M. N. Patel, *J. Therm. Anal. Cal.* 2007, 87, 441.

[42] M. E. El-Zaria, *Spectrochim. Acta. A* 2008, 69, 216.