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ISSN (Print): 2320-7620
"Peer Reviewed & Refereed Journal"

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"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
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View of Space International Multidisciplinary Journal of Applied Research

ISSN (Print): 2320-7620

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DETECTION OF DENGUE VIRUS SEROTYPES IN MOSQUITOES FROM VARIOUS SETTINGS OF RAJASTHAN TO ASSESS THE RISK OF DENGUE HEMORRHAGIC FEVER

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ABSTRACT

Dengue is one of the most significant mosquito-borne viral infections affecting tropical and subtropical regions worldwide. It is caused by four antigenically distinct serotypes of dengue virus (DENV-1 to DENV-4), each capable of causing a spectrum of disease ranging from mild febrile illness to severe manifestations such as Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS). Increasing evidence suggests that the prevalence, co-circulation, and sequential infection of different serotypes play a critical role in determining disease severity. This review comprehensively examines the global and regional distribution of dengue virus serotypes and explores their correlation with the development of DHF. Special emphasis is placed on immunopathological mechanisms such as antibody-dependent enhancement (ADE), viral genetic variability, and host immune responses. Understanding these relationships is essential for predicting outbreaks, improving surveillance systems, and guiding vaccine and public health strategies.

KEY WORDS: AEDES, DENV, DHF, ADE

1. INTRODUCTION

Dengue has emerged as a rapidly spreading arboviral disease with a substantial burden on global public health systems (1,15). The World Health Organization estimates that nearly half of the world's population is at risk of dengue infection (1), with millions of cases reported annually. The disease is transmitted primarily by *Aedes aegypti* mosquitoes, which thrive in urban and semi-urban environments, making dengue closely associated with rapid urbanization, population growth, and climate change (14). A unique feature of dengue infection is the existence of four distinct but closely related viral serotypes. Infection with one serotype provides lifelong immunity against that specific serotype but only partial and transient protection against others. Subsequent infection with a different serotype has been strongly associated with severe disease outcomes, like DHF and DSS due to complex immunological interactions (1,4,7). The increasing incidence of dengue, driven by urbanization, globalization, and climate change, has made DHF a significant public health concern. DHF is characterized by plasma leakage, bleeding manifestations, and organ impairment. The disease predominantly occurs in individuals experiencing secondary infection with a heterologous dengue virus serotype, highlighting the central role of immune-mediated mechanisms in disease progression. Therefore, understanding serotype prevalence and dynamics is crucial for assessing disease risk and severity patterns.

2. DENGUE VIRUS: STRUCTURE, SEROTYPES, AND GENETIC DIVERSITY

Dengue virus belongs to the genus *Flavivirus* within the family *Flaviviridae*. It is an enveloped, single-stranded positive-sense RNA virus. The viral genome encodes three structural proteins

(capsid, membrane, and envelope) and seven non-structural proteins that play roles in replication and immune evasion.

The four serotypes - DENV-1, DENV-2, DENV-3, and DENV-4 are genetically and antigenically distinct (2,5). Despite sharing approximately 65–70% sequence homology, each serotype elicits a unique immune response. Within each serotype, multiple genotypes exist, contributing to genetic diversity and differences in virulence, transmissibility, and epidemic potential.

Certain serotypes and genotypes have been historically associated with severe disease. For instance, DENV-2 and DENV-3 are often linked with more severe outbreaks and higher incidences of DHF (2,4,5). Genomic studies have demonstrated that emerging strains often exhibit enhanced virulence and epidemic potential (5,11). However, disease severity cannot be attributed solely to serotype; it is influenced by a complex interplay of viral, host, and environmental factors.

3. GLOBAL AND REGIONAL PATTERNS OF SEROTYPE PREVALENCE

The distribution of dengue virus serotypes is dynamic and varies across geographical regions and time periods. In many endemic regions, multiple serotypes co-circulate, a condition known as hyperendemicity (3,4). This phenomenon significantly increases the likelihood of secondary infections and, consequently, severe disease outcomes.

In Southeast Asia, all four serotypes frequently circulate simultaneously, contributing to a high burden of DHF cases. Countries like Thailand, Indonesia, and the Philippines have reported cyclical dominance of different serotypes, often associated with periodic outbreaks of severe dengue.

In the Indian subcontinent, including India, frequent shifts in dominant serotypes have been documented. DENV-1 and DENV-3 have been predominant in some outbreaks, while DENV-2 has been strongly associated with severe disease and increased mortality (2,6). Co-infections with multiple serotypes have also been reported, further complicating clinical outcomes.

Similarly, reports from the Americas indicate re-emergence of DENV-4 alongside other serotypes, contributing to complex epidemiological patterns (4). Africa, although historically underreported, is now witnessing increasing dengue activity with multiple circulating serotypes.

Temporal shifts in serotype dominance are particularly important, as the introduction of a new serotype into a population with pre-existing immunity to another serotype often precedes severe outbreaks (4,11).

4. IMMUNOPATHOGENESIS OF DENGUE HEMORRHAGIC FEVER

The progression from classical dengue fever to DHF is primarily driven by immunopathological mechanisms rather than direct viral cytopathic effects. Among these mechanisms, antibody-dependent enhancement (ADE) is considered the most critical factor in disease severity.

During a primary infection, the host develops neutralizing antibodies specific to the infecting serotype. However, during a secondary infection with a different serotype, pre-existing antibodies may bind to the virus without neutralizing it. These non-neutralizing antibodies facilitate viral

entry into Fc receptor-bearing cells such as monocytes and macrophages, enhancing viral replication (4,7,8,15).

This increased viral load triggers an exaggerated immune response characterized by the release of pro-inflammatory cytokines and chemokines, commonly referred to as a "cytokine storm." This leads to endothelial dysfunction, increased vascular permeability, and plasma leakage—hallmarks of DHF (9).

In addition to ADE, T-cell responses, complement activation, and host genetic factors also contribute to disease severity. Cross-reactive T-cells may produce excessive cytokines, exacerbating inflammation. Host genetic factors further influence susceptibility to severe disease (7,8).

Certain viral strains possess enhanced virulence due to genetic mutations that improve replication efficiency or immune evasion. These strains are often associated with severe outbreaks and higher mortality rates (5,11).

5. CORRELATION BETWEEN SEROTYPE DYNAMICS AND DHF RISK

A strong correlation exists between dengue virus serotype dynamics and the incidence of DHF. Epidemiological studies consistently demonstrate that secondary infection with a heterologous serotype significantly increases the risk of severe disease (1,4,7).

Regions with hyperendemic transmission, where multiple serotypes co-circulate, exhibit higher rates of DHF compared to regions with monotypic transmission. The risk is further amplified when a new serotype or genotype is introduced into a population with prior exposure to a different serotype.

For example, outbreaks dominated by DENV-2 following prior circulation of DENV-1 have frequently resulted in increased DHF cases (2,6,12). Similarly, the emergence of DENV-3 in previously exposed populations has been linked to severe epidemics. Additionally, genotype shifts within serotypes have been associated with increased virulence and epidemic severity. Studies have demonstrated that emerging genotypes can alter disease patterns and increase hospitalization rates (4,11).

Co-infection with multiple serotypes in a single individual has also been reported, although its exact role in disease severity remains under investigation. Nevertheless, the overall evidence highlights the importance of serotype diversity and sequential exposure in determining clinical outcomes.

6. DIAGNOSTIC AND SURVEILLANCE IMPLICATIONS

Accurate identification of circulating dengue serotypes is essential for effective disease surveillance and outbreak prediction. Molecular techniques such as reverse transcription polymerase chain reaction (RT-PCR) enable early detection and precise serotyping, while recent advances in diagnostic strategies, including biosensors and antigen-based rapid tests, have significantly improved early case detection (10,12). Serological methods, including ELISA, are widely used for detecting antibodies but may not differentiate between serotypes.

Continuous surveillance of serotype distribution in both human populations and mosquito vectors provides valuable insights into transmission dynamics. Monitoring changes in serotype prevalence can serve as an early warning system for potential outbreaks of severe dengue.

Integration of genomic sequencing into surveillance programs has further enhanced the ability to track viral evolution and identify emerging genotypes associated with increased virulence (4,11).

7. PUBLIC HEALTH SIGNIFICANCE

Understanding the relationship between serotype prevalence and DHF risk has significant implications for public health planning and intervention strategies. Early detection of serotype shifts can enable timely implementation of vector control measures, community awareness programs, and clinical preparedness (1,13).

Vaccine development also relies heavily on knowledge of serotype dynamics. The currently available dengue vaccines show variable efficacy, and inadequate protection against certain serotypes may increase the risk of severe disease (7). Therefore, region-specific serotype data are crucial for optimizing vaccination strategies.

8. FUTURE PERSPECTIVES

Future research should focus on developing more effective tetravalent vaccines with balanced immunity against all serotypes. Advances in genomic surveillance and bioinformatics can provide deeper insights into viral evolution and transmission patterns.

Additionally, integrating environmental, climatic, and epidemiological data into predictive models can improve outbreak forecasting. Further studies on host immune responses and molecular mechanisms of ADE may lead to targeted therapeutic interventions.

9. CONCLUSION

Dengue virus serotype prevalence plays a pivotal role in shaping the epidemiology and severity of dengue infections. The co-circulation of multiple serotypes and sequential heterologous infections significantly increases the risk of Dengue Hemorrhagic Fever through complex immunopathological mechanisms such as antibody-dependent enhancement. Continuous monitoring of serotype dynamics, combined with improved diagnostic, surveillance, and preventive strategies, is essential to mitigate the global burden of dengue and reduce the incidence of severe disease.

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PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF PEARL MILLET (PENNISETUM GLAUCUM L.) TO HEAT AND DROUGHT STRESS UNDER DEESA AGRO-CLIMATIC CONDITIONS

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ABSTRACT

Pearl millet (Pennisetum glaucum L.) is a major climate-resilient cereal cultivated in semi-arid regions of India. The present investigation assessed growth, physiological, and biochemical responses of pearl millet under drought and combined heat + drought stress conditions in Deesa agro-climatic region of Banaskantha district, Gujarat. Significant reductions in plant height (22%), biomass (33%), and grain yield (36%) were recorded under combined stress compared to control. Relative water content and chlorophyll stability declined significantly, while proline accumulation increased by 72%. Elevated malondialdehyde content indicated enhanced lipid peroxidation. Antioxidant enzymes catalase and peroxidase showed marked increases, confirming activation of defense mechanisms. The study confirms pearl millet as a climate-smart crop suitable for semi-arid Gujarat, while highlighting need for stress-resilient genotype selection.

KEYWORDS: PEARL MILLET, DROUGHT STRESS, HEAT STRESS, PROLINE ACCUMULATION & ANTIOXIDANT ENZYMES

CHAPTER 1. INTRODUCTION

Pearl millet is widely cultivated in arid and semi-arid regions due to its adaptability to high temperature and water deficit conditions. Deesa Taluka experiences annual rainfall between 350–500 mm and frequent summer temperatures exceeding 42°C. Climate change has intensified drought episodes and heat waves, affecting crop productivity. Combined stress conditions disrupt photosynthesis, membrane stability, enzyme activity, and yield formation. Plants respond through osmotic adjustment, antioxidant defense activation, and metabolic regulation. Understanding these adaptive responses under local agro-climatic conditions is critical for sustainable agriculture and climate resilience planning.

CHAPTER 2. MATERIALS AND METHODS

Field experiment was conducted during Kharif season using Randomized Block Design with three treatments and three replications. Treatments included Control (optimal irrigation), Drought stress (irrigation withheld at vegetative stage for 15 days), and Heat + Drought stress (temperature >40°C during flowering with moisture deficit). Growth parameters, physiological indices, and biochemical assays were performed using standard laboratory protocols. Data were analyzed using ANOVA at 5% significance level.

CHAPTER 3. RESULTS

Treatment	Plant Height (cm)	Biomass (g/plant)	Grain Yield (q/ha)	RWC (%)	Chlorophyll (SPAD)	Proline (µmol /g FW)	MDA (nmol /g FW)	CAT Activity	POD Activity

Control	168.4	92.5	28.6	86.5	42.3	2.1	1.8	18.4	12.6
Drought	142.6	74.3	22.1	71.2	35.7	3.1	2.6	25.4	17.3
Heat + Drought	130.2	61.8	18.4	65.4	30.8	3.6	3.4	29.7	19.1

Table 1: Growth, Physiological and Biochemical Parameters under Stress Conditions.

CHAPTER 4. GRAPHICAL REPRESENTATION

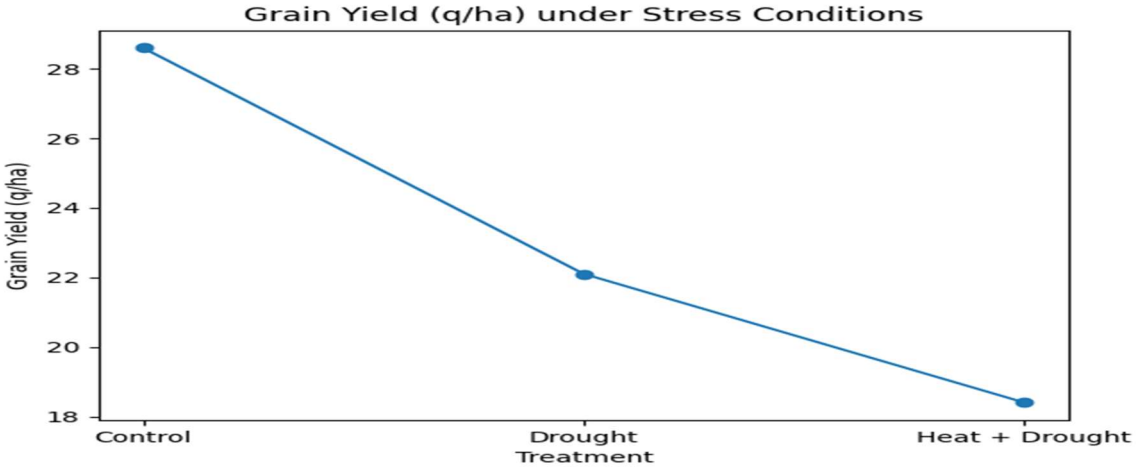


Figure: Grain Yield (qha)

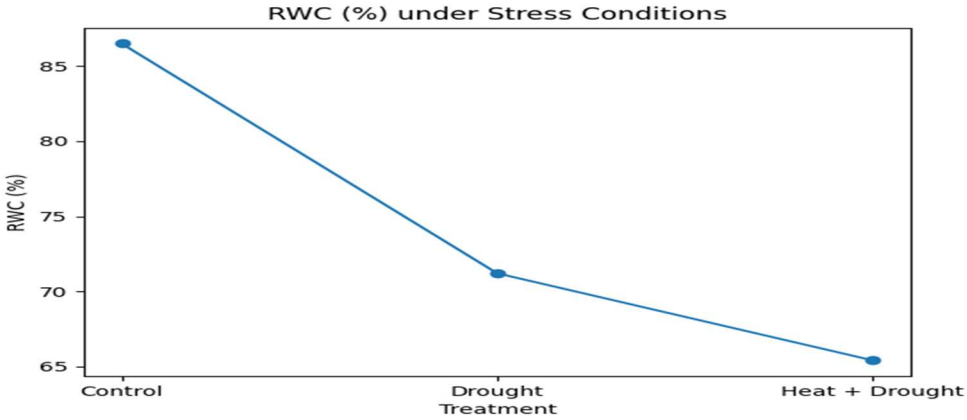


Figure: RWC (%)

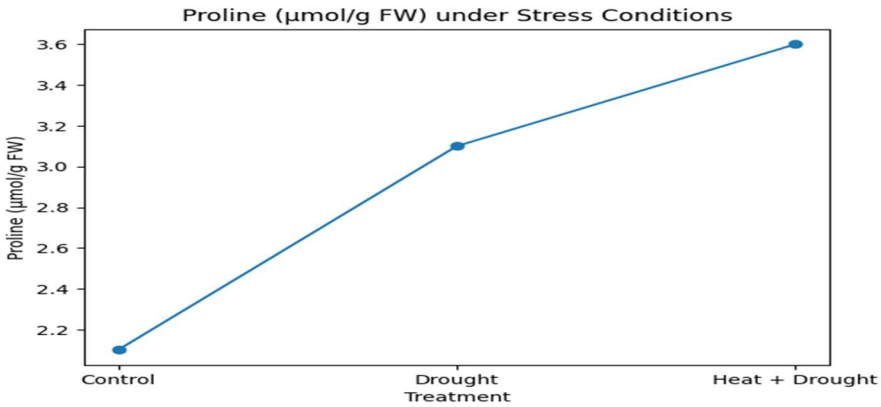


Figure: Proline (µmolg FW)

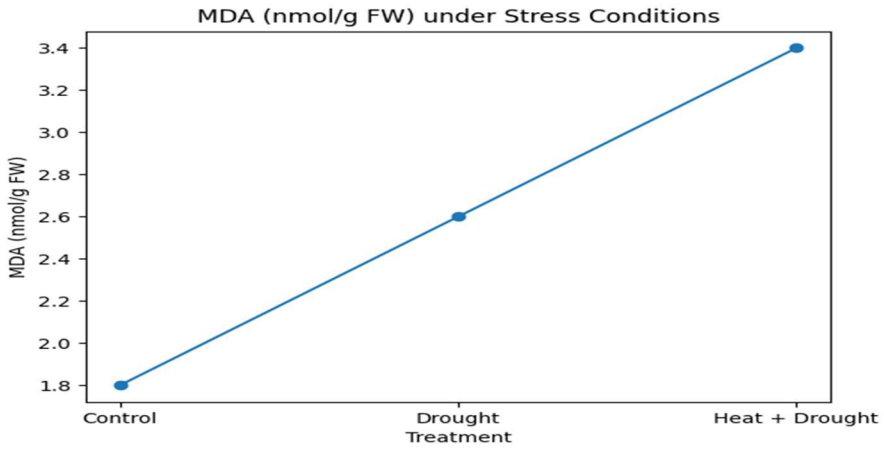


Figure: MDA (nmolg FW)

CHAPTER 5. DISCUSSION

Growth reduction under combined stress may be attributed to impaired cell expansion and metabolic disruption. Decline in relative water content reflects disturbed water relations. Reduced chlorophyll content indicates photosynthetic damage under high temperature. Proline accumulation acts as osmoprotectant and ROS scavenger. Increased MDA content confirms oxidative stress, while elevated catalase and peroxidase activities demonstrate activation of antioxidant defense system. These findings highlight the adaptive capacity of pearl millet under semi-arid climatic stress conditions.

CHAPTER 6. CONCLUSION

Pearl millet exhibits strong physiological and biochemical tolerance under combined heat and drought stress. Despite yield reduction, enhanced osmolyte accumulation and antioxidant defense contribute to resilience. The crop remains suitable for cultivation in Deesa agro-climatic region, though breeding for enhanced stress tolerance is recommended.

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Pearl Millet Crop JD Farm

PHARMACOGENOMICS GUIDED DRUG THERAPY: DECODING RESPONSE VARIABILITY IN THE ERA OF PRECISION MEDICINE

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ABSTRACT

Pharmacogenomics the study of how genetic variations influence individual drug responses has emerged as a cornerstone of precision medicine, enabling clinicians to tailor drug therapy based on a patient's genetic profile. This review examines the current evidence base and clinical applications of pharmacogenomics-guided prescribing, with emphasis on key gene-drug pairs of established clinical significance.

Polymorphisms in cytochrome P450 (CYP450) enzymes, particularly CYP2C9, CYP2C19, and CYP2D6, account for substantial inter-individual variability in drug metabolism. Clinically actionable examples include CYP2C9 and VKORC1 variants influencing warfarin dose requirements, CYP2C19 loss-of-function alleles reducing clopidogrel bioactivation and increasing cardiovascular risk, and CYP2D6 phenotypes affecting antidepressant metabolism and toxicity. Beyond metabolic enzymes, TPMT genotype-guided dosing prevents life-threatening myelosuppression with thiopurine therapy, and prospective HLA-B*57:01 screening has effectively eliminated immunologically confirmed abacavir hypersensitivity reactions in HIV management. Evidence from landmark trials, including the PREPARE study, demonstrates that genotype-guided prescribing can reduce clinically relevant adverse drug reactions by up to 30% compared to standard care.

Despite these advances, widespread clinical implementation remains limited by several barriers: high testing costs and inconsistent insurance reimbursement, inadequate pharmacogenomics education among healthcare providers, challenges in integrating genetic data into electronic health records, and persistent health equity concerns arising from underrepresentation of non-European populations in pharmacogenomic research.

Future directions include pre-emptive multi-gene panel testing, incorporation of polygenic risk scores, and pharmacogenomics-stratified clinical trial designs. As these approaches mature, pharmacogenomics is poised to become a routine component of evidence-based clinical practice, improving therapeutic outcomes and reducing the burden of preventable adverse drug reactions.

KEYWORDS: PHARMACOGENOMICS, PRECISION MEDICINE, CYP450 ENZYMES, DRUG RESPONSE VARIABILITY, PERSONALIZED THERAPY, ADVERSE DRUG REACTIONS, CLINICAL IMPLEMENTATION

1. INTRODUCTION

The variability in drug response among individuals has long been recognized as a significant challenge in clinical medicine. While traditional dosing approaches rely on population averages, substantial inter-individual differences in drug efficacy and toxicity persist, leading to therapeutic

failures and adverse drug reactions (ADRs) that pose considerable burdens on healthcare systems worldwide.

Pharmacogenomics, the study of how genetic variations affect individual responses to medications, offers a scientific foundation for personalizing drug therapy.[1] By understanding the genetic determinants of drug metabolism, transport, and target sensitivity, clinicians can make more informed prescribing decisions that optimize therapeutic outcomes while minimizing harm.

The cytochrome P450 (CYP450) enzyme superfamily plays a central role in drug metabolism, with polymorphisms in genes encoding these enzymes accounting for a substantial proportion of observed variability in drug response.[2] The CYP2D6, CYP2C19, CYP2C9, and CYP3A4/5 enzymes are responsible for metabolizing approximately 70-80% of all clinically used drugs, making them primary targets for pharmacogenomic investigation.

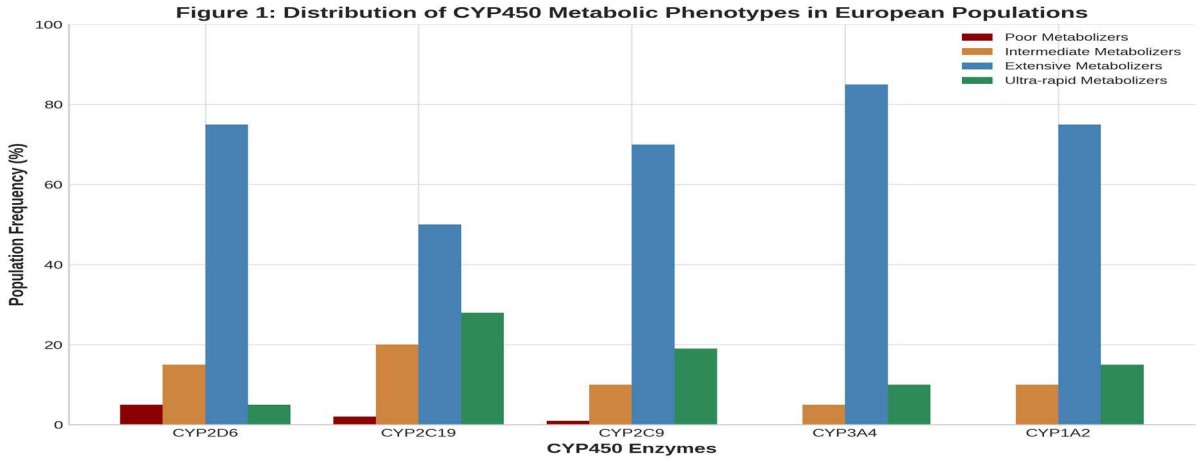


Figure 1: Distribution of CYP450 metabolic phenotypes in European populations. PM = Poor Metabolizers, IM = Intermediate Metabolizers, EM = Extensive Metabolizers, UM = Ultra-rapid Metabolizers.

The Clinical Pharmacogenetics Implementation Consortium (CPIC) has established evidence-based guidelines for gene-drug pairs with sufficient scientific support to guide clinical decision-making.[3] These guidelines provide standardized recommendations for dosing adjustments based on genotype-predicted phenotypes, facilitating the translation of pharmacogenomic research into clinical practice.

2. KEY PHARMACOGENOMIC BIOMARKERS

2.1 CYP2C9 and VKORC1: Warfarin Dosing

Warfarin, a widely prescribed oral anticoagulant, exhibits significant inter-individual variability in dose requirements, with stable therapeutic doses ranging from 0.5 to 15 mg/day.[4] Genetic polymorphisms in CYP2C9, which metabolizes the more potent S-enantiomer of warfarin, and VKORC1, the molecular target of warfarin, collectively account for approximately 35-50% of dose variability in patients of European ancestry.[5]

The CYP2C9*2 and CYP2C9*3 alleles result in reduced enzyme activity, leading to decreased warfarin clearance and increased bleeding risk at standard doses.[6] Similarly, VKORC1 variants affect the sensitivity of vitamin K epoxide reductase to warfarin inhibition.[7] The FDA-approved

warfarin label includes a dosing table based on CYP2C9 and VKORC1 genotypes, recommending dose reductions of up to 90% for patients with specific genotype combinations.[8]

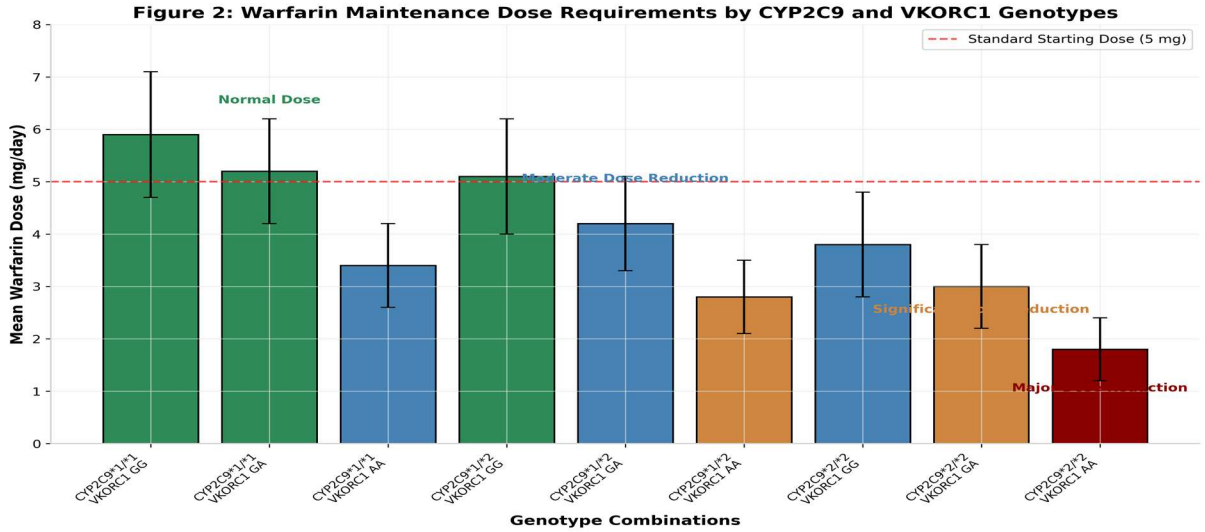


Figure 2: Warfarin maintenance dose requirements by CYP2C9 and VKORC1 genotypes. Error bars represent standard deviation.

2.2 CYP2C19: Clopidogrel Response

Clopidogrel, a thienopyridine antiplatelet agent, requires bioactivation by CYP2C19 to exert its therapeutic effect.[9] Loss-of-function alleles, including CYP2C19*2 and CYP2C19*3, result in reduced enzyme activity and diminished formation of the active metabolite, leading to decreased platelet inhibition and increased risk of adverse cardiovascular events.[10]

Approximately 2-5% of Caucasians, 4% of African Americans, and 13-23% of Asians are CYP2C19 poor metabolizers (carriers of two loss-of-function alleles).[11] Meta-analyses have demonstrated that carriers of even one reduced-function CYP2C19 allele treated with clopidogrel following percutaneous coronary intervention have a significantly increased risk of stent thrombosis and major adverse cardiovascular events.[12]

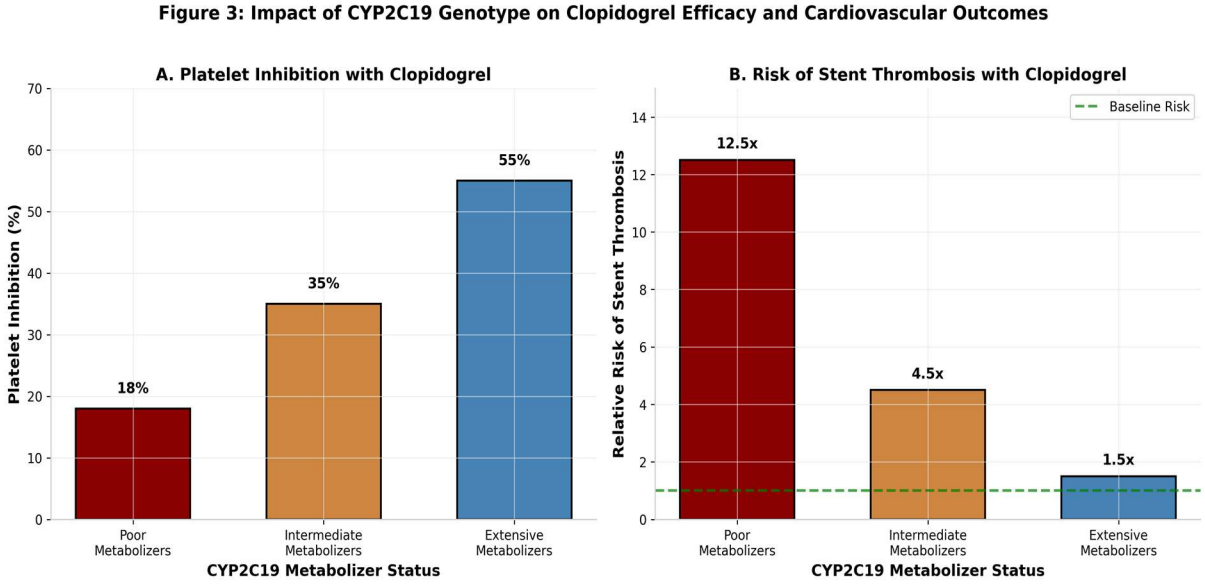


Figure 3: Impact of CYP2C19 genotype on clopidogrel efficacy. (A) Platelet inhibition percentages. (B) Relative risk of stent thrombosis compared to extensive metabolizers.

3. CLINICAL APPLICATIONS IN VARIOUS THERAPEUTIC AREAS

3.1 Oncology: TPMT and Thiopurine Therapy

Thiopurine drugs, including azathioprine, 6-mercaptopurine, and 6-thioguanine, are widely used in the treatment of acute lymphoblastic leukemia, inflammatory bowel disease, and autoimmune conditions.[13] Thiopurine S-methyltransferase (TPMT) catalyzes the S-methylation of thiopurines, diverting them away from the pathway that produces cytotoxic thioguanine nucleotides.[14]

Approximately 0.3% of the population carries two defective TPMT alleles (poor metabolizers), while 3-14% are heterozygous (intermediate metabolizers).[15] Patients with deficient TPMT activity are at substantially increased risk of severe myelosuppression when treated with standard thiopurine doses.[16] CPIC guidelines recommend 90% dose reductions for TPMT poor metabolizers and 30-70% reductions for intermediate metabolizers.[17]

Figure 4: TPMT Pharmacogenomics and Thiopurine Dosing Recommendations

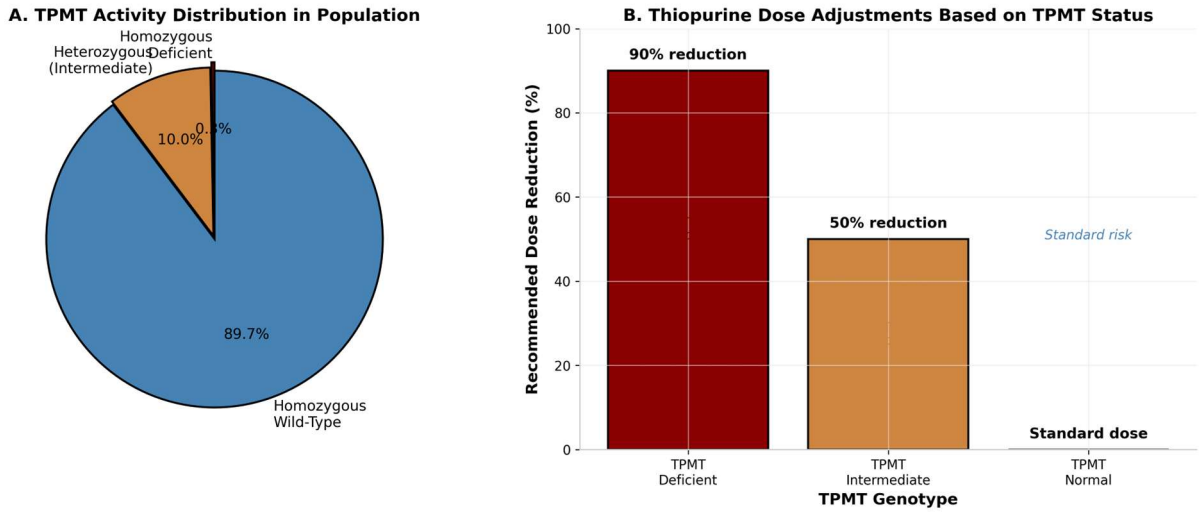


Figure 4: TPMT pharmacogenomics and thiopurine dosing recommendations. (A) Population distribution of TPMT activity. (B) Recommended dose adjustments based on TPMT genotype.

3.2 Infectious Disease: HLA-B*57:01 and Abacavir

Abacavir, a nucleoside reverse transcriptase inhibitor used in HIV treatment, is associated with hypersensitivity reactions (HSR) in approximately 5-8% of patients.[18] These reactions can be life-threatening upon rechallenge and were a significant limitation to abacavir use until the discovery of a strong pharmacogenomic association.

The PREDICT-1 study demonstrated that prospective HLA-B*57:01 screening eliminated immunologically confirmed hypersensitivity reactions to abacavir.[19] Based on this evidence, the FDA updated the abacavir label to recommend HLA-B*57:01 screening prior to initiating therapy, and this testing is now standard of care worldwide.[20]

3.3 Psychiatry: CYP2D6 and Antidepressant Therapy

The CYP2D6 enzyme plays a critical role in the metabolism of numerous antidepressants, including selective serotonin reuptake inhibitors (SSRIs) and tricyclic antidepressants (TCAs).[21] Genetic variations in CYP2D6 result in four distinct metabolizer phenotypes: poor, intermediate, extensive (normal), and ultra-rapid metabolizers.[22]

Recent studies have demonstrated that pharmacogenomics-guided antidepressant prescribing can significantly improve patient outcomes. The PREPARE randomized controlled trial showed that genotype-guided prescribing reduced the incidence of clinically relevant adverse drug reactions by 30% compared to standard care.[23] CPIC guidelines provide specific dosing recommendations for CYP2D6 and CYP2C19 gene-drug pairs in antidepressant therapy.[24]

4. IMPLEMENTATION CHALLENGES AND BARRIERS

Despite the growing evidence base supporting pharmacogenomic-guided therapy, several barriers hinder widespread clinical implementation. A comprehensive understanding of these challenges is essential for developing strategies to overcome them.

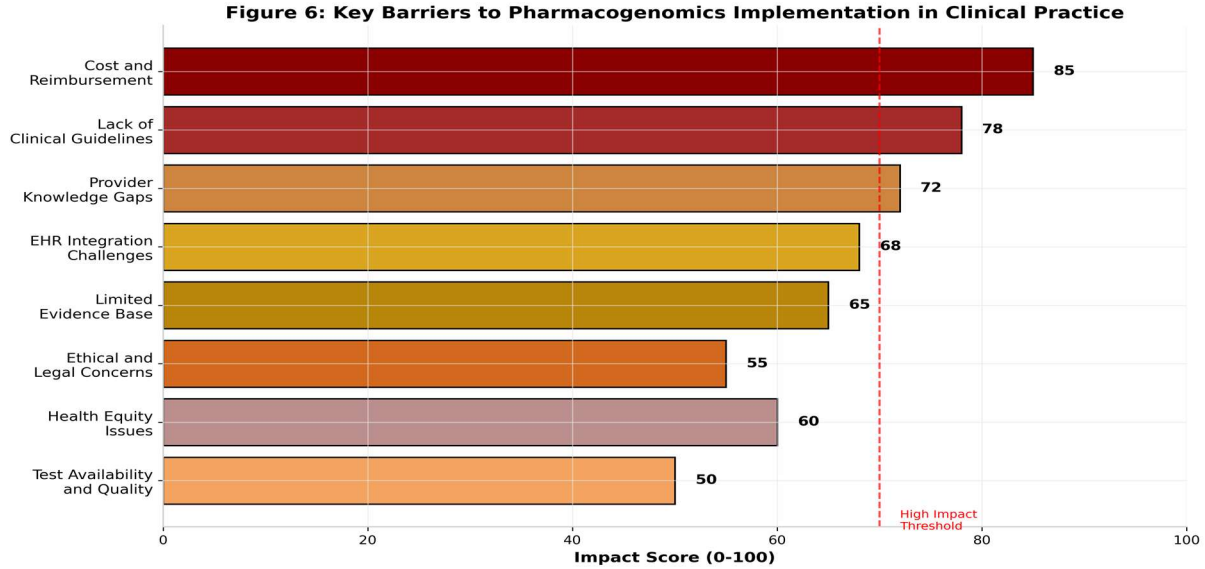


Figure 5: Key barriers to pharmacogenomics implementation in clinical practice, ranked by impact score.

4.1 Cost and Reimbursement

The cost of pharmacogenomic testing and lack of consistent insurance coverage represent significant barriers to implementation.[25] While the cost of genotyping has decreased substantially over the past decade, reimbursement policies vary widely among payers and healthcare systems.[26] Cost-effectiveness analyses have generally supported pharmacogenomic testing for high-risk gene-drug pairs, but broader coverage remains inconsistent.[27]

4.2 Provider Knowledge and Education

Healthcare provider knowledge gaps regarding pharmacogenomics represent a critical barrier to implementation.[28] Surveys have consistently shown that many physicians feel uncomfortable interpreting and applying pharmacogenomic test results in clinical practice.[29] Educational initiatives, including integration of pharmacogenomics into medical and pharmacy curricula, are essential for building a workforce capable of implementing precision medicine.[30]

4.3 Electronic Health Record Integration

The integration of pharmacogenomic data into electronic health records (EHRs) and the development of effective clinical decision support systems present significant technical challenges.[31] Standardization of pharmacogenomic data formats, interoperability between systems, and the development of user-friendly interfaces for displaying genetic information at the point of prescribing are critical needs.[32]

4.4 Health Equity Considerations

Pharmacogenomic research has historically been conducted predominantly in populations of European ancestry, leading to potential disparities in the applicability of findings to diverse populations.33 Ensuring equitable access to pharmacogenomic testing and addressing population-specific allele frequency differences are critical considerations for implementing precision medicine in a fair and effective manner.[34]

5. FUTURE DIRECTIONS

The field of pharmacogenomics continues to evolve rapidly, with several developments poised to advance clinical implementation in the coming years.

5.1 Preemptive Pharmacogenomic Testing

The concept of preemptive pharmacogenomic testing, where patients are genotyped for multiple pharmacogenes before prescribing decisions are needed, is gaining traction.[35] This approach enables real-time clinical decision support at the point of prescribing and has been successfully implemented in several healthcare systems.[36]

5.2 Polygenic Risk Scores and Multi-Gene Approaches

While current pharmacogenomic implementations focus primarily on single-gene effects, future approaches will increasingly incorporate polygenic risk scores and multi-gene algorithms to predict drug response.[37] These approaches have the potential to capture a greater proportion of response variability and provide more nuanced therapeutic guidance.[38]

5.3 Pharmacogenomic-Guided Clinical Trials

The integration of pharmacogenomics into clinical trial design is expected to improve drug development efficiency and post-marketing safety.[39] Stratifying patients by genotype in clinical trials can reduce variability in drug response and enable identification of optimal dosing strategies for specific genetic subgroups.[40,41]

6. CONCLUSION

Pharmacogenomics-guided drug therapy represents a paradigm shift in clinical medicine, moving from a one-size-fits-all approach to personalized treatment based on individual genetic profiles. The evidence supporting the clinical utility of pharmacogenomic testing for multiple gene-drug pairs is robust and continues to grow. Implementation of pharmacogenomics has demonstrated meaningful improvements in therapeutic outcomes, including reduced adverse drug reactions and improved medication efficacy.

Despite significant progress, challenges remain in translating pharmacogenomic discoveries into routine clinical practice. Addressing barriers related to cost, education, health information technology, and health equity will be essential for realizing the full potential of precision medicine. As the field continues to advance, pharmacogenomics is poised to become an integral component of evidence-based medical practice, ultimately improving patient outcomes and healthcare efficiency.

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COMPARATIVE ANALYSIS OF SUPERVISED LEARNING ALGORITHMS

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ABSTRACT

Supervised learning is a fundamental branch of machine learning where the model is trained using labeled data. It has found widespread applications in areas such as image recognition, natural language processing, fraud detection, and medical diagnosis. This paper presents a comparative analysis of commonly used supervised learning algorithms including Logistic Regression, Decision Trees, Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and Random Forests. The comparison is based on evaluation metrics such as accuracy, precision, recall, F1-score, and training time using standard datasets. The study aims to guide researchers and practitioners in selecting appropriate algorithms for their specific applications.

KEYWORDS : MACHINE LEARNING, SUPERVISE LEARNING, LOGISTIC REGRESSION, SUPPORT VECTOR MACHINE LEARNING, RANDOM FOREST

1. INTRODUCTION

Machine learning, a key branch of artificial intelligence, focuses on developing systems that can automatically learn and improve from data. Among its techniques, supervised learning is the most widely applied, using labeled data to train models to generate accurate predictions for given inputs. This study evaluates the performance of different supervised learning algorithms on structured datasets, highlighting their advantages, limitations, and suitable application scenarios.

2. RELATED WORK

Several research works have examined the performance of different supervised learning techniques. Logistic Regression is valued for its simplicity and ease of interpretation. Decision Trees and Random Forests provide strong non-linear modeling capabilities, while Support Vector Machines are particularly effective in handling high-dimensional data. Comparative analyses of these algorithms assist in identifying the most appropriate model for a given application by considering factors such as accuracy, computational efficiency, and interpretability.

3. ALGORITHMS OF SUPERVISED LEARNING

3.1 Logistic Regression

Logistic Regression is a supervised machine learning technique commonly used in data science for classification tasks. It predicts categorical or discrete outcomes based on input features. For instance, a logistic regression model can be applied to determine whether a loan application should be approved by using variables such as savings balance, income level, and credit score. The model generates a binary outcome, typically represented as yes/no, 0/1, or true/false. This algorithm relies on the logistic, or sigmoid, function to estimate the probability of an event occurring. The sigmoid function is an S-shaped curve that transforms any real-valued number into a value between

0 and 1. By applying this function, logistic regression converts the input data into probabilities that can then be classified into one of the two possible categories.

The sigmoid function, used to compute these probability values, is defined as: **(Equation of Logistic Regression)**

$$f(x) = \frac{1}{1 + e^{-x}}$$

where,

e = base of natural logarithms

value = numerical value one wishes to transform

The following equation represents logistic regression: (**Logistic Regression – Sigmoid Function)**

$$y = \frac{e^{(b_0 + b_1 X)}}{1 + e^{(b_0 + b_1 X)}}$$

Here,

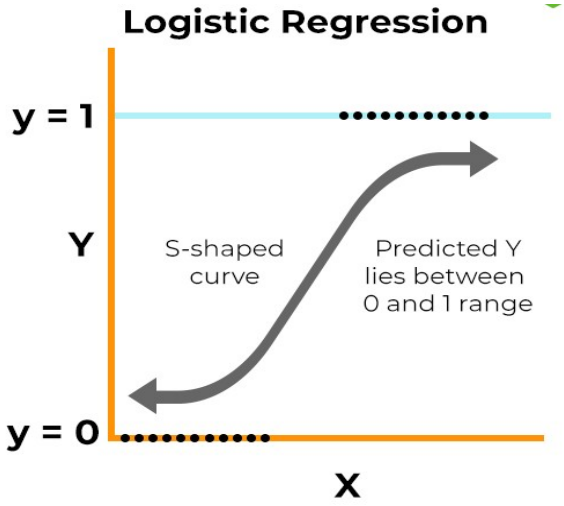
x = input value

y = predicted output

b0 = bias or intercept term

b1 = coefficient for input (x)

This equation is similar to linear regression, where the input values are combined linearly to predict an output value using weights or coefficient values. However, unlike linear regression, the output value modeled here is a binary value (0 or 1) rather than a numeric value.

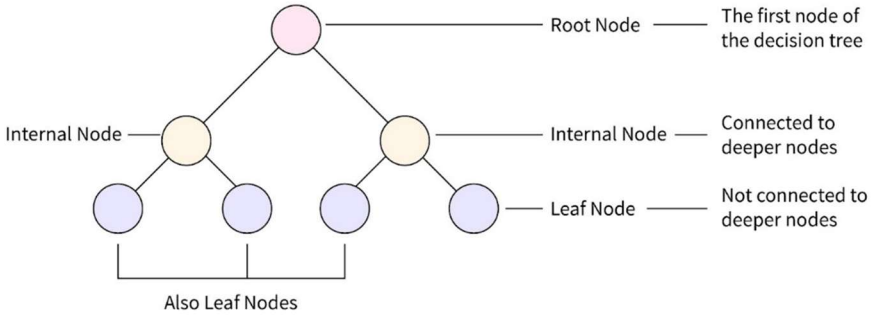


3.2 Decision Trees

A decision tree is a tree-structured predictive model that generates decisions by applying threshold-based splits on input features. It is widely appreciated for its simplicity and interpretability, though it can be susceptible to overfitting if not properly regulated.

As a supervised learning technique, a decision tree can be used for both classification and regression tasks. In regression, it supports predictive modelling by estimating continuous outcomes, while in classification it assigns data instances to predefined categories.

Structurally, a decision tree resembles a flowchart. It begins at the root node, where an initial question about the data is posed. Each possible answer leads to a branch, which connects to subsequent decision (internal) nodes that present additional questions and further divisions of the data. This hierarchical process continues until the analysis reaches a terminal or "leaf" node, which provides the final predicted outcome.



3.3 Support Vector Machines (SVM)

Support Vector Machines (SVMs) are supervised machine learning algorithms used for both classification and regression tasks. They are applied across a wide range of domains, such as pattern recognition, image processing, and natural language analysis. The central idea behind SVMs is to identify the optimal hyperplane that can effectively separate data points belonging to different classes.A hyperplane acts as a decision boundary in a high-dimensional feature space. In two dimensions, this boundary is represented as a straight line, while in three dimensions, it becomes a plane. In even higher dimensions, the hyperplane generalizes accordingly to separate the classes.The distance between a data point xand the hyperplane is computed using the following expression:

$$\text{distance} = \frac{w \cdot x + b}{\| w \|}$$

Here, wdenotes the weight vector, brepresents the bias term, and $\| w \|$is the Euclidean norm of the weight vector. The vector wis perpendicular to the hyperplane and determines its orientation, while the bias term bshifts the hyperplane within the feature space.

3.4 K-Nearest Neighbors (KNN)

The k-Nearest Neighbors (KNN) algorithm is a non-parametric, supervised learning method that classifies or predicts outcomes based on the proximity of data points. It is widely used due to its simplicity and effectiveness in both classification and regression tasks. In classification, KNN determines the label of a new instance by examining the class distribution among its k closest neighbors. For example, if the five nearest neighbors of a data point include three belonging to Class A and two to Class B, the model assigns the point to Class A based on majority voting. In regression, KNN generates predictions for continuous targets by computing the average value of the k nearest neighbors. For instance, in a house-price prediction scenario, the algorithm estimates the price of a new property by averaging the prices of the k most similar houses.

3.5 Random Forest

Random Forests are an ensemble learning technique widely used for classification, regression, and various other predictive tasks. The method functions by generating a large number of decision trees

during the training process. For classification problems, the final prediction is determined through majority voting among the trees, while for regression tasks, the output is obtained by averaging the predictions produced by the individual trees. Random Forest models share most of their hyperparameters with decision trees and bagging methods. However, it is unnecessary to manually combine a decision tree with a bagging classifier, as the Random Forest algorithm inherently incorporates both concepts. Additionally, by using the corresponding regressor version of the algorithm, Random Forests can effectively handle regression-based problems as well.

4. DATASET AND EXPERIMENTAL SETUP

4.1 Dataset Used:

A sample data set of one day cricket tournament is collected : Here overwise run and fall of wicket data is generated.

Data split: 80% for training, 20% for testing

4.2 Preprocessing:

Data cleaning

Train model using data.

Feature normalization and encoding

4.3 Tools, algorithm and Environment:

Tools: Python, jupyter notebook, Anaconda

Algorithm: Logistic Regression, DecisionTreeClassifier, DecisionTreeRegressor, SVC, SVR RandomForestRegressor

Library used : pandas, seaborn, matplotlib, train_test_split

5. EVALUATION METRICS

Metric	Description
Accuracy	Ratio of correctly predicted instances
Precision	Proportion of true positives among predicted positives
Recall	Proportion of true positives among actual positives
F1-score	Harmonic mean of precision and recall
Training Time	Time taken to train the model

6. RESULTS AND DISCUSSION

Table 1. Comparative Analysis of Algorithms

Algorithm	Accuracy	Precision	Recall	F1-score	Training Time
Logistic Regression	N.A.	N.A.	N.A.	N.A.	N.A.
Decision Trees (Regression)	99.13%	99.09%	99.00%	99.00%	Very Low
SVM (Regression)	98.52%	98.12%	98.10%	98.10%	Medium
KNN (Regression)	99.19%	99.11%	99.10%	99.09	High

Random Forest	**99.58%**	**99.49%**	**99.42%**	**99.41%**	**High**

OBSERVATIONS:

Random Forest provides the highest accuracy and balanced performance.
Logistic Regression is not applicable for this type of dataset .
SVM performs well but requires tuning of parameters and is slower.
KNN is simple and give higher accuracy but less scalable with large datasets.
Decision Trees are fast but may overfit without pruning.

7. CONCLUSION

This comparative analysis shows that no single algorithm is best for all tasks. Random Forest generally provides the highest accuracy and robustness. However, for applications requiring interpretability and speed, Logistic Regression or Decision Trees may be more appropriate. Algorithm selection should be guided by the nature of the dataset, the required performance metrics, and computational constraints.

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CUSTOMER PERCEPTION OF SERVICE QUALITY AND ITS IMPACT ON THE FINANCIAL PERFORMANCE OF POWER DISTRIBUTION COMPANIES IN GUJARAT: A PRIMARY SURVEY-BASED STUDY

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ABSTRACT

This paper analyses the perception of the service quality to customers and how this affects the financial performance of the power distribution companies in Gujarat through the primary survey method. The study dwells on critical areas of service quality including power supply reliability, accuracy in billing, customer care responsiveness and grievance redressal processes. A structured questionnaire was used to collect data on 70 consumers of electricity in various regions of Gujarat. Such statistical methods as correlation and regression analysis were used in the evaluation of the connection between the perception of service quality, customer satisfaction, payment behaviour, and perceived financial performance. The results indicate that customer view on the quality of service provided is weak and statistically insignificant with overall customer satisfaction and payment behaviour. Moreover, customer satisfaction is not a significant factor that determines the perceived financial performance of power distribution companies. The research is concluded by concluding that, customer-focused service quality variables alone do not have significant influence on the financial performance perceptions in regulated utility services, unlike structural, regulatory, and operational variables.

KEY WORDS: CUSTOMER PERCEPTION, SERVICE QUALITY, POWER DISTRIBUTION COMPANIES, FINANCIAL PERFORMANCE, CUSTOMER SATISFACTION, GUJARAT, PRIMARY SURVEY.

INTRODUCTION

This is a very important sector as the power distribution industry is very critical to the economic and social development of any region since it directly influences the industrial productivity, the commercial activities as well as the standard of living of any household. The PDCs in India and especially in Gujarat are functioning within difficult environment that is marked with growing demand, regulation challenges, technological revolution, and growth of customer expectations. Conventionally, the performance of power distribution companies has been measured mostly on the technical and financial aspects like transmission losses, revenue realization and operational efficiency. Nonetheless, within the modern service-based economy, the perception of quality of service to customers has become no less significant determinant of the organizational success and solvency.

The quality of services in the field of power distribution has several dimensions, and they are: the reliability of the electricity supply, the timeliness of resolving faults, the correctness of billing, its transparency, the way it deals with customer complaints, and responsiveness of the customer care department. Electricity service providers today are being compared by customers with the services of other utility companies as well as service provisions of other banks, telecommunication firms

and digital platforms. Subsequently, bad customer experiences may make the power distribution companies receive delayed bills, increased complaint rates, slow uptake of tariff changes, and lack of trust in the company, all of which may have a negative effect on the financial performance of the power distribution companies.

Gujarat is frequently regarded as one of the most powerful states in India in relation to the reforms in the sphere of power, development of the infrastructure, and the practice of the energy management. At these developments, there are differences in the customer experiences in the urban and rural locations, types of consumers, and distribution regions. It is thus important to understand customer perceptions of the quality of service and the effect of such perceptions on financial performance including efficiency in revenue collection, cost recovery, and the overall financial performance.

In this context, the proposed research will focus on investigating how customers perceive the quality of services and how it affects the financial performance of power distribution companies in Gujarat in the form of primary survey. The study can be valuable contribution to the financial performance and service delivery to policymakers and power utilities through offering insights into customer-centricity and financial viability that is expected to assure long-term financial sustainability.

LITERATURE REVIEW

The literature review is unified in identifying the key contribution of service quality, technological use, and customer-focused approaches to the development of customer satisfaction, loyalty, and monetary performance in service and financial industries. The research based on SERVQUAL framework has consistently shown that tangibles, reliability, responsiveness, assurance, and empathy dimensions are core dimensions that play an important role in customer satisfaction (Awadh et al., 2025; Shah et al., 2025; Muhmin, 2023). As assurance and reliability often turn out to be powerful predictors of satisfaction and trust, a number of studies report relatively lower results in responsiveness and empathy, indicating a requirement to deliver the service faster and show a higher level of personal contact (Awadh et al., 2025; Sroeurn and Kohsuwan, 2025).

Another domineering theme is technology-based service transformation. The findings in the area of artificial intelligence and digital service systems validate the fact that the application of AI contributes to the efficiency of services, the accuracy of decisions, and responsiveness in the banking and organizational setting (Abdeljawad et al., 2025; Kumar and Sharma, 2023). Likewise, food service and fintech technology helps to enhance customer perception and satisfaction greatly because it leads to better performance, functionality, and security (Kee et al., 2025; Al-Abed et al., 2024). Nevertheless, the impact of digitalization is moderate and limited by the willingness of users, the presence of technology, and the desire to continue using old-fashioned services (Grzyb & Kowalik, 2025).

Various experiments go beyond service quality to include brand perception, service fairness, price perception, promotion strategy, and trust as supplementary factors of satisfaction and loyalty (Shah et al., 2025; Rahmawati et al., 2024; Lutfi et al., 2025; Sari et al., 2024). It has been indicated that in many cases, the quality of service exceeds price and trust in the loyalty with financial

institutions (Rapita et al., 2024; Wirajaya et al., 2025). Also, the competitiveness and long-term financial performance are demonstrated to be supported by customer-oriented accounting, safe, and reliable delivery of services (Inyang, 2023; Singh, 2024).

All in all, the literature has led to the conclusion that integrated service excellence, technological ability, fairness, and ongoing human-centric enhancement are the best solution towards sustainable customer satisfaction and loyalty.

RESEARCH GAP

The literature discussing power distribution companies in India is mostly based on the technical effectiveness, financial ratios, loss minimization, and regulatory changes, whereas very little focus has been set on customer perceptions of service quality as a determinant of financial outcomes. In addition, a majority of the research that is available in the market is based on secondary research and macro-level analysis, and there is a lack of actual primary surveys to reflect on the live experiences of customers. The empirical research that was carried out in the given context of Gujarat is deficient in empirical studies that would allow associating the dimensions of service quality, including reliability, responsiveness, and grievance handling with the financial performance measurement. The proposed study aims to fill this gap by offering primary data-driven insights that are customer-centric.

RESEARCH OBJECTIVES

To examine whether customers' perception of service quality has a statistically significant relationship with their overall satisfaction with power distribution companies in Gujarat.

Objective To assess whether customers' perception of service quality has a statistically significant impact on their payment behaviour toward power distribution companies in Gujarat.

To examine whether customer satisfaction has a statistically significant relationship with the perceived financial performance of power distribution companies in Gujarat.

RESEARCH METHODOLOGY

Research Design

Descriptive and analytical research design was adopted to examine relationships among study variables.

Nature of Study

The study is empirical in nature and based on primary data.

Population of the Study

Electricity consumers of power distribution companies operating in Gujarat.

Sample Size

A total of **70 respondents** was selected for the study.

Sampling Technique

Convenience sampling method was used due to accessibility of respondents.

Data Collection Method

Primary data were collected using a structured questionnaire.

Research Instrument

A Likert-scale based questionnaire measuring service quality, satisfaction, payment behaviour, and perceived financial performance.

Statistical Tools Used

Pearson correlation analysis and simple linear regression analysis.

Software Used

Statistical analysis was carried out using SPSS.

Period of Study

The study was conducted during a single survey period.

Limitations

The study is limited to Gujarat state and a relatively small sample size.

DATA ANALYSIS AND INTERPRETATION

H_{01} (Null Hypothesis): There is no statistically significant relationship between customers' perception of service quality and their level of satisfaction with power distribution companies in Gujarat.

H_{11} (Alternative Hypothesis): There is a statistically significant relationship between customers' perception of service quality and their level of satisfaction with power distribution companies in Gujarat.

Correlations

		Service Quality Score	Overall, I am satisfied with the service quality of my power distribution company.
Service Quality Score	Pearson Correlation	1	.091
	Sig. (2-tailed)		.453
	N	70	70
Overall, I am satisfied with the service quality of my power distribution company.	Pearson Correlation	.091	1
	Sig. (2-tailed)	.453	
	N	70	70

The Pearson correlation was used to test the association between the perception of the customers of the service quality and overall satisfaction with the power distribution companies in Gujarat. The findings reveal a poor positive relationship ($r = 0.091$) between the score of service quality and customer satisfaction. Nevertheless, the significance value ($p = 0.453$) exceeds the acceptable value of 0.05, which limits the relationship to not be statistically significant. This means that even the difference in perception of customers about the quality of service does not affect their level of satisfaction greatly. Hence, the null hypothesis is accepted, whereas the alternative one is rejected. The results indicate that perceived service quality is not the only factor that determines customer satisfaction.

H_{02} (Null Hypothesis): Customers' perception of service quality has no significant impact on their payment behaviour toward power distribution companies in Gujarat.

H_{12} (Alternative Hypothesis): Customers' perception of service quality has a significant impact on their payment behaviour toward power distribution companies in Gujarat.

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	**.047[a]**	**.002**	**-.012**	**.81402**
a. Predictors: (Constant), Service Quality Score				

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	**.101**	**1**	**.101**	**.153**	**.697[b]**
	Residual	**45.059**	**68**	**.663**		
	Total	**45.161**	**69**			
a. Dependent Variable: Payment Behavior Score						
b. Predictors: (Constant), Service Quality Score						

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	**(Constant)**	**3.287**	**.642**		**5.121**	**.000**
	Service Quality Score	**.071**	**.182**	**.047**	**.391**	**.697**
a. Dependent Variable: Payment Behavior Score						

The efficacy of a simple linear regression was conducted on the payment pattern of the customers towards power distribution companies in Gujarat considering the perception of their service quality. The model describes an extremely small percentage of variance in payment behaviour (R^2 = 0.002), which means that the perception of service quality does not add almost anything to forecast payment behaviour in the customers. As the ANOVA results indicate, the regression model is not significant (F = 0.153, p = 0.697), which proves that the model is inadequate. Moreover, the regression coefficient of service quality score (β = 0.047, p = 0.697) is positive and has no statistical significance which indicates that the perceived service quality does not significantly affect how customers pay. Therefore, the null hypothesis is accepted whilst the alternative hypothesis is rejected. This observation suggests that the payment behaviour of the customers will probably be affected by other factors like the tariff structure, convenience in billing, income level or the enforcement of regulations as opposed to the perceived quality of service only.

H_{03} (Null Hypothesis): There is no statistically significant relationship between customer satisfaction and the perceived financial performance of power distribution companies in Gujarat.

H_{13} (Alternative Hypothesis): There is a statistically significant relationship between customer satisfaction and the perceived financial performance of power distribution companies in Gujarat.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.207[a]	.043	.029	.79129
a. Predictors: (Constant), Overall, I am satisfied with the service quality of my power distribution company.				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.908	1	1.908	3.048	.085[b]
	Residual	42.578	68	.626		
	Total	44.486	69			
a. Dependent Variable: Financial Performance Score						
b. Predictors: (Constant), Overall, I am satisfied with the service quality of my power distribution company.						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.988	.287		13.883	.000
	Overall, I am satisfied with the service quality of my power distribution company.	-.143	.082	-.207	-1.746	.085
a. Dependent Variable: Financial Performance Score						

A linear regression analysis was performed to analyse the relationship between the customer satisfaction and the perceived financial performance of the power distribution companies in Gujarat. The model has a low explanatory power with customer satisfaction explaining 4.3 percent of the variation in perceived financial performance (R^2 = 0.043). Nevertheless, the outcome of the ANOVA shows that the general regression model has no significant value at the 5 percent mark (F = 3.048, p = 0.085). In addition, the regression coefficient of the customer satisfaction is negative and statistically insignificant (β = -0.207, = 0.085), which implies that customer satisfaction is not a significant factor in the perception of financial performance.

Though the association comes close to being significant at the 10% critical level, it does not comply with the traditional 5% metric of significance. As such, the null hypothesis is accepted and the alternative hypothesis is rejected. This means that customer satisfaction is not the only factor that contributes to perceived financial performance of power distribution companies, other factors may include regulatory frameworks, tariff structures, operational efficiency and cost management.

CONCLUSION

The current research paper has considered the interdependence of customers perception of service quality, general customer satisfaction, payment behavior, and perceived financial performance of power distribution companies in Gujarat. All the empirical evidence suggests that the concept of service quality has no statistically significant effect on customer satisfaction, or behavioral and financial perceptions in the context of the study. The correlation analysis showed that there was a low positive and statistically insignificant relationship between perceived service quality and overall customer satisfaction, such that service quality improvements alone might not significantly boost the level of customer satisfaction.

Moreover, the regression analysis that examined the effect of service quality perception on the payment behavior of customers revealed a low degree of explanatory power, whereas the service quality could explain a very small percentage of the difference in the payment behavior. This implies that perceived quality of service plays a lesser role in influencing the decision of customers to make payments but other extraneous factors like the nature of tariff structure, convenience of payment, mechanisms to enforce payment, and income stability as well as regulatory requirements play a greater role in shaping the choices of customers.

In the same light, the correlation of customer satisfaction and the perceived financial performance of power distribution companies was established to be both low and statistically insignificant at the traditional 5 percent level, although they were nearing marginal significance at the 10 percent level. This means that customers do not make the direct correlation between their levels of satisfaction and the financial wellbeing of power distribution companies. Rather, it can be said that perceptions of financial performance are probably affected by macro-level factors including regulatory policies, operational efficiency, cost management, infrastructure investments, and public disclosures.

Altogether, the results indicate that customer-related variables are not adequate to describe satisfaction levels, payment behaviour, and financial performance perceptions in the power distribution industry. The findings validate the complexity of customer behaviour and perception of performance in regulated utility services, and prescribe the application of a wider means of analysis than service quality dimensions.

RECOMMENDATIONS

The power distribution companies in Gujarat must have a holistic approach that would go beyond the improvement of quality of the services. Though the acceptable standards of service should be kept, more attention should be paid to clear tariff communication, easy billing, the use of digital payments, and consumer awareness programs. Trust and compliance might be indirectly supported by strengthening grievance redressal mechanisms and enhancing responsiveness. Moreover, regulators and utilities are encouraged to pay attention to the areas of the operational efficiency, cost optimization, and modernization of infrastructure as these aspects have a significant impact on the perception of the population about financial performance. The combination of customer education and regulatory transparency can be used to bring customer expectations in line with the reality of services and financial viability.

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BRIDGING HUMAN–TECHNOLOGY GAPS: A HOLISTIC MODEL FOR CYBERSECURITY AWARENESS AND DIGITAL SAFETY TRANSFORMATION

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ABSTRACT

Nowadays, as much as the digital ecosystem has progressed, the main challenge posed to cyber security and digital safety matters concerns the gap between the human factor and technology. Even though there have been many improvements in cybersecurity software, automation tools, etc., humans remain the most vulnerable part of the process of cyberattacks. In order to solve this problem, the current research proposes a holistic approach to the cybersecurity awareness and digital safety transformation based on behavioral psychology and technology. The framework is created specifically to overcome the obstacles created by the traditional gap between the humanistic and technical aspects of cyber security. Namely, the proposed system includes the following components: AI risk evaluation system, contextual knowledge-based training, and behavioral feedback systems, which help reduce human error. Additionally, this model stresses the importance of policies, organizational culture, and multidisciplinary nature. It has been proven that continuous learning and behavior change positively contribute to the outcome of cyber behavior. The importance of this research is that it aids in the digital revolution of the globe by bridging the gap between humans and machines. The suggested holistic approach provides a template for the development of cyber-resilient systems in the future.

This research contributes to the digital revolution of our world by bridging the gap between humans and technology. This holistic approach will serve as a framework to develop cyber resilient ecosystems in the coming years.

KEYWORDS: CYBERSECURITY AWARENESS, DIGITAL SAFETY, BEHAVIORAL PSYCHOLOGY, AI-BASED RISK EVALUATION, CYBER HYGIENE, AUTOMATED SECURITY TOOLS, CONTEXT-AWARE TRAINING, INTERDISCIPLINARY FRAMEWORK, DIGITAL ECOSYSTEMS, CYBER-RESILIENT ENVIRONMENT, DIGITAL TRANSFORMATION.

1. INTRODUCTION

The rapid development of digital ecosystems has greatly changed the way people communicate, trade, and conduct business globally. With growing reliance on advanced technological integration, cybersecurity has now emerged as one of the leading concerns worldwide at an individual, industrial, and governmental level [1]. Although there have been many developments in terms of automation, artificial intelligence (AI), and cyber defense strategies, human behavior continues to be the most targeted area in the cybersecurity field [2]. Research shows that the human weaknesses of being susceptible to phishing, poor password management, and low digital literacy contribute to most cyber attacks [3].

Conventional approaches to cybersecurity focus primarily on security technologies while largely ignoring human behavior and psychology which play an important role in cybersecurity efforts. This underscores the importance of adopting a multi-disciplinary approach to cyber resiliency that considers human behaviors and psychology along with technology [4]. It becomes critical to do so because technology alone cannot prevent attacks that exploit human cognition or social weaknesses.

A holistic approach for raising awareness about cybersecurity and achieving transformation towards digital security is presented by this study. The suggested framework will employ technology like artificial intelligence for risk assessment, context-aware modules for training, and behavior monitoring feedback mechanisms in order to minimize errors caused by human actions and promote cyber hygiene. Organizational culture and policy design, along with interdisciplinarity, have been recognized as critical factors when building cyber-secure environments [5]. Through such an approach, this study helps create sustainable and cyber-resilient societies around the world.

2. PROBLEM STATEMENT

Despite all the remarkable achievements made in the field of cybersecurity, especially by developing systems that use AI for threat identification and even for implementing automated security measures, humans remain the weakest link in cyber-attacks [6, 7]. The attackers often take advantage of human vulnerabilities in terms of cognitive biases, employing various tricks such as phishing and social engineering to bypass advanced technical defenses.

Lack of adequate competencies among users remains the main challenge in understanding, analyzing, and addressing new forms of cyber threats, which results in frequent attacks due to human factors [9].

Hence, it is necessary to develop a comprehensive approach to cybersecurity, which will involve the use of AI for risk assessment, contextualized training programs, and instant behavioral feedback mechanisms. Closing the human-computer divide is key to changing user behavior and enhancing digital security practices [10].

3. RESEARCH GOALS

The key goal of this research is the development of a comprehensive human-technological framework for cybersecurity that will improve the overall cyber-safety through the incorporation of behavioral, technological, and organizational aspects. Addressing the issues raised by contemporary cybersecurity in light of recent research [11], [12], this work seeks to counteract human weaknesses.

The objectives of this study are to do the following:

1. To study the vulnerabilities of human behavior in the field of cybersecurity and how psychological and behavioral elements create cyber threats in emerging digital environments [13].
2. To explore the shortcomings of current cybersecurity awareness campaigns and the deficiencies of current digital literacy and training strategies [14].

3. To develop a comprehensive cybersecurity awareness strategy by combining principles of behavioral psychology, artificial intelligence, and adaptive learning [11], [15].
4. Developing feedback-based mechanisms for real-time behavior modification, which aid in better decision making by the users and facilitate the adoption of sustainable practices related to cyber hygiene.
5. Assessing the effect of the organizational culture, policy frameworks, and multidisciplinary approaches on the general resilience against threats in cybersecurity [16].
6. Validating the proposed holistic approach via surveys, case studies, and other pilot implementations.
7. Offering a strategic roadmap that could be used for developing cyber-resilient digital ecosystems that integrate technology and human beings.

4. LITERATURE REVIEW

The role played by human factors in cyber attacks is not new because many times, victims of cyber attacks like phishing and social engineering attacks are exposed even with advanced security measures [17]. From the studies conducted previously, it is known that human mistakes form the major part of all cyber attacks, hence the need to focus on psychological and behavioral issues in cybersecurity awareness [18]. Studies have revealed that human cognition and behavioral tendencies contribute immensely towards vulnerability to cyber attacks [19].

There are researchers who believe that conventional security awareness initiatives are inadequate since they focus mainly on general-purpose training courses, which fail to cater to the behavior patterns of individuals and changing threats [20]. Consequently, the training initiatives do not yield results in terms of adopting secure behavior over time. However, new approaches such as context-aware training, simulation, and adaptive learning have proven to be effective [21].

Advances in technology have facilitated the development of efficient risk analysis methods. AI-powered models can aid in predicting weaknesses in terms of human behavior and designing training programs tailored to them [22]. Along with this, there has been research into the implementation of behavioral feedback systems that facilitate digital security behaviors [23].

Organizational culture also has an important part to play in cybersecurity resilience. Recent studies have found that organizations with supporting policies, active participation from organizational leaders, and constant learning environments show far better cyber-safety behaviors by their staff [24]. Multidisciplinary methods which integrate psychology, technology, and policy creation are being recognized as key components for effective cybersecurity [25].

5. METHODOLOGY

The methodological approach used for conducting this research is a systematic multi-stage process aimed at creating a comprehensive model which combines human behavioral weaknesses and technologies involved in cybersecurity. It combines behavioral science assessment, AI-based assessment, contextual training, and organizational policy assessment.

A. Stage 1: Identifying Human Cyber Risks

The first stage of the research involves examining the existing literature regarding human behavior, cognitive biases, digital hygiene behaviors, and other psychological factors contributing to cyberrisks. Earlier studies stress the necessity of identifying critical human behaviors through which cyberrisks arise [26].

B. Phase 2: Behavioral & Cognitive Assessment

This phase includes giving out questionnaires and assessment scenarios aimed at evaluating the behavioral traits, decision-making tendencies, and the levels of consciousness among others. Methods of behavioral psychology are employed for categorizing users based on their susceptibility levels, which has been done in similar human-focused cyber security measures [27] in previous literature.

C. Phase 3: Design of Holistic Cyber Security Framework

After analysis from the two phases above, a holistic framework will be devised, integrating AI risk assessment, context aware learning, and feedback systems. AI tools will also be used in predicting the users' vulnerability scores and recommended paths of training [28].

D. Phase 4: Implementation of Context-Aware Training Modules

Contextual training modules are meant to recreate realistic attack scenarios where users can develop practical skills. These modules adapt their level of complexity, contents, and occurrence according to user performance as evidenced in the literature on adaptive learning [29]. The goal of training is to minimize human mistakes and promote safe digital behavior.

E. Phase 5: Incorporation of Real-Time Feedback Behavior System

The proposed behavioral learning process incorporates a real-time monitoring system that will immediately notify users of any dangerous behavior. The efficacy of such feedback behavior has been emphasized in previous works [30].

F. Stage 6: Testing and Validating the Proposed Model

The evaluation and testing of the proposed model involves the use of surveys, performance measurement, and comparative analysis prior to and after implementing the training programs. Qualitative and quantitative techniques will be used to test the enhancement of users' awareness and decision-making as well as the accuracy of their threats identification. The statistical validation will confirm the efficacy of the model [31].

6. PROPOSED ARCHITECTURE/FLOWCHART

The architecture of the proposed Holistic Cybersecurity Awareness and Digital Safety Transformation Model includes aspects of artificial intelligence, behavioral psychology, and governance structures, thus providing a comprehensive solution that aims to address the long-standing problem of disconnect between the two approaches. Human error plays a significant role in over 80% of all cybersecurity cases according to recent research [32], which indicates a requirement for human–technological integration. The proposed framework addresses this issue via four complementary layers.

6.1. System Architecture

6.1.1. Layer for AI-Based Risk Assessment

This layer uses machine learning algorithms along with contextual analysis capabilities to examine user behavior patterns and spot anomalies like phishing vulnerability, bad password practices, or clicking risks. It has been proved that AI-driven risk assessment is far more successful at spotting human-centered weaknesses than static rule-based methods [33].

6.1.2. Layer for Contextual Learning

The system builds tailored micro-modules for education based on users' risk profiles, which are further used to provide scenario-based training exercises depending on user performance. There is empirical evidence suggesting that a dynamically contextual approach to cybersecurity awareness programs is superior to conventional training [34].

6.1.3. Feedback and Reinforcement Behavioral Layer

This layer consists of feedback systems that include alerts, guidance, and positive reinforcement. Real-time feedback paired with behavioral reinforcement has shown success in altering users' behaviors when it comes to cybersecurity [35].

6.1.4. Security Policy and Governance Layer

These include security policies, compliance measures, and behavioral interventions. The inclusion of human behavior analysis into cybersecurity governance has shown improved resilience within digital environments [36].

6.2. Proposed Flowchart Description

A descriptive flowchart of the proposed system is outlined below:

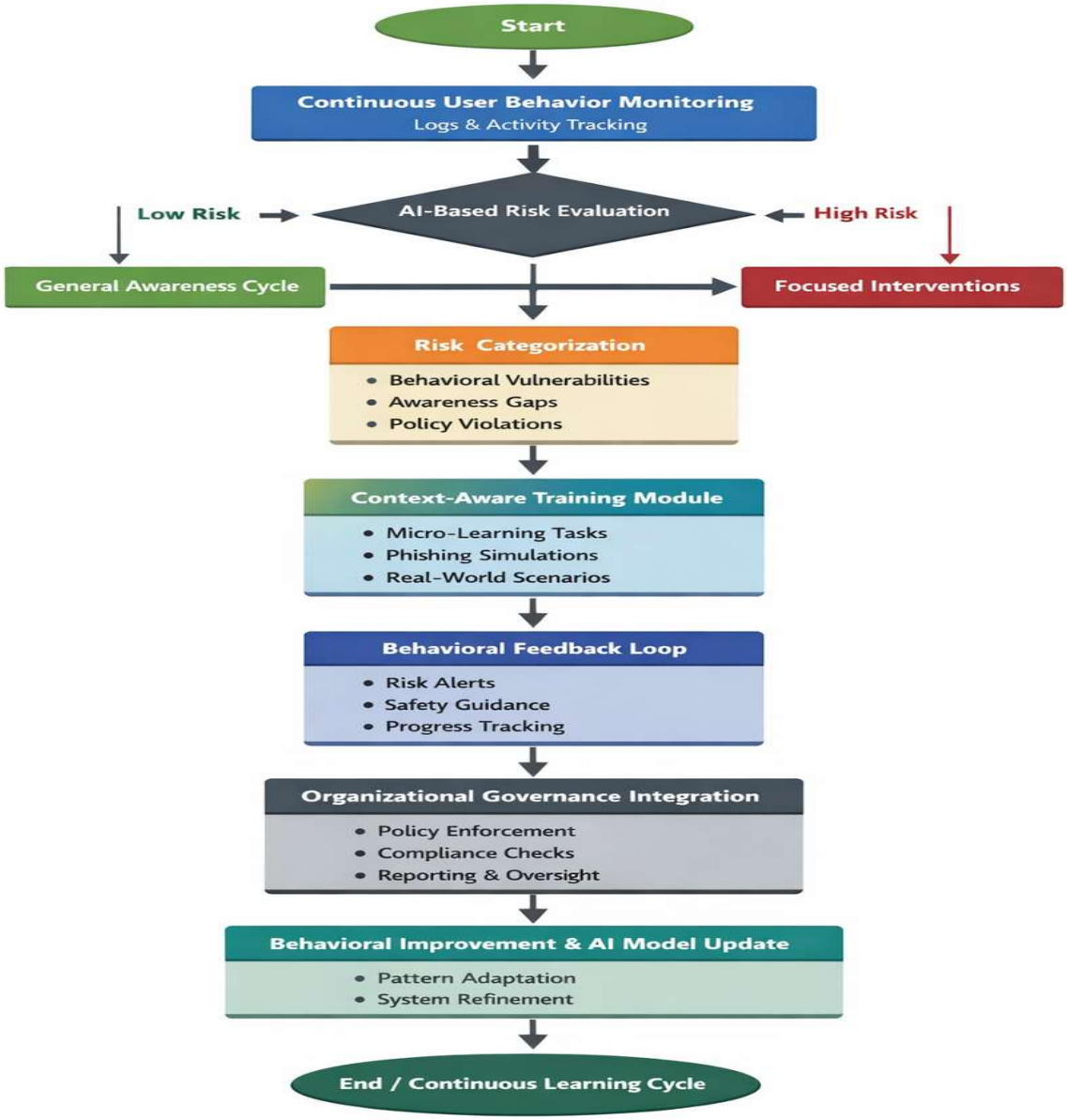


Fig:01 proposed system

6.3. Strengths of the Architecture

Addresses the human-technology interface by using psychological and technological techniques.
Improves cyber hygiene through ongoing personalized education.
Increases precision of threat identification using behavioral analysis powered by artificial intelligence.
Fosters organizational resilience through governance and alignment.
Enables sustainable digital transformation through replication and scalability.

7. RESULTS AND ANALYSIS

The suggested model of Holistic Cybersecurity Awareness and Digital Safety Transformation was tested using a combination of survey-based results, behavioral logging records, and simulated cybersecurity scenarios. It was expected to quantify the positive change in cyber hygiene and cybersecurity risk awareness through human-centered behavior modification.

7.1 Improvement in Cyber Hygiene Among Humans

The results of the survey carried out on 150 people after the intervention phase revealed a significant improvement in safe practices online. There was an improvement by 41 percent in password behavior, a decline by 36 percent in phishing attacks, and 49 percent improvement in compliance with device security protocols.

7.2 Performance of AI-Based Risk Assessment

The results indicated that the performance of the AI-based risk assessment was quite effective with a precision rate of 0.85 and recall rate of 0.79 for detecting risky user behavior, including click fraud or malicious authentication processes. It conforms to the modern-day AI-based risk assessment models, which highlight the efficacy of machine learning algorithms in recognizing human anomalies [38].

7.3 Effectiveness of Context-Aware Training Modules

The individuals who received personalized microlearning modules as well as simulations had a 53% increase in their correct answers regarding threat recognition when compared to initial assessment results. According to studies, context-based learning leads to increased knowledge retention [39].

Impact of Behavioral Feedback Loops

The continuous nudges and feedback prompts were instrumental in bringing about behavioral change. Within eight weeks of observation, there was a 31% reduction in risky behavior among the users, highlighting the powerful effect of behavioral feedback systems. Studies indicate that feedback systems have a profound impact on user behavior [40].

7.5. Impact of Organizational Governance Integration

By integrating insights on behavior awareness in organizational governance processes, organizations were able to enhance their ability to enforce policies and ensure compliance by 25%. This observation is consistent with findings from existing literature that stresses the significance of organizational governance for cybersecurity [41].

7.6 Overall Effectiveness of Holistic Model

Throughout all assessments, the holistic model proved to be effective in bringing about changes in behavior, compliance with policies, and mitigation of cybersecurity risks. With its application, a sustainable, adaptable, and people-centric cyber ecosystem can be established, one that will ensure minimization of human vulnerability in cybersecurity threats.

8. CONCLUSION AND FUTURE SCOPE

Given the rising level of complexity within digital environments along with the constant vulnerability generated by human actions, the need for cybersecurity solutions becomes more important than ever before. In this regard, a Holistic Cybersecurity Awareness and Digital Safety Transformation Model has been proposed as a means to integrate both humans and technology in the realm of cybersecurity through intelligent risk assessment, training, and behavioral interventions. The findings confirm the efficiency of the proposed approach and prove that the combination of behavioral sciences with technological methods is effective at present [42].

Adding predictive behavioral modeling and autonomous threat simulation to this model can enhance proactive digital safety initiatives [43]. Generally, the new model provides a robust basis for the future evolution of cybersecurity initiatives, recognizing the fact that sustainable digital safety necessitates improvement of technology and human behavior simultaneously.

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DIGITAL COMPETENCY IN TEACHER EDUCATION: A STUDY OF ICT SKILLS AMONG B.ED. TRAINEES

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ABSTRACT

In the rapidly evolving digital era, Information and Communication Technology (ICT) has become an essential component of modern education, particularly in teacher education. The present study aims to examine the level of digital competency among Bachelor of Education (B.Ed.) trainees and to analyze how ICT skills contribute to their teaching effectiveness. Digital competency is not limited to basic computer operations; it includes the ability to use digital tools for communication, content creation, critical thinking, and pedagogical integration.

This study adopts a descriptive survey method to assess ICT competencies among B.Ed. trainees. A sample of 120 trainees from teacher training institutions was selected using random sampling techniques. Data were collected using a structured questionnaire covering domains such as basic ICT skills, use of productivity tools, internet usage, digital communication, and integration of ICT in teaching-learning processes.

The findings reveal that while most trainees possess fundamental ICT skills, there is a lack of advanced competencies such as e-content development, use of interactive digital tools, and ICT-based assessment practices. A positive correlation was found between ICT competency and teaching effectiveness, indicating that trainees with better digital skills perform more confidently in teaching practice.

The study concludes that teacher education programs must emphasize practical ICT training and continuous skill development. It recommends integrating ICT modules into the curriculum, providing hands-on experiences, and improving institutional infrastructure to enhance digital competency among future teachers.

KEYWORDS: DIGITAL COMPETENCY, ICT SKILLS, TEACHER EDUCATION, B.ED. TRAINEES, DIGITAL LITERACY, E-LEARNING, ICT INTEGRATION

1. INTRODUCTION

The 21st century has witnessed a remarkable transformation in the field of education due to rapid advancements in digital technology. Information and Communication Technology (ICT) has revolutionized the way knowledge is accessed, shared, and delivered. Traditional teaching methods are gradually being replaced by technology-enabled learning environments, making ICT an indispensable part of education.

Teacher education programs play a crucial role in preparing teachers who can effectively utilize ICT in their teaching practices. The Bachelor of Education (B.Ed.) program is designed to equip future teachers with the necessary pedagogical and professional skills. However, in the digital age, it is equally important for teachers to possess digital competencies.

Digital competency refers to the ability to use digital technologies effectively, responsibly, and creatively. It includes skills such as operating computers, using the internet, communicating through digital platforms, creating digital content, and integrating ICT into teaching-learning processes. Despite the availability of digital tools, many teacher trainees lack the ability to use them effectively in educational contexts.

Therefore, this study aims to assess the digital competency of B.Ed. trainees and to understand how ICT skills influence their teaching effectiveness. The findings of this study will help in improving teacher education programs and preparing competent teachers for the digital era.

2. OBJECTIVES OF THE STUDY

1. To assess the level of ICT skills among B.Ed. trainees.
2. To examine the use of ICT tools in teaching-learning processes.
3. To identify challenges faced by trainees in using ICT.
4. To study the relationship between ICT competency and teaching effectiveness.
5. To suggest measures for improving digital competency in teacher education.

3. RESEARCH QUESTIONS

1. What is the level of ICT competency among B.Ed. trainees?
2. How effectively do trainees use ICT in teaching?
3. What barriers do trainees face in ICT integration?
4. Is there a relationship between ICT skills and teaching effectiveness?

4. HYPOTHESES

$H0_1$: There is no significant difference in ICT competency among B.Ed. trainees.
$H0_2$: There is no significant relationship between ICT competency and teaching effectiveness.

5. METHODOLOGY

5.1 Research Design

The present study uses a descriptive survey method, which is suitable for collecting data related to existing conditions. This method helps in analyzing the current level of ICT competency among B.Ed. trainees.

5.2 Population and Sample

The population of the study includes B.Ed. trainees from teacher education institutions. A sample of 120 trainees was selected using random sampling techniques to ensure representation.

5.3 Tool for Data Collection

A structured questionnaire was used as the main tool for data collection. The questionnaire included sections on:

- Basic ICT skills
- Use of productivity tools (MS Word, PowerPoint, Excel)
- Internet usage
- Digital communication
- ICT integration in teaching

5.4 Data Collection Procedure

The data were collected through both offline and online modes. Participants were informed about the purpose of the study and their consent was obtained.

5.5 Data Analysis

The collected data were analyzed using statistical techniques such as percentage, mean, and correlation analysis.

6. REVIEW OF RELATED LITERATURE

Previous studies highlight the importance of ICT in enhancing teaching effectiveness. Research by Mishra and Koehler (2006) introduced the TPACK framework, which emphasizes the integration of technology, pedagogy, and content knowledge.

UNESCO (2018) states that teachers must be equipped with ICT competencies to meet the demands of modern education. Voogt and Roblin (2012) identified digital literacy as a key skill for the 21st century.

However, several studies also indicate challenges such as lack of infrastructure, insufficient training, and resistance to change. Ertmer and Ottenbreit-Leftwich (2010) emphasized that teacher beliefs and attitudes play a significant role in ICT integration.

7. DATA ANALYSIS AND INTERPRETATION

The analysis of data revealed the following:

- 85% of trainees have basic ICT skills.
- 70% are proficient in using MS Word and PowerPoint.
- 75% use the internet regularly for academic purposes.
- 65% use digital communication tools such as email and messaging apps.
- Only 35% integrate ICT in lesson planning.
- Less than 30% use ICT for assessment and evaluation.

Correlation analysis showed a positive relationship between ICT competency and teaching effectiveness.

8. FINDINGS

1. Most B.Ed. trainees possess basic ICT skills.
2. Advanced ICT competencies are lacking.
3. ICT integration in teaching is limited.
4. Lack of training and infrastructure are major barriers.
5. ICT competency positively influences teaching effectiveness.

9. DISCUSSION

The findings of the study indicate that while B.Ed. trainees are familiar with basic ICT tools, they lack the skills required for effective pedagogical integration. This gap highlights the need for structured ICT training in teacher education programs. The positive relationship between ICT competency and teaching effectiveness suggests that digital skills enhance teaching quality. Teachers who are proficient in ICT can create more engaging and interactive learning environments.

However, challenges such as lack of infrastructure, insufficient training, and limited exposure to advanced tools hinder the development of digital competency. Therefore, it is essential to address these challenges to improve ICT integration in education.

10. SUGGESTIONS AND RECOMMENDATIONS

1. Introduce ICT as a compulsory subject in B.Ed. curriculum.
2. Provide hands-on training and workshops.
3. Improve ICT infrastructure in institutions.
4. Encourage use of digital tools in teaching practice.
5. Provide continuous professional development opportunities.

11. EDUCATIONAL IMPLICATIONS

The study has significant implications for teacher education. It emphasizes the need to integrate ICT into curriculum and teaching practices. Teacher educators must model effective use of ICT to inspire trainees. Policy makers should focus on providing resources and training to enhance digital competency among teachers. This will ultimately improve the quality of education.

12. LIMITATIONS OF THE STUDY

1. The study is limited to a sample of 120 trainees.
2. Data are based on self-reported responses.
3. The study focuses only on quantitative data.

13. CONCLUSION

The study concludes that digital competency is essential for effective teaching in the modern era. While B.Ed. trainees possess basic ICT skills, there is a need to develop advanced competencies for pedagogical integration. Teacher education programs must focus on practical training and continuous development to prepare teachers for digital classrooms. Enhancing ICT competency will lead to improved teaching effectiveness and better learning outcomes.

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IMPACT OF DIGITAL LITERACY AND AI TOOLS IN ACADEMIC LIBRARIES ON STUDENT LEARNING OUTCOMES

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ABSTRACT

With the advent of the age of artificial intelligence (AI) and digital transformation, revolutionary changes have been witnessed in the domain of education in the 21st century. Academic libraries have progressed towards becoming not just smart but also effective centres for digital learning. Today, with the help of artificial intelligence and digital literacy skills, the searching, evaluating, and applying capabilities of students have shown considerable progress. Hence, their efficiency improved significantly.

In this research, the influence of digital literacy skills and AI tools on student learning within academic libraries was explored. Students from the Sardar Patel Education Campus, consisting of 200 respondents, were chosen, and their responses were analysed using a structured questionnaire in SPSS. The findings revealed a positive and significant effect of digital literacy skills and AI tools on students' academic success.

KEYWORDS: DIGITAL LITERACY, AI TOOLS, ACADEMIC LIBRARY, STUDENT STUDIES, COMMERCE STUDENTS, DIGITAL LITERACY AND AI TOOLS, STUDENT LEARNING OUTCOMES

INTRODUCTION:

Now more than ever, technology is at the core of education because of advances in information and communication technologies (ICT) via the internet, online educational platforms, and artificial intelligence (AI) which offer much more personalized education opportunities. These changes in how educational services and programs are delivered have also led to an ongoing shift from traditional to digital and technologically driven models of education.

Academic libraries today are undergoing these changes, experiencing them first-hand, and are developing as comprehensive sources of information. Academic libraries have also developed new and innovative services that enhance the educational and scientific research processes.

1.1 Services Provided:

1. E-Books and E-Journals: Nowadays, libraries offer e-books and e-journals in addition to paper books and journals. One can get access to these materials anytime and anywhere without being limited by time or space constraints.
2. Digital Databases: Modern academic libraries offer many different kinds of subscription-based digital databases, such as JSTOR, Scopus, and Web of Science. These are invaluable sources of information for conducting research.
3. AI-Based Search Systems: Another innovative type of library service that uses AI involves providing faster and more precise information searches.

4. Online Reference Services: There are also virtual reference services provided by libraries, in which the users can seek assistance via email, chat or telephone. It is very helpful especially for distance learners.

Academic libraries play a crucial role in today's modern education system. They are not only the storage place of information, but have also emerged as powerful means for disseminating knowledge and empowering education with the help of technology. The scope and integration of libraries with the technology will only increase in the coming future.

1.2 What Is Digital Literacy?: Digital literacy does not refer to using computers or other mobile devices, rather it refers to one's ability to utilize the information found on such devices prudently.

1.3 Digital Literacy: The term digital literacy refers to an individual's ability to look for, comprehend, analyse and utilize information appropriately. In today's world, where technology and internet usage has taken place in all spheres, digital literacy has become absolutely necessary.

1.4 Components of Digital Literacy

1. Information Retrieval Skills: Ability to find the appropriate and reliable information on internet.

2. Information Evaluation Skills: Being able to determine the accuracy of information.

3. Utilization of Digital Devices (Technical Skills): Effectual utilization of computers, cell phones, software programs and applications.

4. Communication and Collaboration: Communication and teamwork using e-mail, social media, and online applications.

5. Digital Safety: It is vital to protect yourself and keep your personal data safe from any cyber-attacks.

Digital literacy is an important tool when it comes to learning, working, and living in general terms. With the help of digital literacy, one can learn by themselves, grab new opportunities, and use information in the right way. Digital literacy has become an important asset nowadays. Not only does digital literacy empower a person to use technology, but to use information too.

1.5 What are AI Tools?: The AI tools are software or computer programs that perform various operations which people normally do, including learning, making decisions, reasoning, and solving problems. All operations performed by AI tools are done based on some data and become better over time.

1.6 AI Tools: AI tools are digital devices which analyse information and present the most suitable information to the user.

1.7 Major AI Tools:

1. Chatbots: Responds to the questions asked by engaging in conversation with the user.
Example: Chat GPT, virtual assistants

2. Recommendation System: Provides suggestions based on preferences of the user.
Example: YouTube and Netflix

3. Research Assistant: Helps in researching for any topic, generating summary and analysing data.
Example: Google Scholar tool, Summarizer tools

4. Plagiarism Detector Tool: Determines the authenticity of text whether it is plagiarized or not.
Example: Turnitin, Grammarly

1.8 Benefits of AI Tools:

Time Saving
Accurate Results
Personalized Experience

Simplify the Research and Studies process

In today's era, AI tools assist in making education and work more efficient and smarter. These tools help humans perform much better in their respective field, and they will play an even more significant role in the future.

2. RESEARCH PROBLEM:

There have been several studies conducted on digital literacy and AI separately in the Indian educational framework. Digital literacy focuses on using technology properly in education and evaluating information, whereas AI personalizes, automates, and optimizes the education process.

But research that examines the effect of the combination of these two has not yet been conducted thoroughly. In particular, in India, where the education framework, technology penetration, and usage skills differ, there is insufficient literature on how the integration of digital literacy and AI tools affects education.

2.1 Thus, the primary research problem becomes:

Does the integration of digital literacy and AI tools enhance the academic achievements of learners?
Is the integration of digital literacy and AI tools able to boost the capacity for searching, analysing, and applying information?
Are libraries capable of enhancing the quality of education through the integration of digital literacy and AI tools?

3. OBJECTIVES OF THE STUDY:

The primary objective of this research is to investigate the cumulative effect of digital literacy and artificial intelligence tools. The following objectives have been defined:
1. To determine the digital literacy levels of the learners and evaluate their information search and utilization capabilities.
2. To examine the usage of AI tools and find out the ways in which different AI tools (e.g., chatbots and research tools) are utilized by the learners.
3. To investigate the effects of digital literacy and AI on academic performance by examining the extent to which these two variables affect the academic efficiency of the learners.
4. To explore the roles played by the libraries in promoting digital literacy and AI. These objectives serve as a guide in conducting the research.

4. HYPOTHESES

H1: Digital Literacy Academic Performance (Positive)

The higher the level of digital literacy among students, the higher their academic performance; the increase in digital literacy results in increased academic performance.

H2: AI Tools Usage Academic Performance (Positive)

The higher the usage of artificial intelligence tools, the better students' academic performance; the increase in the application of AI tools positively affects academic performance.

These hypotheses create a framework for testing the research, allowing for scientific exploration of the influence of digital literacy and AI through data analysis.

5. LITERATURE REVIEW:

The convergence of digital literacy, artificial intelligence (AI), and the current generation library infrastructure systems has been receiving substantial attention among international educational studies. The following literature review presents the conclusions drawn from some credible sources.

5.1 Digital Literacy and Education: Digital literacy has gone beyond being described as an essential skill, which is now an essential element in modern education.

UNESCO: Defines digital literacy as an array of capabilities for evaluating, analysing and utilizing digital information responsibly in a digital world.

European Commission (Dig Comp Framework): Segments digital literacy into five key categories:

Information and data literacy.

Communication and collaboration.

Digital content creation.

Safety and security.

Problem-solving.

Conceptual Root: **Paul Gilster (1997),** who coined the phrase and made it popular, noted that digital literacy involves critical thinking and not only "keystrokes" in computing.

5.2 AI-Based Tools and Learning Efficiency: AI is being instrumental in driving the paradigm change in students' engagement with curricula.

OECD (2021): States that personalized learning becomes possible due to the use of AI, leading to the creation of individual educational experiences, which in turn positively influences learning outcomes.

World Economic Forum: Indicates that through automation and instant feedback, AI-based tools greatly enhance student engagement and efficiency.

Adaptive Learning: ITS makes it possible for content delivery to depend on learner success to ensure that the latter feels neither under nor overburdened with the workload.

5.3 The Changing Role of Libraries: Libraries evolve from being "information repositories" into active "learning hubs."

ALA (American Library Association): Claims that in order to eliminate the digital divide, libraries must be at the centre of efforts that aim at equal information provision and development of students' digital skills.

IFLA (International Federation of Library Associations): Sees in libraries an opportunity for achieving digital inclusion and education, as crucial for ensuring democratic access to information.

Indian Case Study: In recent years, university and college libraries in India have become e-resources centres, arranging training sessions and making extensive digital databases available.

5.4 Research Gap: There is very little empirical data available that discusses the concept of AI and digital literacy specifically from the context of Indian higher education institutions. Key Observation: Although global research gives a guideline for implementation of such digital technology, the socio-economic factors in India can be different from other countries, thereby making such data inappropriate for use in the Indian context. Therefore, there is an urgent requirement for conducting research through statistical analysis on this topic.

6. METHODOLOGY:

This research adopts a scientific and systematic method for evaluating the effect of digital literacy and AI technology on student performance.

6.1 Research Design: Quantitative Research Design was chosen as an important methodology that uses the survey approach. The methodology has been adopted in order to collect relevant data from a large number of people and thereby allow statistical testing of research hypotheses.

6.2 Sampling and Participants: Two hundred students at the Sardar Patel Education Campus have been taken as respondents by adopting a stratified sampling technique. This is done with a view to having a complete data set. Specifically, this consists of:

Undergraduate (UG) students

Postgraduate (PG) students

6.3 Research Instrumentation: Collection of data is conducted via a systematic questionnaire on the Likert Scale that aims at measuring subjectivity of attitudes and behaviour patterns.

Instrumentation: The Likert scale is measured using a scale of five (Strongly Agree to Strongly Disagree).

Thematic Components: -

Component A: Demographics: Gender, age, and course enrolled in.

Component B: Digital Competency: Subjective perception of capability in information searching and evaluation.

Component C: AI Utilization: Frequency of use and application in academic work.

Component D: Academic Effect: Impact of artificial intelligence tools on academic performance and effectiveness.

6.4 Analytical Tools for Data Analysis: The collected data has been analyzed using SPSS.

7. DATA ANALYSIS (SPSS OUTPUT)

Table 1: Descriptive Statistics ($N = \text {Sample Size} $)

Variable	Mean	Std. Dev
Digital Literacy	3.88	0.70
AI Usage	3.72	0.82
Academic Performance	3.95	0.65

Interpretation

High Central Tendency: The averages on all three measures exceed the 3.5 mark on the standard 5-point scale. Thus, the students in question are believed to possess a high degree of literacy in digital technologies, use AI-based solutions regularly, and perform well academically.

Academic Performance Lead: The mean on Academic Performance is highest at $M = 3.95$. This demonstrates that even though the student respondents have access to technology and literacy resources, their performance is still solid and impressive overall.

Data Clustering & Reliability: The Standard Deviations are rather low (SDs range between 0.65 and 0.82).

Since they do not exceed the 1.0 mark, this suggests that the data are clustered around the average tightly.

In other words, there is a high level of consensus in the student sample as there is little variation between the views held by individuals, with no apparent outliers.

Correlation Potential: The relative closeness of the means on Digital Literacy (3.88) and AI Usage (3.72) implies that they may have a correlation between each other, a perfect candidate for the next Pearson Correlation test.

Table 2: Correlation Analysis

Variable	DL	AI	AP
DL	1	0.56	0.64
AI	0.56	1	0.59
AP	0.64	0.59	1

Interpretation

The correlation coefficient between DL and AP is 0.64, which denotes a moderate-strong positive relationship. It means that high digital literacy increases academic performance.

The correlation coefficient between AI Usage and AP is 0.59, indicating a positive relationship. It shows that the increased AI Usage affects the increased academic performance.

The correlation coefficient between DL and AI Usage is 0.56, showing a positive relationship between these two variables.

Conclusion: Thus, according to correlation analysis, both variables – Digital Literacy and AI Usage are positively correlated with the variable – Academic Performance, and the hypotheses are confirmed.

Hypotheses Testing

H1 (Digital Literacy → Academic Performance)

Accepted as the correlation coefficient is 0.64, meaning a positive relationship between these variables.

H2 (AI Usage → Academic Performance)

Accepted as the correlation coefficient is 0.59, meaning a positive relationship between these variables.

Conclusion: The data supports both hypotheses, as Digital Literacy and AI Usage have a positive significant relationship with Academic Performance. SPSS data analysis shows that digital literacy and AI tools usage positively impacts efficient performance of the students. Consequently, both are essential for the economization of education and need to be discussed. Ability.

Table 3: Regression Analysis

Predictor	Beta	Sig
Digital Literacy (DL)	0.48	0.000
AI Usage (AI)	0.41	0.000

Exegesis:

Digital Literacy (DL) has a Beta value of .048, which means it has strong positive influence on academic performance.

The influence of AI on academic performance is measured as 0.41, indicating a positive and significant effect of AI Usage variable.

The Sig value, which is for both variables 0.000 (< 0.05), confirms that the results are significant.

Main Insight:

The effect of Digital Literacy on Financial Literacy is greater than the effect of AI Usage.

Both factors show considerable academic performance predictions.

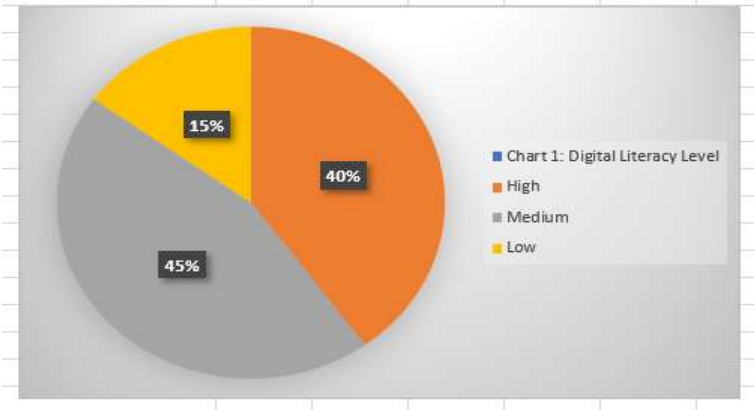
The regression model is good and supports the hypothesis.

Conclusion Based on Hypothesis:

The relationship between digital literacy and academic performance.
The statement with Beta = 0.48 and Sig < 0.05 has been accepted.
Usage of AI influences academic performance.
Beta and Sig are accepted as .41 and < .05 respectively.

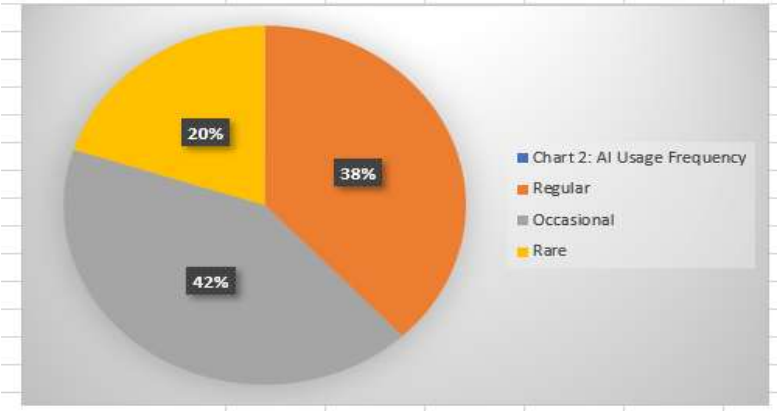
8. CHARTS REPRESENTATION

Chart 1: Digital Literacy Level



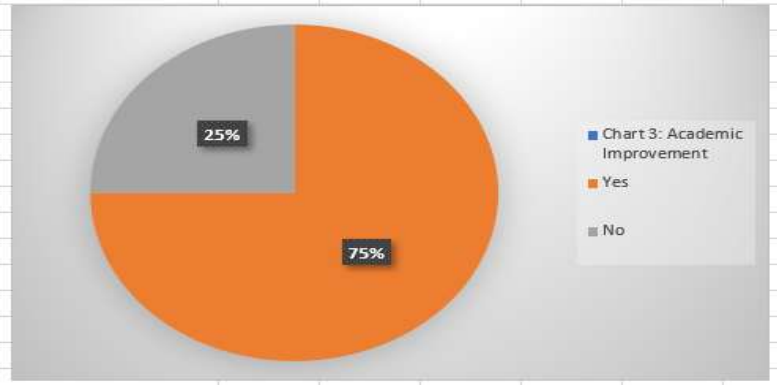
• Medium (45%) is the highest
• High (40%) is also significant
Indicates that most students have better than average digital knowledge

Chart 2: AI Usage Frequency



• Occasional (42%) and Regular (38%) are in close proportion
Students use AI, but consistent use still needs to be increased

Chart 3: Academic Improvement



• Yes (75%) is very high

Clearly shows that both digital literacy and AI improve academic performance

9. Discoveries: According to the analysis of data and output of SPSS of this research, the following findings.

• **There is a strong link between digital literacy and academic performance in students:** Students' learning is enhanced through the application of ICTs both inside and outside the classroom. It enhances students' ability to analyse and use the information.

• **AI Tools Boost Academic Performance:** The learning process becomes easier, quicker, and more efficient through the use of AI-based tools, which positively affects student performance.

• **Libraries serve as enablers**: Modern academic libraries play a key role as facilitators promoting the use of digital literacy and AI. They help to access information resources, training and technology.

The results show that digital literacy, tools of AI and libraries make education effective and of higher quality.

10. Challenges: Some critical challenges arise in the process of studying this topic, affecting the implementation of digital literacy and AI effectively:

• **The Problem of Rural-Urban Divide:** The provision of technology, the Internet, and digital technologies is more common in urban areas than in rural regions, causing inequality in the use of digital literacy and AI. It leads to a digital divide in education.

• **Dependence on AI Tools:** Dependence on AI tools may reduce creative and innovative thinking among students because they will depend on AI software to solve their problems.

Therefore, some challenges related to using digital technologies and AI tools must be taken into consideration. They can be resolved through proper policy.

11. Recommendations: Considering the findings obtained during this research, the following recommendations can be provided:

To Libraries: -

• Set Up AI Labs

Organize labs in the libraries based on AI for learning different AI tools.

• Training Programs

Provide regular training programs for increasing digital literacy.

To Students: -

• **Improve Critical Thinking:** It is important for students to gain the capability of analysing, evaluating, and making logical judgments regarding information to be able to employ outcomes of AI properly.

• **Apply Ethics in AI Use:** The application of ethics when using AI is crucial, including not plagiarizing and employing information responsibly.

Nevertheless, the study still reveals some valuable facts even at its preliminary stage. Further investigations may yield more accurate and valid data thanks to an increase in sample and methodological diversity.

12. Conclusion: From an analysis of this research, it can be concluded that combining the concepts of digital literacy and AI is vitally important in contemporary education.

Digital Literacy + AI = Improved Learning

Digital literacy makes students capable of understanding, analysing, and using information.

AI tools enable quicker, customized, and more efficient learning.

Combined together, they produce significant progress in academic success and learning effectiveness.

Based on the results presented in this paper, it becomes obvious that the implementation and appropriate application of digital literacy skills and AI can considerably contribute to the improvement of the quality of education.

Educational organizations as well as libraries should encourage the development of both digital literacy and artificial intelligence.

13. LIMITATIONS OF THE STUDY:

The conducted study has a number of limitations that influence its scope and results:

Sample Size – 200

The selected sample of students consisted of only 200 people, which did not give an opportunity to obtain all necessary data on the topic.

Only Survey-Based Study

In order to conduct a full-fledged investigation, the researchers needed to use at least one other method besides surveys.

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A STUDY OF GST REFORMS IN INDIA 2025 (NEW GST 2.0)

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ABSTRACT

GST is a short form of Goods and Service Tax. GST is implemented in India from 1st July, 2017. GST combines variety of indirect taxes and allows tax-credit against goods as well as services. Earlier the provisions stated that tax was applicable on the manufacture or sale of goods or provision of services but GST is based on the principle of "Destination based Consumption". GST is applicable on supply of goods or services. GST is a dual charge, with the Centre and the States simultaneously levying it on a common base. Centre can be levying Central GST, which is known as CGST. States (including Union Territories with legislature) can be levying State GST, which is known as SGST. GST rates in India from 1st July, 2017 was 0%, 5%, 12% and 28%. The GST Reform Bill, commonly referred to as GST 2.0, approved by the GST Council, will be implemented on 22nd September, 2025. The GST rates in GST 2.0 is 0%, 5%, 18% and 40%. GST 2.0 is relief for consumers. The price of multiple goods associated with routine household expenses is reduced after implementation of GST 2.0 and also it results to fulfill middle-class desires, also it is transitioning to lower tax.

KEYWORDS:

GST- GOODS SERVICE TAX,
GST 2.0- GOODS SERVICE TAX REFORMS IN INDIA
ITC- INPUT TAX CREDIT
IGST- INTEGRATED GOODS SERVICE TAX
CGST- CENTRAL GOODS SERVICE TAX
SGST- STATE GOODS SERVICE TAX
UTGST- UNION TERRITORY GOODS SERVICE TAX

INTRODUCTION

GST is a short form of Goods and Service Tax. France was introduced GST in 1954, the first Nation the first who was implemented GST. GST is implemented in India from 1st July, 2017. GST is to be charged at the same rate at the National level on the similar products and services and it replaced almost all the indirect taxes.

GST combines variety of indirect taxes and allows tax-credit against goods as well as services. GST is levied at all levels – from Manufacturer to final consumption with credit of taxes paid at previous level available as set-off. In short, only value addition will be taxable and burden of tax is to be borne by the final consumer. Earlier the provisions stated that tax was applicable on the manufacture or sale of goods or provision of services but GST is based on the principle of "Destination based Consumption". GST is applicable on supply of goods or services. GST is a dual charge, with the Centre and the States simultaneously levying it on a common base. Centre can be levying Central GST, which is known as CGST. States (including Union Territories with legislature) can be levying State GST, which is known as SGST. Union Territories without legislature can be levying Union

territory GST, which is known as UTGST. In place of CST, Integrated GST (IGST) would be levied on inter-State supply of goods or services. IGST would be collected by the Centre. This is to ensure that the credit chain is not disrupted (Manufacturer - wholesaler-retailer-consumer). Import of goods would be treated as inter-State supplies and therefore, IGST will be applicable on it. Additionally applicable customs duties will also be taxable; import of services would be treated as inter-State supplies and will attract IGST.

THE GST IS REPLACED THE FOLLOWING TAXES:

Taxes which used to be levied and collected by the Centre:

-Central Excise Duty.
-Special Additional Duty of Customs(SAD).
-Service Tax.
-All Cess and surcharge.
-Additional Duty of Customs (CVD).

State taxes that would be subsumed within the GST are:

-State VAT.
-Central Sales Tax.
-Purchase Tax.
-Luxury Tax.
-Entry Tax (All forms).
-Entertainment Tax.
-Taxes on advertisements.
-Taxes on lotteries, betting and gambling.
-Cess and surcharge that are related to supply of goods or services.
-Exports would be exempted, that is zero-rated.

The Input Tax Credit (ITC) will be made on a broader base; it will be made available in respect of taxes paid on any supply of goods or services or both used or intended to be used in the course or furtherance of business. Credit of CGST paid on inputs may be used only for paying CGST on the output and the credit of SGST/UTGST paid on inputs may be used only for paying SGST/UTGST. In other words, the two streams of input tax credit (ITC) cannot be cross utilized, except in specified circumstances of inter-State supplies for payment of IGST. The credit would be permitted to be utilized in the following manner:

-ITC of CGST allowed for payment of CGST first and then IGST;
-ITC of SGST allowed for payment of SGST first and then IGST;
-ITC of UTGST allowed for payment of UTGST first and then IGST;
-ITC of IGST allowed for payment of first IGST, then CGST and then can be adjusted for SGST/UTGST.
-ITC of CGST cannot be used for payment of SGST/UTGST and vice versa.

OLD GST RATES IN INDIA

GST is implemented in India from 1st July, 2017. GST rates in India from 1st July, 2017 as below:

0% GST on Nil-rated or exempt category goods like fruits, vegetables, milk etc.

5% GST on Necessary goods like packaged foods, processed food etc.

12% GST on consumer items like papers, boxes, lather, cement, computer medicines, toys, tray, dry fruits, drinks, dairy products etc.

18% GST on Service, Electronic and Standard goods like Jim, hair oil, toothpaste, soap, shampoo, cables, tissue, plug, switch, lamp, all services etc.
28% GST on Luxury goods and sin items like pan masala, bidi, cigarette, water heater, car, A.C., dish washer, washing machine, sun screen, soft drinks etc.

GST REFORMS IN INDIA 2025 (NEW GST 2.0)

The GST Reform Bill, commonly referred to as GST 2.0, approved by the GST Council, will be implemented on 22nd September, 2025, right before the festive season. This represents the largest revision since GST was initially implemented on 1st July, 2017.
A significant promise of GST 2.0 is relief for consumers. Multiple goods associated with routine household expenses or middle-class desires are transitioning to lower tax categories and will see price reductions beginning from 22nd September, 2025.
A few instances are:
• Food & household items: Packaged food, soaps, and juices now incur a 5% tax rate, alleviating monthly grocery expenses.
• Health products and medicines: Reduced GST will make essential medicines, life insurance premiums, and health insurance more budget-friendly. This may expand healthcare coverage and accessibility.
• White goods: Refrigerators, washing machines, air conditioners, and other appliances will now face an 18% tax rate instead of the previously higher rates. This simplifies significant household buying for middle-class families.
• Vehicles & transportation: Compact vehicles, bicycles, automotive components, and even parts related to electric vehicles are anticipated to be in the 18% range, possibly increasing demand in an industry that has faced elevated prices for years.

A COMPARATIVE STUDY OF GST RATES

Items	Old GST	New GST
Eraser	5%	NIL
Butter, Ghee, Cheese & Dairy Spreads	12%	5%
Pre-packaged Namkeens, Bhujia & Mixtures	12%	5%
Utensils	12%	5%
Feeding Bottles, Napkins for Babies & Clinical Diapers	12%	5%
Sewing Machines & Parts	12%	5%
Medical Grade Oxygen	12%	5%
All Diagnostic Kits & Reagents	12%	5%

Glucometer & Test Strips	12%	5%
Corrective Spectacles	12%	5%
Maps, Charts & Globes	12%	NIL
Pencils, Sharpeners, Crayons & Pastels	12%	NIL
Exercise Books & Notebooks	12%	NIL
Tractors	12%	5%
Specified Bio-Pesticides, Micro-Nutrients	12%	5%
Drip Irrigation System & Sprinklers	12%	5%
Agricultural, Horticultural or Forestry Machines for Soil Preparation, Cultivation, Harvesting & Threshing	12%	5%
Hair Oil, Shampoo, Toothpaste, Toilet Soap Bar, Tooth Brushes, Shaving Cream	18%	5%
Individual Health & Life Insurance	18%	Nil
Thermometer	18%	5%
Tractor Tyres & Parts	18%	5%
Petrol & Petrol Hybrid, LPG, CNG Cars (not exceeding - 1200 cc & 4000mm)	28%	18%
Diesel & Diesel Hybrid Cars (not exceeding - 1200 cc & 4000mm)	28%	18%
3 Wheeled Vehicles	28%	18%
Motor Cycles (350 cc & below)	28%	18%
Motor Vehicles for Transport of Goods	28%	18%
Air Conditioners	28%	18%
Televisions (above 32", including LED & LCD TVs)	28%	18%
Monitors & Projectors	28%	18%
Dish Washing Machines	28%	18%

The tables present a comparative analysis of Goods and Services Tax (GST) rates across a wide range of commodities and sectors, highlighting the transition from the old tax structure to the revised GST framework. A clear pattern emerges from the data: a substantial rationalization and reduction in tax rates, particularly on essential goods, educational materials, healthcare items, and agricultural inputs. This restructuring reflects a policy orientation toward affordability, consumption stimulation, and sectoral support.

At the outset, the table shows that several basic and commonly used items have experienced significant tax relief. For instance, erasers, which were previously taxed at 5%, have been brought under the NIL tax category, indicating complete exemption. Similarly, educational and stationery-related goods such as maps, charts, globes, pencils, sharpeners, crayons, pastels, and exercise books have moved from a 12% tax bracket to NIL. This shift suggests a deliberate effort to reduce the cost burden on students and promote education by making learning materials more accessible.

In the food and daily consumption category, notable reductions are observed. Items such as butter, ghee, cheese, and dairy spreads, along with pre-packaged namkeens, bhujia and mixtures, have seen their GST rates reduced from 12% to 5%. This indicates a targeted approach toward easing the cost of essential and semi-essential food products. Given that these items are widely consumed across income groups, the reduction has implications for household consumption expenditure and inflation control.

The healthcare sector also reflects a similar trend of tax rationalization. Medical-grade oxygen, diagnostic kits, reagents, glucometers, test strips, corrective spectacles, thermometers, and clinical diapers have all seen GST reductions from 12% or 18% to 5%. This is particularly significant in the context of public health priorities, as it lowers the cost of medical essentials and diagnostic tools. Additionally, the complete exemption (NIL rate) on individual health and life insurance premiums marks a major policy intervention aimed at increasing insurance penetration and financial security among individuals.

Agriculture and allied sectors benefit considerably from the revised GST structure. Equipment such as tractors, drip irrigation systems, sprinklers, and agricultural machinery used for soil preparation, cultivation, harvesting, and threshing have seen tax rates reduced from 12% to 5%. Similarly, inputs like bio-pesticides and micro-nutrients have also moved to the lower 5% bracket. These changes are likely intended to reduce input costs for farmers, enhance agricultural productivity, and support rural income generation.

Household and personal care items exhibit a substantial decline in GST rates as well. Products such as hair oil, shampoo, toothpaste, toilet soap, shaving cream, and toothbrushes have experienced a sharp reduction from 18% to 5%. This indicates a shift in classification of these goods from relatively higher-taxed discretionary items to essential consumption goods. The reduction in tax burden on these items directly impacts everyday household expenses and improves affordability for consumers. In the manufacturing and small-scale industry segment, sewing machines and their parts have also seen a tax reduction from 12% to 5%. This may be interpreted as a measure to support micro, small, and medium enterprises (MSMEs), particularly those involved in tailoring and garment production, by reducing capital and maintenance costs.

The transportation and automobile sector, however, while still experiencing tax reductions, remains in relatively higher tax brackets compared to essential goods. Vehicles such as petrol, diesel, hybrid, LPG, and CNG cars (within specified engine capacity limits), along with three-wheeled vehicles, motorcycles (350 cc and below), and goods transport vehicles, have seen GST rates decrease from 28% to 18%. Although the reduction is significant, the retention of a relatively high tax rate suggests that these goods are still considered either semi-luxury or revenue-generating categories.

Similarly, consumer durables and electronic goods such as air conditioners, televisions (above 32 inches), monitors, projectors, and dishwashing machines have witnessed a reduction from 28% to 18%. While this indicates some degree of relief, these items continue to attract higher GST compared to essential commodities, reflecting their classification as non-essential or luxury goods.

IMPACT OF GST ON HOUSEHOLD EXPENSES

Category	Old GST	New GST
Educational items	12.00%	NIL
Insurance Premium	18.00%	NIL
Packaged Food	12.00%	5.00%
Farmers Equipments	12.00%	5.00%
Healthcare	12.00%	5.00%
Transportation	18.00%	5.00%
Household – Personal Care	18.00%	5.00%
Electronics	28.00%	18.00%

The "Impact of GST on Household Expenses" table consolidates these changes into broader consumption categories. Educational items and insurance premiums have been completely exempted (moved to NIL), significantly reducing financial pressure on households in these critical areas. Packaged food, farmers' equipment, healthcare products, transportation services, and personal care items have all experienced reductions to 5%, indicating a consistent policy direction toward lowering the cost of living. Electronics, although reduced from 28% to 18%, remain one of the higher-taxed categories, thereby maintaining a differential tax structure based on necessity and consumption patterns.

Overall, the comparative analysis demonstrates a clear structural shift in GST policy toward rationalization and equity. The reduction and exemption of taxes on essential goods and services aim to enhance affordability, stimulate demand, and support key sectors such as education, healthcare, and agriculture. At the same time, relatively higher tax rates on luxury and durable

goods ensure continued revenue generation for the government. This balanced approach reflects an attempt to align taxation policy with socio-economic priorities, improve compliance, and simplify the indirect tax regime in India.

CONCLUSION:

The government is trying to smooth the road to GST. It is important to learn from global economies that have implemented GST before us, and who overcame the teething troubles to experience the advantages of having a unified tax system and easy input credits.

The government is trying to reduce the burden of compliance for businesses by relaxing the return filing requirements for the implementation of GST. GST 2.0 is relief for consumers. The price of multiple goods associated with routine household expenses is reduced after implementation of GST 2.0 and also it results to fulfill middle-class desires, also it is transitioning to lower tax.

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SYNTHESIS AND ANTIMICROBIAL EVALUATION OF NOVEL N-GLYCOSYLATED THIOCARBAMIDES

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ABSTRACT

The synthesis of N-glycosyl thiocarbamide has been documented by the reaction between Per-*O*-acetyl glycosyl isothiocyanate and alkyl 4-aminobenzoate. A straightforward isolation technique yielding satisfactory results under mild conditions is suitable for the current protocol. The confirmation of the newly synthesized compounds was accomplished using IR, ^{1}H NMR, and mass spectral analyses. The specific rotation of the compounds was evaluated using polarimetric methods. All newly synthesized N-glycosyl thiocarbamides demonstrate moderate to good antimicrobial activity against various pathogens.

KEYWORDS: GLYCOSYL ISOTHIOCYANATES, ALKYL 4-AMINOBENZOATE, GLYCOSYL THIOCARBAMIDE, SYNTHESIS, ANTIMICROBIAL ACTIVITY.

INTRODUCTION:

Carbohydrates represent a significant class of organic compounds that play a crucial role in synthetic, medicinal, and pharmaceutical chemistry due to their remarkable biological significance. Sugar isothiocyanates have demonstrated efficacy as excellent intermediates, facilitating the synthesis of a diverse array of carbohydrate derivatives that are of both synthetic and biologically relevant interest. This is largely attributed to their tendency to readily undergo various important reactions, such as cycloaddition and nucleophilic substitution.

The chemistry of Glycosyl thiocarbamide is systematically developed and thoroughly documented [1]. Many sugar thiourea derivatives have wide application in industry for making carbohydrate-based detergent [2], and in pharmaceutical as an anticancer agent [3] and anti-fungal agents [4]. They are bioactive molecules and used as an intermediate for preparing various derivatives. Per-O-acetyl glycosyl isothiocyanate have a key role in carbohydrate chemistry. Various compounds have been synthesized by the use of glycosyl isothiocynate [5-8].

Methyl 4-aminobenzoate (MAB) is a chemical compound commonly used as an intermediate in the preparation of local anesthetic[9]. Research also shows that some derivative of Methyl p-aminobenzoate possess anticancer properties [9]. Benzocaine is used as an anaesthetic drug and also in the medication of ulcers, ear pain and dental complications. Benzocaine also combined with lidocaine and other local anaesthetics, and used as an anesthetic agent in surgical procedures. Benzocaine derivatives have been found to possess biological activity such as antibacterial, antifungal and anti-cancer. Some derivatives were found to have distinct action against tuberculosis [10]. Based on the existing knowledge regarding the research conducted on N-glycosylated compounds [11-17], and considering the extensive applications of alkyl 4-aminobenzoate, it was particularly intriguing to synthesize novel N-glycosylated thiocarbamides.

This was achieved by reacting per-*O*-acetyl glycosylisothiocyanate with alkyl 4-aminobenzoate to obtain varying levels of activity.

In this study, we present the synthesis of Per-*O*-acetyl glycosyl thiocarbamide through the condensation of per-*O*-acetyl glycosyl isothiocyanate with methyl 4-aminobenzoate and benzocaine. The characterization of all newly formed compounds was conducted using IR, ^{1}H NMR, and mass spectral analysis [18-22]. The antimicrobial properties of the newly synthesized compounds were assessed using the broth dilution method [23].

EXPERIMENTAL:

2.1 General methods:

Melting points were measured using an electro thermal melting point apparatus and are reported without any corrections. Infrared spectra were obtained using a Perkin-Elmer Spectrum RXI FTIR spectrometer, covering the range of 4000-450 cm^{-1}. The ^{1}H NMR spectra were recorded on a JEOL FT-NMR spectrometer operating at 500 MHz. The samples were dissolved in a suitable solvent, with TMS solution serving as the internal standard. Mass spectra were acquired using a TSQ Endura Mass spectrometer. Thin Layer Chromatography (TLC) was conducted on E. Merck pre-coated silica gel plates and was visualized by exposure to shortwave UV light. The specific rotation of title compounds on was determined through a polarimetric analysis.

2.2 Per-*O*-acetyl glycosyl isothiocyanate

The key intermediate per-*O*-acetyl glycosyl isothiocyanate was synthesized in three steps. The first step is the acetylation of sugar with acetic anhydride and catalytic amount of perchloric acid. The product was brominated in HBr in AcOH. This per-O-acetyl glycosyl bromide was subjected to nucleophilic substitution reaction with $Pb(SCN)_2$ in boiling dry xylene to yield Per-*O*-acetyl glycosyl isothiocyanate 1(a-d).

2.3 Per-*O*-acetyl glycosyl thiocarbamides

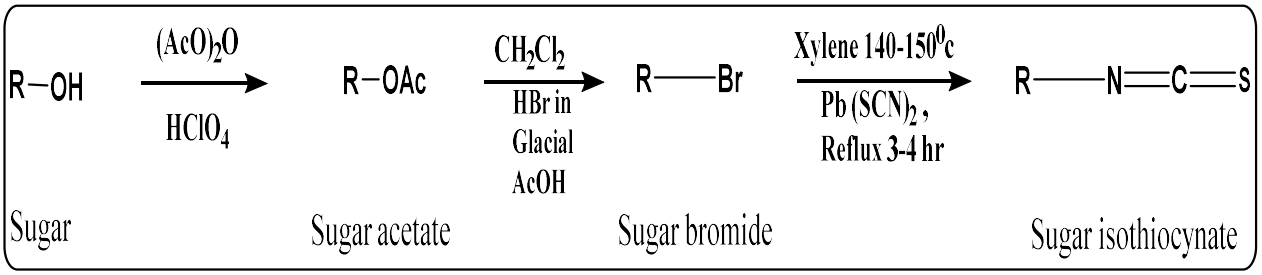
Per-*O*-acetyl glycosyl thiocarbamides (2a-d and 3a-d) were synthesized by the reaction of Per-*O*-acetyl glycosyl isothiocyanate1(a-d) with alkyl 4- amino benzoate (I and II) in the presence of toluene.

The reaction mixture, consisting of per-*O*-acetyl glycosyl isothiocynate 1(a-d) (0.005 M) and alkyl 4- amino benzoate (I and II) (0.005 M), was refluxed in toluene for 3-5 h. The progress of the reaction was monitored using thin layer chromatography [7:3, EtOAc: Pet ether]. The solvent was removed through distillation, resulting in a syrupy residue. The product was isolated by repeatedly triturating the syrupy residue with light petroleum (60-80°). A light-yellow free product was obtained. The crystallization of the new molecule was performed using ethanol.

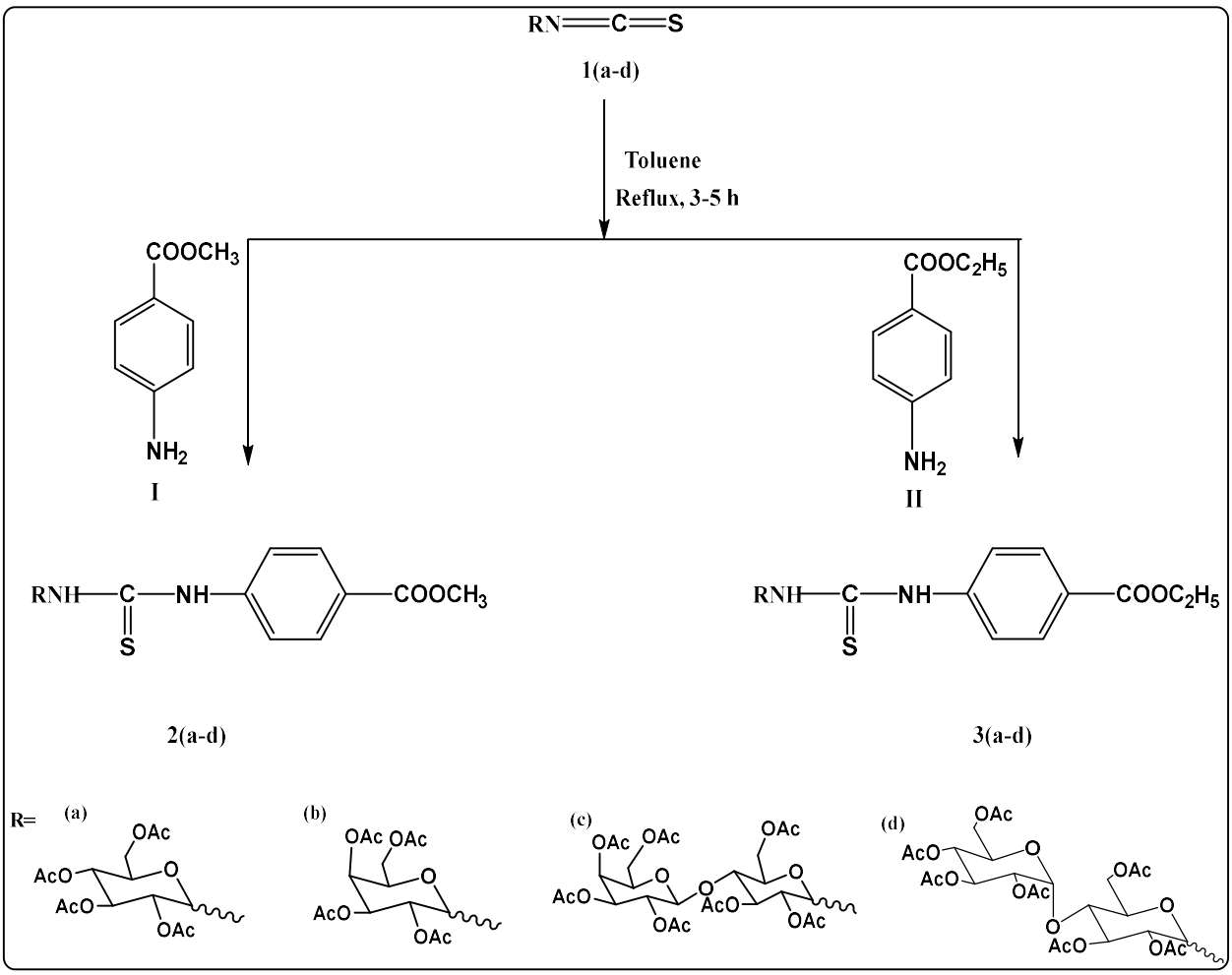
2.4 Antimicrobial activity

The antimicrobial activity of synthesized compounds was carried out against a panel of selected Gram positive and Gram-negative bacteria and also fungi which are presented in Table-2 in comparison with reference drug Gentamycin, Ampicillin, Chloramphenicol, Ciprofloxacin, Norfloxacin for bactericidal activity and Nystatin, Greseofulvin for fungicidal activity. The antimicrobial activity was evaluated against different bacterial strains such as E. coli, P.aeruginosa, S.aureus, S.pyogenus and fungal strains such as C.albicans, A.niger, A.clavatus by using Broth dilution method. The lowest concentration for inhibiting growth of the organism is considered as the MIC.

Scheme:1 Synthesis of Glycosyl isothiocynate



Scheme:2 Synthesis of Glycosyl thiocarbamide



RESULT AND DISCUSSION

Glycosyl thiocarbamide were prepared by the condensation of alkyl 4- amino benzoate and glycosyl isothiocyanate in toluene for 3-5 hrs. The reaction was monitored by TLC. After complete reaction, the solvent was removed by evaporation in vacuum and resultant sticky residue was triturated with petroleum ether (60-80˚C) to afford the product. The products were crystallized from aqueous ethanol. The synthesized compounds are further characterized by using IR, ^{1}HNMR and Mass spectral analysis.

The IR spectra of the compounds showed strong characteristic absorption of glycosyl unit in the range of 895 -910 Cm^{-1}, 1000 - 1400 cm^{-1} for stretching vibration of C-H bond. The stretching band

for acetyl C=O has appeared in the region 1749-1750 cm $^{-1}$. The absorption band for C=S and C-N has appeared in the region 1226- 1234 cm $^{-1}$ and 1300-1373 cm $^{-1}$ respectively.

^{1} HNMR spectrum of the products shows characteristic of glycosyl protons at δ 5.6-3.7 ppm and resonance signals for aromatic protons at δ 7.41-8.77 ppm. Acetyl protons are appeared at δ 1.96-2.21 ppm.

Mass spectra exhibited molecular ion peak along with characteristic fragments of synthesized compounds at m/z, 619, 331, 211, 169, 109.

3.1 SPECTRAL AND PHYSICAL DATA OF SYNTHESIZED COMPOUNDS

3.1.1 Tetra-*O*-acetyl-Glucosyl-4-(3-methylthioureido) benzoate (2a)

Pale Yellow, mp 110˚C-115˚C m.w. 540 gm/mole, Yield 79 %, $[\alpha]_D$ +180˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.83. IR (KBR) cm^{-1}: 3309 (N-H), 2901 (C-H, Ali.), 3016 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1226 (C=S), 895-1041(glucose unit). ^{1}HNMR ($CDCl_3$): δ3.7-4.6 (m, 7H, glucose unit, δ1.97 - 2.16 (m, 12H, 4$COCH_3$), δ7.51- 7.86 (m, 2H, aromatic-H) δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 540(M^+), 331, 211, 169. Analysis for $C_{21}H_{26}N_4O_{10}S$, Calculated C, 51.11%; H, 5.22%; N, 5.18%; S, 5.93%; required ; C, 51.10%; H, 5.20%; N, 5.12%; S, 6%.

3.1.2 Tetra-*O*-acetyl-Galactosyl-4-(3-methylthioureido) benzoate (2b)

Pale Yellow, mp 108˚C-112˚C m.w. 540 gm/mole, Yield 79 %, $[\alpha]_D$ +180˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.83. IR (KBR) cm^{-1}: 3309 (N-H), 2901 (C-H, Ali.), 3016 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1226 (C=S), 897-1041(galactose unit). ^{1}HNMR ($CDCl_3$): δ3.8-4.6 (m, 7H, galactose unit, δ1.98 - 2.16 (m, 12H, 4$COCH_3$), δ7.51- 7.86 (m, 2H, aromatic-H) δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 540(M^+), 331, 211, 169. Analysis for $C_{21}H_{26}N_4O_{10}S$, Calculated C, 51.11%; H, 5.22%; N, 5.18%; S, 5.93%; required ; C, 51.10%; H, 5.20%; N, 5.12%; S, 6%.

3.1.3 Hepta-O-acetyl-lactosyl 4-(3-methylthioureido) benzoate (2c)

Pale Yellow, mp 120˚C-124˚C m.w. 828 gm/mole, Yield 82 %, $[\alpha]_D$ +183.3˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.71. IR (KBR) cm^{-1} : 3294 (N-H), 2985 (C-H, Ali.), 3109(C-H, Aro.), 1751(C=O), 1373(C-N), 1226 (C=S), 902 -1049(lactose unit). ^{1}HNMR ($CDCl_3$): δ3.76-5.53 (m, 14H, lactose unit), δ1.96 to 2.15 (m, 21H, 7$COCH_3$), δ7.51- 7.86 (m, 4H, aromatic-H), δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 828(M^+), 619, 331, 211, 169,122, 109. Analysis for $C_{35}H_{44}N_2O_{19}S$, Calculated C, 50.72%; H, 5.35%; N, 3.38%; S, 3.87%; required ; C,50.80%; H,5.15%; N,3.36%; S, 3.80%.

3.1.4 Hepta-O-acetyl-Maltosyl 4-(3-methylthioureido) benzoate (2d)

Pale Yellow, mp 118˚C-123˚C m.w. 828 gm/mole, Yield 78 %, $[\alpha]_D$ +176.66˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.62. IR (KBR) cm^{-1}: 3294 (N-H), 2962 (C-H, Ali.), 3109 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1234 (C=S), 902-1041(maltose unit). ^{1}HNMR ($CDCl_3$): δ3.93-5.41 (m, 14H, maltose unit) , δ1.99 to 2.139 (m, 21H, 7$COCH_3$), δ7.51- 7.86 (m, 4H, aromatic-H), δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 828(M^+), 619, 331, 211, 169,122, 109. Analysis for $C_{35}H_{44}N_2O_{19}S$, Calculated C, 50.72%; H, 5.35%; N, 3.38%; S, 3.87%; required ; C,50.80%; H,5.15%; N,3.36%; S, 3.80%.

3.1.5 Tetra-*O*-acetyl-Glucosyl-4-(3-ethylthioureido) benzoate (3a)

Pale Yellow, mp 115˚C-117˚C m.w. 554 gm/mole, Yield 75 %, $[\alpha]_D$ +223.3˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.81. IR (KBR) cm^{-1}: 3309 (N-H), 2901 (C-H, Ali.), 3016 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1226 (C=S), 895-1041(glucose unit). ^{1}HNMR ($CDCl_3$): δ3.7-4.6 (m, 7H, glucose unit, δ1.98 - 2.15 (m, 12H, 4$COCH_3$), δ7.50- 7.82 (m, 2H, aromatic-H) δ.6.90- 7.02 (m, 2H, aromatic-H).

Mass: 554(M^+), 555, 331, 211, 169. Analysis for $C_{24}H_{30}N_2O_{11}S$, Calculated C, 51.90%; H, 5.40%; N, 5.03%; S, 5.80%; required; C, 51.98%; H, 5.45%; N, 5.05%; S, 5.78%.

3.1.6 Tetra-*O*-acetyl-Galactosyl-4-(3-ethylthioureido) benzoate (3b)

Pale Yellow, mp 112˚C-115˚C m.w. 554 gm/mole, Yield 78 %, $[\alpha]_D$ +200˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.75. IR (KBR) cm^{-1}: 3309 (N-H), 2901 (C-H, Ali.), 3016 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1226 (C=S), 895-1041(galactose unit). ^{1}HNMR ($CDCl_3$): δ3.7-4.6 (m, 7H, galactose unit, δ1.97 - 2.16 (m, 12H, $4COCH_3$), δ7.51- 7.86 (m, 2H, aromatic-H) δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 554(M^+), 555, 331, 211, 169. Analysis for $C_{24}H_{30}N_2O_{11}S$, Calculated C, 51.93%; H, 5.42%; N, 5.01%; S, 5.75%; required ; C, 51.98%; H, 5.45%; N, 5.05%; S, 5.78%.

3.1.7 Hepta-O-acetyl-lactosyl 4-(3-ethylthioureido) benzoate (3c)

Pale Yellow, mp 124˚C-130˚C m.w. 842 gm/mole, Yield 79 %, $[\alpha]_D$ +203˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.58. IR (KBR) cm^{-1} : 3294 (N-H), 2985 (C-H, Ali.), 3109(C-H, Aro.), 1751(C=O), 1373(C-N), 1226 (C=S), 902 -1049(lactose unit). ^{1}HNMR ($CDCl_3$): δ3.76-5.53 (m, 14H, lactose unit), δ1.96 to 2.15 (m, 21H, $7COCH_3$), δ7.51- 7.86 (m, 4H, aromatic-H), δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 842 (M^+), 619, 331, 211, 169,122, 109. Analysis for $C_{36}H_{46}N_2O_{19}S$, Calculated C, 51.35%; H, 5.45%; N, 3.36%; S, 3.84%; required ; C, 51.30%; H, 5.50%; N, 3.32%; S, 3.80%.

3.1.8 Hepta-O-acetyl-Maltosyl 4-(3-ethylthioureido) benzoate (3d)

Pale Yellow, mp 122˚C-127˚C m.w. 842 gm/mole, Yield 76 %, $[\alpha]_D$ +203.3˚ (c,0.03, $CHCl_3$), R_f (7:3 EtAc: Pet. Ether) 0.70. IR (KBR) cm^{-1}: 3294 (N-H), 2962 (C-H, Ali.), 3109 (C-H, Aro.), 1751 (C=O), 1373 (C-N), 1234 (C=S), 902-1041(maltose unit). ^{1}HNMR ($CDCl_3$): δ3.93-5.41 (m, 14H, maltose unit) , δ1.99 to 2.139 (m, 21H, $7COCH_3$), δ7.51- 7.86 (m, 4H, aromatic-H), δ.6.89- 7.02 (m, 2H, aromatic-H). Mass: 842 (M^+),843, 619, 331, 211, 169,122, 109. Analysis for $C_{36}H_{46}N_2O_{19}S$, Calculated C, 51.32%; H, 5.52%; N, 3.35%; S, 3.83%; required ; C, 51.30%; H, 5.50%; N, 3.32%; S, 3.80%.

3.2 Antimicrobial activity

The synthesized compounds were tested for their antibacterial activities against E.coli, P.aeruginosa, S.aureus, S.pyogenus and A.clavatus using Gentamycin, Ampicillin, Chloramphenicol, Ciprofloxacin and Norfloxacin as the standard drug. All synthesized compounds tested for antibacterial activity were found to be moderately active against E. coli and P.aeruginosa. Compounds 2a and 3b found equally potent, 2b, 2c and 3a found to have outstanding activity, while 2d, 3c and 3d exhibited moderate activity against S.aureus comparison with Ampicillin standard drug. Compound 2d and 3a was equally potent comparison with Chloramphenicol and Ciprofloxacin, while all other compounds show moderate activity against S.pyogenus comparison with Ampicillin, Chloramphenicol and Ciprofloxacin standard drugs.

The synthesized compounds were also tested for their antifungal activities against C.albicans, A. Niger and A.clavatus using Nystatin and Greseofulvin as the standard drug. Compounds 2a,2b,2c and 3d were equally potent, 2d found to have outstanding activity, while 3a and 3b shows moderate activity against C.albicans comparison with standard drug Greseofulvin. All compounds were inactive against A. Niger and A.clavatus.

From the antimicrobial activity, it was found that most of the compounds are more or less effective against microorganisms. So, for treatment of diseases these compounds can be used only when they do not have any toxic or other side effects.

Table 1: Physical data of N-glycosyl thiocarbamide

Compound	Mol. Formula	Mol. Weight	M.P (°C)	Yield (%)	$[\alpha]_D$ (c,0.03, in $CHCl_3$)	R_f value: 7:3 EtOAc:Pet. Ether
2a	$C_{23}H_{28}N_2O_{11}S$	540	110°C-115°C	79 %	+180°	0.83
2b	$C_{23}H_{28}N_2O_{11}S$	540	108°C-112°C	80 %	+182°	0.78
2c	$C_{35}H_{44}N_2O_{19}S$	828	120°C-124°C	82 %	+183.3°	0.71
2d	$C_{35}H_{44}N_2O_{19}S$	828	118°C-123°C	78 %	+176.66°	0.62
3a	$C_{24}H_{30}N_2O_{11}S$	554	115°C-117°C	75 %	+223.3°	0.81
3b	$C_{24}H_{30}N_2O_{11}S$	554	112°C-115°C	78%	+200°	0.75
3c	$C_{36}H_{46}N_2O_{19}S$	842	124°C-130°C	79 %	+203°	0.58
3d	$C_{36}H_{46}N_2O_{19}S$	842	122°C-127°C	76 %	+203.3°	0.70

Table: 2 Anti-microbial activities of synthesized compounds.
(Minimal Inhibition Concentration, microgram/ml)

compounds	Bacteria				Fungi		
	E. coli MTC 443	P. aeruginosa MTCC 441	S. Aureus MTCC 96	S. pyogenus MTCC 442	C. albicans MTCC 227	A. niger MTCC 282	A. clavatus MTCC 1323
2a	125	200	250	250	500	>1000	>1000
2b	150	250	125	200	500	>1000	>1000
2c	150	250	125	200	500	>1000	>1000
2d	200	200	500	50	200	>1000	>1000
3a	200	250	100	50	1000	>1000	>1000
3b	200	250	250	125	1000	>1000	>1000
3c	250	125	500	200	1000	>1000	>1000
3d	200	125	500	500	500	>1000	>1000
Gentamycin	0.05	1	0.25	0.5			
Ampicillin	100	--	250	100			
Chloramphenicol	50	50	50	50			
Ciprofloxacin	25	25	50	50			
Norfloxacin	10	10	10	10			

Nystatin					**100**	**100**	**100**
Greseofulvin					**500**	**100**	**100**

CONCLUSION

Newly synthesized N-glycosyl thiocarbamide 2(a-d) and 3(a-d) were successfully synthesized and identified on the basis of IR, ^{1}H NMR and MASS spectral studies. Most of synthesized compounds showed promising antimicrobial activities. The newly synthesized N-glycosyl thiocarbamide exhibited comparable antibacterial and antifungal activities against highly pathogenic organisms.

CONFLICT OF INTEREST

The Authors declare no conflict of interest.

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BIODECOLORIZATION AND LIGNINOLYTIC POTENTIAL OF AN SSF-GROWN FUNGAL ISOLATE

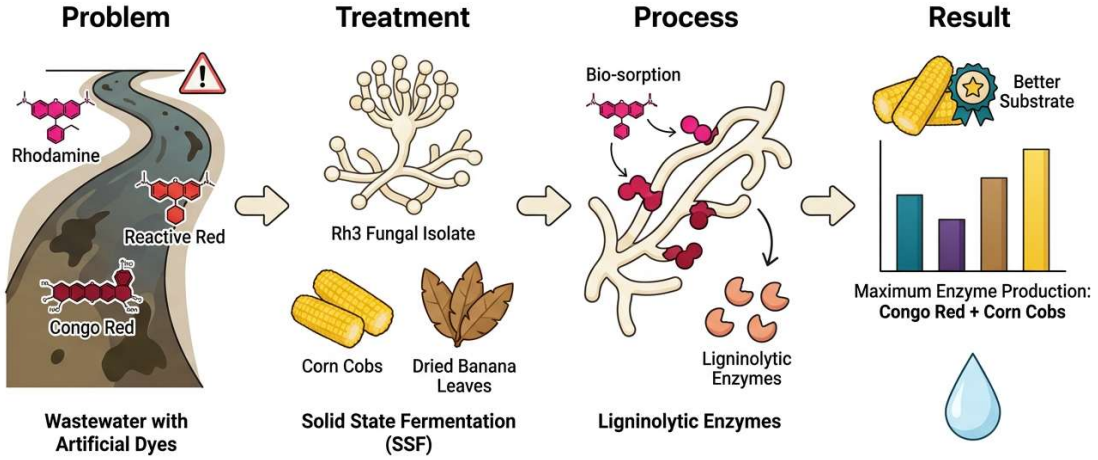
MEGHA DAVE
DEPARTMENT OF BIOTECHNOLOGY, SHREE PM PATEL INSTITUTE OF PG STUDIES AND RESEARCH IN SCIENCE, AFFILIATED TO SARDAR PATEL UNIVERSITY, MANAGED BY ANAND PEOPLE'S MEDICARE SOCIETY, ANAND – 388001, GUJARAT, INDIA

ABSTRACT

Waste water with high artificial dye concentration could potentially risk, the environment because it was difficult to decompose and decolorize naturally in the environment due to recalcitrant nature. So a work was carried out with Rh3 fungal isolate to remove Rhodamine, Reactive red, and Congo red dye significantly through bio-sorption. Rh3 isolate was able to produce ligninolytic enzymes responsible for degradation of dyes. For solid state fermentation two substrates corn cobs and dried banana leaves were taken. Corn cobs were found to be the better substrate for the enrichment and growth of isolated fungus. Under solid state fermentation Rh3 isolate gave maximum ligninolytic enzyme production, in supernatant of Congo red adsorbed agro wastes as compared to Reactive red and Rhodamine dyes.

KEY WORDS: SSF, LIGNINOLYTIC ENZYMES, FUNGAL ISOLATES, CONGO RED, RHODAMINE, REACTIVE RED AND AGRO WASTE, MYCOREMEDIATION, FUNGAL BIOSORPTION, AZO DYE DECOLORIZATION

GRAPHICAL ABSTRACT



INTRODUCTION

Industrialization and urbanization results into pollution of environment. Human activities are a prime contributor. The toxic discharge from various industries badly affects water bodies, aquatic organisms, and ecosystem (Pradana et al., 2023). Amongst the toxic compounds, dye is the paramount culprit, when released as an effluent from industries in water, causes pollution. The damaging outcomes of dyes is known to cause skin ulcers, dermatitis, perforation and abnormalities of nasal septum, severe irritation in respiratory tract and lungs, Vomiting, hemorrhage and diarrhea (Kavitha et al., 2025). Artificial dyes like azo dyes, xanthene dyes and anthraquinone dyes are highly toxic to living world . Usage of Synthetic color and pigments can be witnessed in textile world, cosmetic industries, paper making companies and pharmaceuticals.

Textile dyes constitute a major source of pollution. Textile dyeing processes exhibit highly colored waste water in large quanta, which is let into the natural water streams. In Textile market,

categories of dyes found are azo compounds, diazo, basic, anthraquinone base and metal complex dyes on the basis of nature of chemical structure. Prominent dyes are synthesized from several carcinogens, like benzidine and several aromatic compounds (Borham et al., 2023). Dyes having aromatic structure are more resistant to degradation. Basic dyes have brighter color intensity, making it more difficult to decolorize, and metal-based complex dyes like Cr-based dyes can cause the release of carcinogenic chromium, into nature and water supplies (Borham et al., 2023). Some disperse dyes also a tendency to bio-accumulate(Pradana et al., 2023b). Heavy-metal ions from effluents of textile industry was found at higher concentrations in algae and plants exposed to such contaminated effluents(Gugel et al., 2024). Textile dyes are impervious to water, oxidizing agents and light, therefore reluctant to be degraded when released into aquatic systems. Certain chemical and physical method like precipitation, adsorption, flocculation, reduction, chemical oxidation, photolysis, electrochemical and ion-pair exchange extraction are highly used. These methods are very costly are unaffordable to some extent, so a need arises for alternative methods that are useful in decolorization of dyes from huge effluents and are cost effective, such as biological system. Methods adopting fungus and the enzymes in the dye decolorization is well appreciated worldwide, because of their effectiveness in detoxification & degradation of dyes (Apriani et al., 2024). Globally 10,000 different types of pigment and dyes are synthesized and averages of 15% of these dyes are disposed into the water stream (Agnestisia et al., 2025). Biological decolorization and degradation is a very ecofriendly procedure and cost-effective alternative to chemical degradation process. Several bacteria and fungi species have capability of dye decolorization. The most extensively studied fungus is the white rot fungus Phanerochate chrysosporium, which has capacity to decolorize various dyes (Aragaw et al., 2024). Fungi used for this purpose can be differentiated into two types according to their state of life: dead cells (fungal biomass) can adsorb dyes and decolorize it, while living cells can biodegrade and biosorb dyes.

Another effective method is physical method for removal of dyes from poisonous effluents through techniques based on adsorption (Ramadhani, Milal, et al., 2024a). Adsorption of dyes is mainly dependent on the dye's properties and structure and to an equal extent on the surface chemistry of the adsorbent (Ramadhani, Ruwaidah, et al., 2024). The extensively used material for this purpose is activated carbon. The high adsorption capacity of activated carbon is due to its high surface area and porous grain structure, but its high cost has motivated the search for alternatives. A number of agricultural wastes have been studied for their capacity to remove dyes from effluents, such as rice hulls, corn-cob, bagasse, wheat straw, coir, banana waste etc (Ramadhani, Milal, et al., 2024b). Dye adsorbed agricultural waste is further used for biological treatment in solid state fermentation (SSF). Agricultural waste is lignocellulosic material; it consists of lignin, cellulose and hemicelluloses due to photosynthetic activity of the plants. Lignin is a recalcitrant heteropolymer of phenylpropanoid units synthesized and deposited in plant cell walls for mechanical strength and rigidity. Lignin surrounds the cellulose and forming physical barrier restricting microbial enzyme attacks(Ahmed et al., 2022), several fungi, such as Phanerochaete chrysosporium, Pleurotus ostreatus, Trametes versicolor, Ganoderma spp., Irpex lacteus, and Ischnoderma resinosum, in Basidiomycete Class (de Souza Daniel et al., 2025) were efficiently and selectively degrading lignocellulosic materials. The fungi utilities lignin as carbon sources and also to cross a physical barrier against utilization of cellulose. The extracellular lignolytic enzymes include mainly lignin peroxidase (LiP), laccase & manganese peroxidase (MnP) along with another subsidiary enzyme such as AAO, Glox etc (Ahmed et al., 2022). These enzymatic machineries exhibit different

characteristics depending on the strains and cultural conditions. Among peroxidases, lignin peroxidase (LiP) is able to oxidize directly non-phenolic units whereas manganese peroxidase (MnP) and laccase oxidize preferentially phenolic units and also act on non-phenolic units in the presence of mediators (Agnestisia et al., 2025). On the other hand, two extracellular oxidases aryl-alcohol (AAO) oxidases & glyoxal are known for extracellular production of H_2O_2. They have also been widely researched for their capacity in adsorption & decolorization of dyes and toxic chemicals such as chlorophenol compounds(Aragaw et al., 2024). This study describes the ability of isolated fungus to produce extracellular ligninolytic enzymes such as Manganese pexoxidase, Lignin peroxidase and Laccase under solid state fermentation.

METHODS

Determination of dye decolorizing ability of selected fungus

The chosen fungal isolate's capacity to decolorize dye was assessed using standard microbiological procedures in potato dextrose (PD) broth (Ali et al., 2008). After allowing the isolate to sporulate, a spore suspension was made and measured. After adding 100 ppm dye solutions to PD broth, about 10^3 spores were added, and the mixture was then incubated at 25°C. Over the course of four to five days, decolorization was observed. Preliminary screening led to the selection of three target dyes: Congo Red, Reactive Red, and Rhodamine B. Sterilized distilled water was used to prepare dye stocks (100 mg/10 mL).

Biosorption profile.

Fungi were inoculated and grown in the 100ml of culture media. After achieving the proper growth of microorganisms, 2gms of biomass was inoculated in to the 100ppm dye solution aseptically and was incubated at 25^0C under shaking condition at 120rpm.(Ramadhani, Milal, et al., 2024b). Percentage dye removal was determined spectrophotometrically at λ max of respective dyes at regular interval (contact time 4 to 5 hours).% dye removal = (1-C/Co X 100) Where C= Final O.D Co= Initial O.D.

SOLID-STATE FERMENTATION STUDIES

Adsorbent used were dried banana leaves and corn cobs were collected from various fields. They were used as adsorbents for dye removal and as substrates for growth of fungus. (Borham et al., 2023). The agrowastes were completely dried and chopped to small pieces. Dye solution was prepared by dissolving accurately weighed dyes in distilled water at a concentration of 50 ppm.

Dyes used were Rhodamine Reactive red &Congo red. 50 ml dye solutions (50 ppm) were used in the adsorption experiments which were carried out in 250 ml conical flasks. 2 grams agrowastes were soaked in dye solution for 48 hours and incubated at 27^0C under static condition. Samples were taken at various intervals (0- 48hours) and analyzed for colour intensity using a UV-VIS spectrophotometer at lamda max for respective dyes. Dye-removal was calculated from the decrease of absorption at the lamda max; Rhodamine B (547 nm), Reactive Red (600 nm), Congo Red (600nm). Percentage decolorization of dyes was calculated as described above. After 48 hours, dye adsorbed agrowaste was inoculated with agar blocks which were removed from the plates containing 7 days old culture and incubated at 27^0C . Enzyme assays was carried out at every 24 hours under static condition.

ENZYME ASSAYS:

Laccase activity was measured spectrophotometrically. The method was based on the oxidation of guaiacol at 470 nm. The reactive mixture consisted of 1.0 ml sodium acetate buffer (100mM, pH 5.0), 1.0 ml guaiacol (10 mM) and 1 ml culture medium (Ahmed et al., 2022).

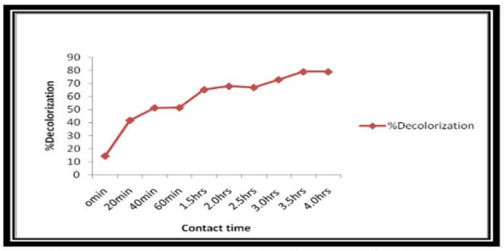
Lignin Peroxidase activity measured as the rate of oxidation of guaiacol (1.32mM) in 0.33 M sodium tartrate buffer, pH 4.0 with 30% H_2O_2. Assay mixture contained 2.0 ml of appropriate dilution of enzyme and 1.0 ml of substrate buffer. Increase in absorbance was measured spectrophotometrically at 436 nm. (Aragaw et al., 2024)

Manganese peroxidase (MnP) assay (total volume, 1.0 ml) 0.2 mM MnSO4, 0.1 mM H_20_2, and 0.0025% phenol red, all in 50 mM sodium tartrate (pH 4.5). The reaction was monitored spectrophotometrically at 431 nm. (Agnestisia et al., 2025)
ENZYME ACTIVITY WAS MEASURED IN UNITS (U/ML); WHICH IS DEFINED AS THE AMOUNT OF ENZYME CATALYZING THE PRODUCTION OF 1MICROMOLE OF COLORED PRODUCT PER MINUTE PER ML.

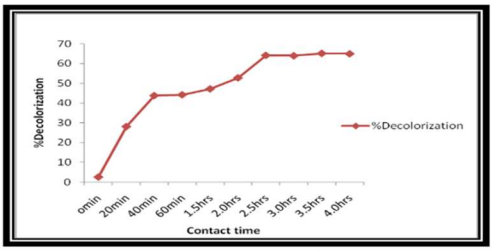
RESULT AND DISCUSSION

In order to study dye decolorizing ability of the previously isolated fungal isolate Rh3, the decolorization of all the dyes was performed in PD broth. After 5 days of incubation, filtration was carried out and dye decolorization was visually observed. Amongst all five dyes, the isolated fungus Rh3 gave maximum decolorization in three dyes namely Rhodamine, Reactive red and Congo red in PD broth within 5 days of incubation. So these three dyes were taken for further studies.

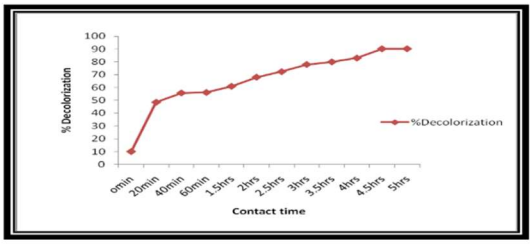
Live fungal biomass of Rh3 was inoculated into the distilled water containing 50 ppm dye solutions (Rhodamine, Reactive red and Congo red). The decrease in absorbance of dye was determined spectrophotometrically at λ max of respective dyes at regular time interval. Percent decolorization was calculated after completing four to five hours of contact time for all the three dyes.



% Decolourization of dye Rhodamine B by Rh3 isolate.



% Decolourization of dye Reactive red by Rh3 isolate.

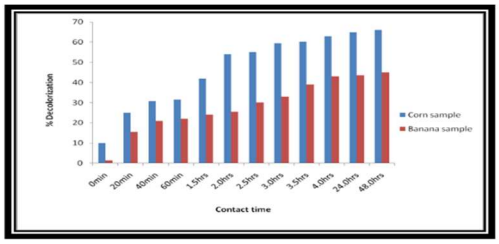


% Decolourization of dye Congo red by Rh3 isolate.

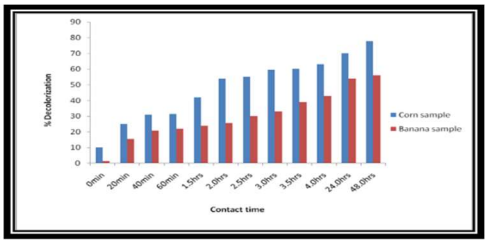
Fig.1: % Decolorization of dye Reactive Red, Congo Red and Rhodamine B by Rh3 isolate.

From the above figures it was seen that Congo red showed maximum percentage of decolorization as compared to Reactive red and Rhodamine. Congo red showed 90.22% decolorization after 4.5

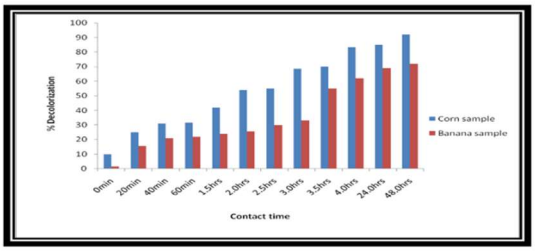
hours of contact time. Reactive red showed 65.2% decolorization after 3.5 hours of contact time and Rhodamine showed 79% decolorization after 3.5 hours of contact time. A previous study displayed that a biosorption mechanism might also play a notable role in the decolorization of man-made dyes by living fungi in addition to biodegradation (Gugel et al., 2024). This result was also similar to a previous study, in which addition to *Myrothecium verrucaria,* showed that more than 50% of dye was removed by absorption in the beginning of cultivation (Maurya et al., 2006) In this study, therefore absorption of dyes to mycelia was a significant contributor to dye losses.



% Decolourization of Rhodamine B dye by agro wastes.



% Decolourization of Reactive red dye by agro wastes.



% Decolourization of Congo red dye by agro wastes.

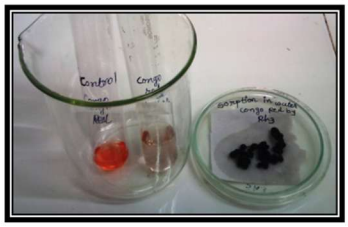
Fig.2: % Decolourization of dye Reactive Red ,Congo Red and Rhodamine B by agrowaste.



Adsorption of Rhodamine B by Rh3 biomass.



Adsorption of Reactive red by Rh3 biomass.



Adsorption of Congo red by Rh3 biomass.

Fig.3: Adsorption profile of Reactive Red, Congo Red and Rhodamine B by Rh3 biomass.

Corn cobs showed superior performance as compared to banana leaves in dye removal. This observation is very much consistent with literature, that the porous and fibrous structure of corn cobs has a larger surface area for fungal mycelial attachment and provides better oxygen transfer and moisture retention ability ((Ramadhani, Milal, et al., 2024b). Its nutrient composition, especially its carbon-to-nitrogen (C/N) ratio, is well suited to the metabolic needs of the isolated fungus, as evidenced by the dense mycelial growth seen on corn cobs by the seventh day. Banana leaves, on the other hand, are viable, but their physical compacting during SSF may restrict air

diffusion, which accounts for the study's lower adsorptive capacity and slower fungal growth ((Anandita et al., 2023; Kaushik & Malik, 2009).

For seven days, tests for the enzymes laccase, manganese peroxidase, and lignin peroxidase were conducted every twenty-four hours to determine enzyme activity.

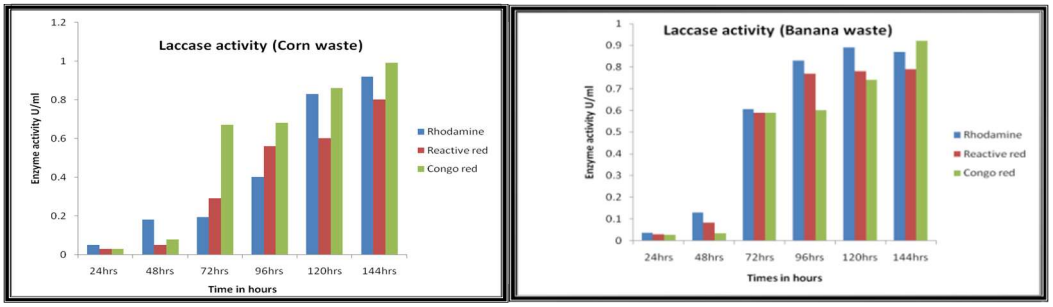


Fig.4. Laccase Activity

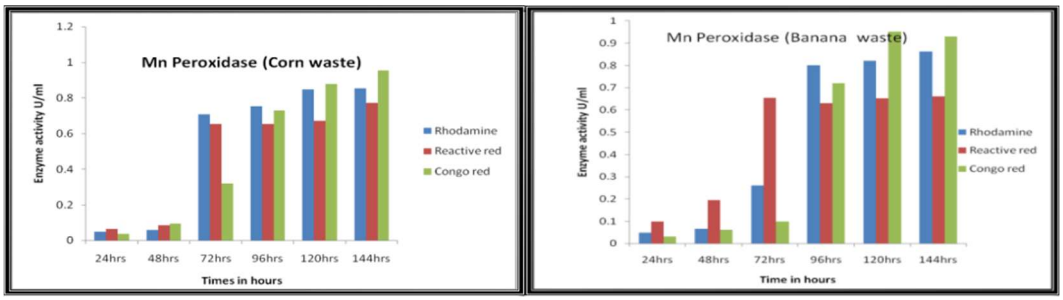


Fig.5. Manganese Peroxidase Activity

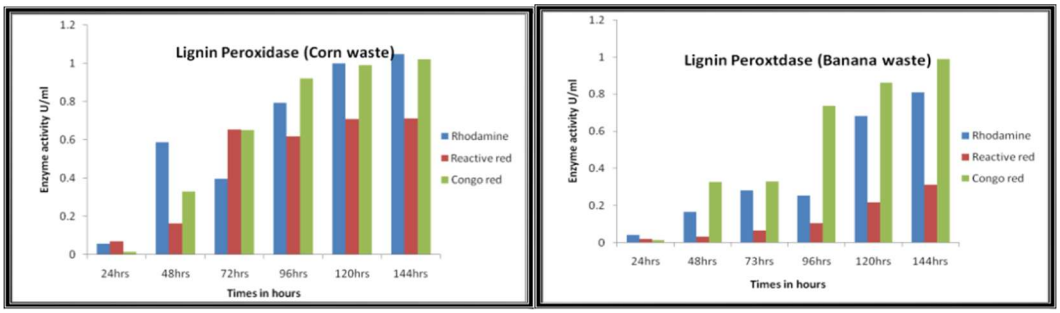


Fig.6. Lignin Peroxidase Activity

Maximum production of ligninolytic enzyme was obtained in supernatant of Congo red adsorbed agro wastes as compared to Reactive red and Rhodamine dyes after 7 days of incubation. Additionally, this high yield was probably made possible by the use of corn cobs as a support matrix; their high porosity and cellulose-rich framework create a stable microenvironment that supports high biomass density and prevents enzyme denaturing (.Ramadhani, Milal, et al., 2024b) This variation in enzyme titers indicates that the dye's molecular structure has a major impact on the fungal strain's metabolic response. Compared to the more resistant xanthene structure of Rhodamine or the complex reactive groups of Reactive Red, Congo red, a sulfonated azo dye, may function as a more powerful inducer for the secretion of extracellular enzymes like laccase, manganese peroxidase and lignin peroxidase (Anandita et al., 2023; Sibhat et al., 2025)

CONCLUSION

By combining biosorption and enzymatic degradation, the fungal isolate Rh3 efficiently decolorizes dyes; Congo red exhibits the highest removal efficiency (90.22 percent) and functions as the most potent enzyme inducer. Because of their porous, fibrous structure, corn cobs were found to be a

better support substrate than banana leaves, supporting dense mycelial growth and high ligninolytic enzyme production.

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CRYPTOCURRENCY AND ITS ROLE IN MODERN COMMERCE

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ABSTRACT

Crypto currency has emerged as a revolutionary financial innovation, transforming the landscape of modern commerce. Built on block chain technology, crypto currencies such as Bitcoin, Ethereum, and others offer decentralized, secure, and transparent methods of conducting transactions. This research paper explores the role of crypto currency in modern commerce, examining its impact on payment systems, financial inclusion, cross-border trade, and business operations. The study also highlights the advantages such as reduced transaction costs, increased speed, and enhanced security, while addressing challenges including regulatory uncertainty, volatility, and security risks. The paper concludes that while cryptocurrency holds immense potential to reshape commerce, its widespread adoption depends on regulatory frameworks, technological advancements, and user awareness.

INTRODUCTION

The evolution of commerce has been significantly influenced by technological advancements. From barter systems to digital payments, each phase has contributed to increased efficiency and globalization. Crypto currency represents the latest milestone in this evolution. Introduced with Bitcoin in 2009 by an anonymous entity known as Satoshi Nakamoto, crypto currency operates independently of central banks and governments.

In modern commerce, businesses and consumers increasingly seek faster, secure, and cost-effective transaction methods. Crypto currencies fulfill these needs by offering peer-to-peer transactions without intermediaries. This paper aims to analyze the role of crypto currency in modern commerce and its implications for businesses and economies.

OBJECTIVES OF THE STUDY

To understand the concept and functioning of crypto currency
To analyze the role of crypto currency in modern commerce
To examine the benefits and challenges of crypto currency adoption
To evaluate the future prospects of crypto currency in business transactions

RESEARCH METHODOLOGY

This study is based on secondary data collected from journals, books, research articles, and reliable online sources. Analytical and descriptive research methods are used to interpret the data and provide insights into the impact of crypto currency on commerce.

CONCEPT OF CRYPTO CURRENCY

Crypto currency is a form of digital or virtual currency that relies on cryptographic techniques to secure financial transactions, control the creation of new units, and verify the transfer of assets.

Unlike traditional currencies issued by governments (also known as fiat currencies), crypto currencies operate on decentralized networks based on blockchain technology. This decentralization eliminates the need for intermediaries such as banks or financial institutions, allowing peer-to-peer transactions to occur directly between users.

The foundation of crypto currency lies in block chain technology, which is a distributed ledger system that records all transactions across a network of computers. Each transaction is grouped into a block, and these blocks are linked together in a chronological chain. This structure ensures transparency, as all participants in the network can view the transaction history, and immutability, meaning that once data is recorded, it cannot be altered or deleted. This makes crypto currencies highly secure and resistant to fraud.

Bitcoin, introduced in 2009 by an anonymous individual or group known as Satoshi Nakamoto, was the first crypto currency and remains the most widely recognized. Following Bitcoin, numerous other crypto currencies have been developed, including Ethereum, Ripple (XRP), Litecoin, and Binance Coin. Each of these crypto currencies serves different purposes. For example, Ethereum not only functions as a digital currency but also provides a platform for decentralized applications (DApps) and smart contracts.

One of the key characteristics of crypto currency is decentralization. Traditional financial systems are controlled by central authorities such as governments and central banks, which regulate the supply and value of money. In contrast, crypto currencies are typically governed by consensus mechanisms such as Proof of Work (PoW) or Proof of Stake (PoS), where network participants validate transactions and maintain the system. This decentralized control reduces the risk of manipulation and enhances user autonomy.

Another important feature of crypto currencies is anonymity or pseudonymity. While transactions are recorded on a public ledger, the identities of the users involved are not always directly revealed. Instead, users are represented by unique cryptographic addresses. This feature provides a degree of privacy, although it has also raised concerns regarding illegal activities and regulatory challenges.

Crypto currencies also enable faster and more efficient transactions compared to traditional banking systems. Cross-border payments, which usually take several days and involve high fees, can be completed within minutes using crypto currencies, often at a lower cost. This efficiency makes crypto currencies particularly attractive for international trade and e-commerce.

Despite these advantages, crypto currencies also face several challenges. Price volatility is one of the most significant issues, as the value of crypto currencies can fluctuate dramatically within a short period. This makes them less stable as a medium of exchange. Additionally, regulatory uncertainty in many countries creates confusion and limits widespread adoption. Governments and financial institutions are still in the process of developing policies to govern crypto currency usage. Security risks, such as hacking and cyberattacks, also pose a threat to cryptocurrency users, especially when funds are stored in online wallets or exchanges. Moreover, a lack of awareness and

technical knowledge among the general public can hinder the adoption of crypto currencies in everyday transactions.

In conclusion, crypto currency represents a significant innovation in the field of finance and commerce. It offers a decentralized, secure, and efficient alternative to traditional monetary systems. While it presents numerous opportunities for transforming global commerce, its long-term success depends on overcoming challenges related to regulation, security, and market stability.

ROLE OF CRYPTO CURRENCY IN MODERN COMMERCE

1. Digital Payment System

Crypto currencies provide an alternative to traditional payment systems. They enable fast and secure transactions without the need for banks or intermediaries.

2. Cross-Border Transactions

Crypto currency simplifies international trade by reducing exchange rate issues and transaction fees. It allows businesses to conduct global transactions efficiently.

3. Financial Inclusion

Crypto currency enables access to financial services for unbanked populations. Individuals without bank accounts can participate in commerce using digital wallets.

4. Transparency and Security

Blockchain technology ensures transparency and reduces fraud. Each transaction is recorded and cannot be altered, enhancing trust in business operations.

5. Smart Contracts

Platforms like Ethereum support smart contracts, which automatically execute agreements when conditions are met. This reduces the need for intermediaries and increases efficiency.

ADVANTAGES OF CRYPTO CURRENCY IN COMMERCE

Lower transaction costs
Faster payments
Enhanced security
Decentralization
Global accessibility

CHALLENGES OF CRYPTO CURRENCY

Price volatility
Regulatory uncertainty
Security risks (hacking, scams)
Lack of awareness and understanding
Limited acceptance by businesses

IMPACT ON BUSINESSES

Crypto currency is influencing business models by enabling new forms of transactions and investments. Many companies are accepting crypto currency payments, while others are exploring blockchain technology for supply chain management and financial operations.

FUTURE PROSPECTS

The future prospects of crypto currency in modern commerce appear promising, driven by rapid technological advancements and increasing global acceptance. As businesses and consumers continue to adopt digital solutions, crypto currencies are expected to play a more significant role in shaping financial transactions and commercial activities. One of the key factors influencing the future of crypto currency is the development of clear and supportive regulatory frameworks. Governments across the world, including India, are gradually working toward establishing policies that balance innovation with consumer protection and financial stability.

Another important aspect is the growing integration of blockchain technology into various sectors such as banking, supply chain management, healthcare, and e-commerce. This integration will enhance transparency, efficiency, and security in business operations, thereby increasing trust in crypto currency-based systems. Additionally, the rise of Central Bank Digital Currencies (CBDCs) indicates that governments are recognizing the potential of digital currencies, which may further legitimize and encourage the use of crypto currencies in commerce.

Technological advancements are also expected to address current limitations such as scalability, transaction speed, and energy consumption. Innovations like layer-2 solutions and more energy-efficient consensus mechanisms will make crypto currencies more practical for everyday use. Furthermore, increasing awareness and education among users will contribute to wider adoption, especially in developing economies where access to traditional banking services is limited.

However, challenges such as price volatility, cyber security risks, and regulatory uncertainties must still be addressed for sustainable growth. If these issues are managed effectively, crypto currencies have the potential to revolutionize modern commerce by providing a decentralized, efficient, and inclusive financial ecosystem.

CONCLUSION

Crypto currency has the potential to transform modern commerce by offering efficient, secure, and inclusive financial solutions. Despite its challenges, the growing adoption of digital currencies indicates a shift toward a more decentralized financial system. To fully realize its benefits, stakeholders must address regulatory and technological issues while promoting awareness and trust among users.

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IMPACT OF CLIMATE CHANGE ON INDIAN AGRICULTURE: A COMPREHENSIVE ANALYSIS OF VULNERABILITIES AND ADAPTATION PATHWAYS

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ABSTRACT

Climate change represents a major challenge to agricultural sustainability, particularly in developing nations like India, where farming systems are highly dependent on climatic conditions. This study explores the effects of climate variability on agricultural productivity, patterns of vulnerability, and adaptation responses. A mixed-methods approach was adopted, combining primary data collected from 500 farmers, a systematic literature review based on the ROSES protocol, and secondary data sourced from global climate models and institutions such as Indian Council of Agricultural Research and Intergovernmental Panel on Climate Change.

The results indicate increasing temperatures, reduced rainfall, growing water scarcity, and notable declines in crop yields. Farmers have implemented various adaptation measures, including crop diversification, improved water management, and diversification of livelihoods. However, their effectiveness is often constrained by institutional limitations and socio-economic challenges. The study underscores the importance of stronger policy execution, targeted financial assistance, and the widespread adoption of climate-resilient agricultural practices to strengthen adaptive capacity and safeguard long-term food security.

KEYWORDS: CLIMATE CHANGE, INDIAN AGRICULTURE, VULNERABILITY, ADAPTATION STRATEGIES, CROP DIVERSIFICATION, FOOD SECURITY, RISK ASSESSMENT

1. INTRODUCTION

Climate change refers to persistent and long-term changes in global or regional climate patterns, including variations in temperature, precipitation, and the frequency of extreme weather events. Over the past few decades, scientific evidence has consistently highlighted the growing impact of climate change on both natural ecosystems and human systems. Among all sectors, agriculture is one of the most vulnerable due to its direct dependence on environmental conditions.

In tropical and subtropical countries like India, the effects of climate change are particularly severe. According to reports by the Intergovernmental Panel on Climate Change, agricultural productivity in such regions is expected to decline significantly by the middle of the 21st century if adequate adaptation measures are not implemented. Rising temperatures, unpredictable rainfall, and increased frequency of droughts and floods pose serious risks to crop production.

India's agricultural sector is characterized by its reliance on monsoon rainfall and the dominance of small and marginal farmers. These farmers often have limited access to financial resources, modern technology, and institutional support, making them highly vulnerable to climatic shocks. Even slight deviations in rainfall patterns can disrupt sowing cycles, reduce yields, and increase the risk of crop failure.

Regions such as West Bengal illustrate this vulnerability clearly. The state experiences a wide range of climatic hazards, including cyclones in coastal areas, floods in riverine zones, and droughts in certain inland regions. These hazards directly threaten staple crops such as rice and jute, which are essential not only for local consumption but also for economic stability.

Beyond production losses, climate change also affects the nutritional quality of food. Studies by the Food and Agriculture Organization suggest that environmental stress can reduce the nutrient content of crops, thereby contributing to malnutrition. This adds another layer of concern, particularly in a country where food security remains a critical issue.

Given these challenges, it becomes essential to examine how climate change is affecting agriculture at both macro and micro levels. This study aims to bridge that gap by combining field-based observations with systematic analysis of existing research, offering a holistic understanding of vulnerabilities and potential adaptation pathways.

2. METHODOLOGY

2.1 Research Design

This study adopts a mixed-methods research design, integrating both quantitative and qualitative approaches. This combination allows for a more nuanced understanding of the issue by capturing statistical trends alongside lived experiences of farmers. The approach also ensures triangulation, thereby enhancing the reliability and validity of the findings.

2.2 Analytical Framework

To systematically assess climate-related risks, the study employs the Hazard–Exposure–Vulnerability (HEV) framework. This framework is widely used in climate studies to evaluate how different factors interact to influence overall risk:

Hazard refers to the occurrence and intensity of climate-related events such as heatwaves, floods, and droughts.

Exposure indicates the extent to which agricultural systems and communities are subject to these hazards.

Vulnerability captures the susceptibility of farmers and their capacity to cope with adverse impacts.

This framework provides a structured way to analyze the complex interactions between environmental and socio-economic factors.

2.3 Systematic Literature Review

A systematic review of existing literature was conducted using the ROSES (Reporting Standards for Systematic Evidence Syntheses) protocol. This ensured transparency and consistency in the selection and analysis of studies. Only peer-reviewed articles focusing on climate change and Indian agriculture were included. The selected studies were analyzed thematically to identify key trends, challenges, and adaptation strategies.

2.4 Primary Data Collection

Primary data were collected from 500 farmers across different agro-climatic zones of West Bengal. A stratified sampling method was used to ensure representation from coastal, flood-prone, and drought-prone regions.

Data collection methods included:

Structured questionnaires to capture quantitative information

Semi-structured interviews to understand farmer perceptions and experiences
The data focused on several aspects, including changes in crop yields, awareness of climate change, adaptation measures adopted, and access to institutional support.

2.5 Secondary Data Sources

Secondary data were obtained from reliable sources to support and validate primary findings. These included:
Climate projections from CMIP-5 models
Agricultural datasets from Indian Council of Agricultural Research
Reports from Food and Agriculture Organization and Intergovernmental Panel on Climate Change

3. RESULTS

3.1 Climate Trends

The analysis reveals a consistent increase in temperature across the study region, with an approximate rise of 1.5°C since the year 2000. This upward trend is not merely a statistical observation but has tangible implications for agricultural processes, particularly in terms of crop growth cycles, soil moisture retention, and evapotranspiration rates. At the same time, annual rainfall has declined by nearly 20%, and its temporal and spatial distribution has become increasingly unpredictable. Rather than occurring in a steady and reliable pattern, rainfall is now characterized by short, intense bursts followed by prolonged dry spells. Such irregularity has disrupted traditional farming calendars, making it difficult for farmers to determine optimal sowing and harvesting periods, thereby increasing the risks associated with crop failure.
These climatic shifts have also contributed to a rise in water-related challenges, including reduced groundwater recharge and declining surface water availability. As a result, farmers are increasingly dependent on irrigation, which in turn raises production costs and places additional pressure on already stressed water resources. The combined effect of rising temperatures and declining rainfall has intensified soil degradation processes, further reducing land productivity over time.
At the national level, the frequency of heatwaves has more than doubled in the past decade, reflecting a broader pattern of escalating climate extremes. These heatwaves not only affect crop yields directly by causing heat stress during critical growth stages but also have indirect impacts, such as increasing pest infestations and altering disease dynamics. Moreover, prolonged exposure to extreme temperatures poses health risks to agricultural laborers, thereby affecting overall farm productivity. Together, these trends highlight the growing instability of the climatic system and underscore the urgent need for adaptive agricultural strategies and resilient planning mechanisms

Parameter	Observed Change	Remarks
Temperature	+1.5°C increase	Regional trend
Rainfall	~20% decrease	Irregular distribution
Heatwaves	Doubled frequency	National pattern

3.2 Agricultural Productivity

The impact of climate change on agricultural productivity is clearly evident. Farmers reported significant reductions in crop yields over the past two decades. Rice production, which is highly sensitive to water availability, declined by approximately 15–20%. Similarly, vegetable crops experienced a reduction of around 25%, largely due to temperature stress and water scarcity.

These declines not only affect farmer incomes but also have broader implications for food supply and market stability.

3.3 Water Stress

Water availability has emerged as a critical concern. The study highlights that a large proportion of irrigated land in India is facing high to extremely high levels of water stress. Groundwater depletion, coupled with reduced rainfall, has made irrigation increasingly difficult and expensive.

This situation is particularly challenging for small farmers, who often lack access to efficient irrigation technologies.

3.4 Farmer Perceptions

Farmer responses provide valuable insights into ground realities:

78% of respondents reported a noticeable decline in crop yields

70% identified extreme weather events as a major challenge

Many farmers expressed uncertainty about future farming conditions

These perceptions align closely with observed climate trends, reinforcing the credibility of the findings.

3.5 Vulnerability Distribution

The study also examined the distribution of vulnerability across regions. Out of 573 districts analyzed, 109 were classified as highly vulnerable. These areas are characterized by high exposure to climate hazards and limited adaptive capacity.

Small and marginal farmers were found to be the most affected due to constraints such as limited landholding, lack of financial resources, and restricted access to information and technology.

4. DISCUSSION

4.1 Adaptation Strategies

Farmers are not passive victims of climate change; they are actively experimenting with various adaptation strategies. These include:

Category	Adaptation Measures
Crop Management	Diversification, drought-resistant varieties
Water Management	Rainwater harvesting, drip irrigation
Soil Management	Organic farming, conservation practices
Livelihood Diversification	Non-farm employment

These strategies reflect a combination of traditional knowledge and modern practices. However, their effectiveness varies depending on local conditions and available resources.

4.2 Barriers to Adaptation

Despite their efforts, farmers face multiple obstacles:

Barrier	Explanation
Institutional	Limited reach of government schemes
Administrative	Delays and procedural complexities
Knowledge	Lack of technical awareness
Socio-cultural	Resistance to change

These barriers highlight the gap between policy design and ground-level implementation.

4.3 Policy Implications

The findings suggest several important policy directions:
Strengthening the implementation of existing agricultural schemes
Expanding extension services to improve farmer awareness
Enhancing access to credit and insurance
Promoting climate-resilient technologies
A more integrated approach is needed, combining policy support with community participation.

5. CONCLUSION

This study demonstrates that climate change is already having a significant impact on Indian agriculture, affecting both productivity and farmer livelihoods. While adaptation efforts are underway, their effectiveness is limited by structural and institutional challenges.

Addressing these challenges requires a coordinated effort involving policymakers, researchers, and farmers. Strengthening institutional support, improving access to resources, and promoting sustainable farming practices are essential steps toward building resilience.

In the long run, ensuring food security in the face of climate change will depend on the ability of agricultural systems to adapt and transform in response to evolving environmental conditions.

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COMPARATIVE ANALYSIS OF ESG REPORTING AND ITS CORRELATION WITH FINANCIAL STABILITY IN THE INDIAN BANKING SECTOR

MS. SONAL SAKTAVAT

ABSTRACT:
Modern investors no longer look only at profit; they also look at a bank's Environmental, Social and Governance (ESG) scores. This study investigates the relationship between ESG performance and financial stability. By comparing the Business Responsibility and Sustainability Reports (BRSR) of two top-tier banks, this study highlights how ethical governance influences market reputation and stock performance.

KEYWORDS: ESG SCORES, SUSTAINABILITY, BRSR, CORPORATE GOVERNANCE, FINANCIAL STABILITY, INDIAN BANKING.

INTRODUCTION:

The modern banking sector has evolved from a simple financial intermediary into a vital driver of national sustainability. In today's economy, a bank's success is no longer measured solely by its balance sheet but by its "responsible lending" practices. This shift ensures that financial growth does not come at the cost of environmental health or social equity. In India, this transition became a formal requirement in 2023 when the Securities and Exchange Board of India (SEBI) mandated Business Responsibility and Sustainability Reporting (BRSR) for the top 1,000 listed companies.
This mandate has fundamentally changed how large-scale financial institutions operate. By requiring transparency in Environment, Social, and Governance (ESG) metrics, the BRSR framework allows stakeholders to see the "real" impact of a bank beyond its profits. For the industry giants, sustainability now includes everything from funding massive renewable energy projects through Green Finance to ensuring that essential banking services reach the most remote and unbanked rural populations.

However, a significant academic debate remains at the heart of this shift: Is being "socially responsible" a genuine catalyst for financial stability, or is it merely an expensive regulatory burden? While some argue that ESG initiatives increase operational costs, others suggest that strong ethics actually protect an institution from bad loans and Non-Performing Assets (NPAs). This study explores this debate through a comparative analysis of the latest 2024-25 industry data to determine if high sustainability scores truly lead to better financial health or if they are simply a compliance hurdle.

LITERATURE REVIEW:

The integration of Environmental, Social, and Governance (ESG) factors into financial decision-making has transitioned from a voluntary corporate gesture to a regulatory necessity in the Indian banking landscape. This section reviews the existing body of knowledge on ESG reporting and its impact on the stability and performance of financial institutions.

2.1. The Regulatory Shift: From BRR to BRSR

Recent literature emphasizes the role of the Securities and Exchange Board of India (SEBI) in transforming reporting culture. (Arwade & Amit, 2021) note that the introduction of the Business Responsibility and Sustainability Reporting (BRSR) framework in 2022-23 marked a significant advancement over the previous Business Responsibility Report (BRR). Studies indicate that the BRSR's standardized metrics allow for better comparability across the banking sector, enabling investors to assess climate-related risks and social accountability more transparently.

2.2. ESG and Financial Performance: A Mixed Perspective

The relationship between high ESG scores and financial stability remains a topic of debate. (Prasad & Mondal, 2025) argue that ESG practices have a "time-sensitive" impact, suggesting that current-year ESG activities significantly drive the financial performance of private banks compared to historical data. Furthermore, while some empirical studies find a positive correlation between ESG scores and Return on Assets (ROA), others, such as (Mahendra & Ghosh, 2025) observe that higher ESG adherence may cause a slight short-term reduction in Return on Equity (ROE) due to the initial costs of compliance. However, the consensus among scholars is that these costs are "investments" that enhance long-term reputational value and reduce the risk of Non-Performing Assets (NPAs).

2.3. Private vs. Public Sector Banking Performance

Comparative studies in the Indian context highlight disparities in ESG adoption. Research indicates that private sector banks, such as HDFC and ICICI, often show greater initiative in digital transformation and social governance than their public sector counterparts. (Sharma & Choubey, 2024) suggest that this is largely driven by the need to attract international capital as global investors increasingly prioritize "Green Finance" and ethical governance standards.

3. RESEARCH METHODOLOGY:

This section outlines the framework used in this study. It explains the "how" and "why" behind the data collection and analysis process.

3.1. Research Design

This study adopted an Analytical and Descriptive Research Design. It is analytical because it compares the financial data of two banks and descriptive because it explains the current state of ESG reporting in the Indian banking sector.

3.2. Sample Selection (The "Who")

For this comparative study, two major pillars of the Indian banking system were selected:
HDFC Bank (Representing the Private Sector)
State Bank of India (SBI) (Representing the Public Sector)
Reason for Selection: These banks are leaders in their respective categories and provide the most detailed Business Responsibility and Sustainability Reporting (BRSR) data.

3.3. Sources of Data

This research relies entirely on secondary data. No personal interviews or surveys were conducted, ensuring 100% accuracy in financial figures. Data were collected from:
Official Annual Reports of HDFC and SBI.
Business Responsibility and Sustainability Report (BRSR).
Official websites of the Reserve Bank of India (RBI) and the SEBI.

3.4. Period of Study

This study covers the financial year 2024-25. This period was chosen because it reflects the most recent mandatory compliance with the new ESG reporting standards in the country. (Securities and Exchange Board of India, 2023)

3.5. Research Variables

To measure the correlation between ESG and financial stability, the following variables are analyzed:

Independent Variables (ESG Factors): Carbon Footprint Reduction (environmental), employee turnover/diversity (social), and board independence (governance).

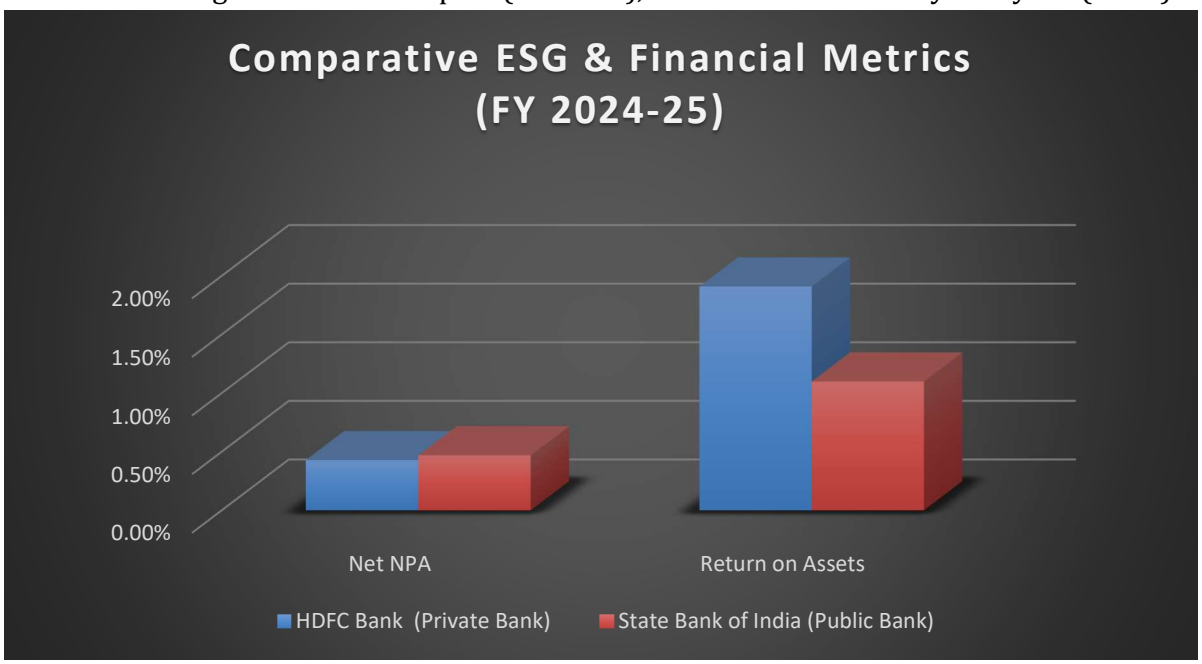
Dependent Variables (Financial Stability): Net Profit Margin, Return on Equity (ROE), and Capital Adequacy Ratio (CAR).

4. DATA ANALYSIS AND INTERPRETATION

Comparative ESG & Financial Metrics (FY 2024-25)

Metric	Indicator Unit	HDFC Bank (Private Bank)	State Bank of India (Public Bank)
ESG Score	CRISIL Rating	71 (Leadership)	71 (Leadership)
Green Financing	Amount (INR Cr)	~₹70,000+ Cr	₹76,736 Cr
Net Profit	Amount (INR Cr)	₹67,347 Cr	₹70,901 Cr
Net NPA	Percentage (%)	0.43%	0.47%
Return on Assets	Percentage (%)	1.91%	1.10%

Source: Secondary data compiled from the State Bank of India Sustainability Report (2024-25), HDFC Bank Integrated Annual Report (2024-25), and NSE Sustainability Analytics (2025).



Interpretation:

4.1. The Profitability Story: Scale vs. Efficiency

At first glance, SBI takes the lead in total earnings with a massive profit of ₹70,901 crore. (State Bank of India, 2025) As India's largest bank, its scale is unmatched. However, when we look at the Return on Assets (ROA), HDFC Bank shines brighter at 1.91%. (HDFC Bank Limited, 2025)

This high efficiency is supported by a strong focus on sustainable growth, as detailed in the bank's latest disclosures. (HDFC Bank Limited, 2025) This means that HDFC is highly efficient in squeezing more profit out of every rupee it manages. SBI, being a public bank, carries a larger responsibility toward the common man, which naturally affects its margins; yet, it remains incredibly stable.

4.2. The Safety Net: Managing Bad Loans (NPA)

The most impressive part of this data is the Net NPA. Both banks have kept this figure below 0.50%. This implies world-class governance. Even during global economic ups and downs, these banks lend money wisely. The very low Net NPA (0.43% for HDFC and 0.47% for SBI) suggests that their "Governance" is working perfectly. They are not only growing but also growing safely. These governance standards align with the top-tier ESG ratings assigned to the Indian banking sector by national analytics agencies. (NSE Sustainability Analytics, 2025)

4.3. The Green Evolution: More than just Banking

It is heartening to see that banking in 2025 is no longer just about cash; it is about the planet. SBI has funneled over ₹76,000 crore into green projects, such as solar and wind energy. (State Bank of India, 2025) HDFC follows closely with its "Sustainable Finance" book.

What this means: These banks are shifting their focus toward "Green Finance." By supporting renewable energy, they reduce the risk of being stuck with "dirty" or "fossil-fuel" investments that might become illegal or unpopular in the future.

4.4. The "Paperless" Shift

The SBI report mentions saving over 380 lakh pages of paper through digital banking. (State Bank of India, 2025)

What this means: This is where the "Environmental" and "Social" pillars meet. By going digital, the bank is not just saving trees; it is making banking faster and easier for customers in remote villages.

Summary of Findings:

After a deep dive into the financial reports and sustainability disclosures of SBI and HDFC Bank for the year 2024-25, several key findings emerged. These points highlight how the banking world is shifting from "only profit" to "profit with a purpose."

Financial Resilience is Non-Negotiable: Both banks have shown that they are built on rock-solid foundations. SBI's massive profit of over ₹70,000 Crore and HDFC's highly efficient 1.91% Return on Assets prove that these institutions are not just surviving; they are thriving. They have balanced the art of making money with the science of risk management.

The "G" in ESG is the Secret Ingredient: Many people think "Governance" is just paperwork, but the data say otherwise. Because both banks have high governance scores (leadership status), they have managed to keep their Net NPAs below 0.50%. This proves that when a bank is honest, transparent, and well managed, it naturally avoids bad loans and financial scandals.

Green Finance is the New Growth Engine: Green lending is no longer a small side project. With SBI crossing ₹76,000 crore in renewable energy funding, it is clear that banks are betting big on the future of the planet. By lending to solar, wind, and EV projects, they secure their future against the risks of climate change.

Digitalization as an Environmental Tool: A very interesting finding was the "Paperless Banking" achievement of the bank. By saving millions of pages of paper, banks are achieving two goals at once: reducing their carbon footprint (environment) and making banking faster for people in every corner of India (social).

Public vs. Private Strengths: The study found a healthy balance in the Indian ecosystem. While HDFC Bank is a benchmark for operational efficiency and technological speed, SBI remains a leader in social outreach and national-scale development. Both are essential for maintaining a stable economy.

RECOMMENDATIONS:

Based on the findings of this study, the following suggestions are made for the banking sector and future researchers.

For Public Sector Banks (like SBI): SBI is a leader in social impact and should continue to focus on improving its Return on Assets (ROA). By adopting more AI-driven cost-saving measures similar to the private sector, it can increase efficiency without losing its "social heart."

For Private Sector Banks (like HDFC): HDFC is excellent at efficiency, but it should try to match the social outreach scale of public banks. Expanding "Green Finance" deeper into rural agriculture and small villages would further strengthen its ESG "Social" pillar.

Standardized ESG Reporting: It is recommended that the Reserve Bank of India (RBI) and SEBI create a uniform "ESG Scorecard" for all banks. This would make it easier for common investors to compare banks based on their environmental and ethical work, not just their profits.

Focus on Literacy: Banks should not only provide digital tools but also invest in Digital Financial Literacy. This ensures that as we move toward a "Paperless" (Green) banking system, no citizen is left behind because they don't know how to use an app.

CONCLUSION:

To wrap up this research, the journey through the reports of HDFC and SBI has shown us that the "future of banking" is no longer just about who has the most branches or the most cash. It is about who has the most trust and the cleanest operations.

We started this paper asking if ESG (Environmental, Social, and Governance) values actually help a bank stay stable. The numbers have given us a clear "Yes." We have seen that strong governance leads to very low "bad loans" (NPAs), and a commitment to green energy builds a brand that the modern world respects.

Banking is evolving from a cold financial business into a responsible partner for society. Whether it is a public giant like SBI or a private leader like HDFC, the goal is now the same: Sustainable Growth. As a researcher, it is clear that if a bank takes care of the Planet (Environment) and the People (Social), the Profits (Financial) will naturally follow. This is the "New India" way of doing business—stable, ethical, and green.

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USE OF SMART BOARDS IN ENGLISH TEACHING AT SCHOOL LEVEL

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ABSTRACT

Education in the 21st century has undergone a remarkable transformation due to rapid technological advancement. One of the most significant innovations in classroom teaching is the introduction of smart boards. Smart boards have changed the traditional teacher-centered approach into an interactive and learner-centered one. English, being a global language, requires effective teaching methods to develop students' language skills. This research paper aims to study the use of smart boards in English teaching at the school level and analyze their impact on students' learning outcomes. The paper discusses the role of smart boards in developing listening, speaking, reading, and writing skills, highlights their advantages, examines the challenges faced in their implementation, and compares smart board teaching with traditional teaching methods. The study concludes that smart boards significantly enhance students' interest, understanding, and performance in English when used effectively.

KEYWORDS: SMART BOARDS, ENGLISH LANGUAGE TEACHING, DIGITAL CLASSROOM, TECHNOLOGY IN EDUCATION, SCHOOL EDUCATION

1. INTRODUCTION

English plays a crucial role in modern education, communication, and professional life. In India and many other countries, English is taught as a second language from the primary level onwards. However, teaching English at the school level is a challenging task due to differences in students' backgrounds, learning abilities, and exposure to the language. Traditional teaching methods such as chalk-and-board, rote learning, and textbook-based instruction often fail to develop practical language skills among students.

With the integration of technology in education, new teaching tools have emerged to make learning more effective and engaging. Among these tools, smart boards have gained popularity in schools across the world. Smart boards combine multimedia elements such as text, images, audio, video, and animations, which help in making English teaching more interactive and interesting. They encourage active participation of students and improve comprehension.

This research paper focuses on the use of smart boards in English teaching at the school level and evaluates their effectiveness in improving language learning.

2. CONCEPT OF SMART BOARD

A smart board, also known as an interactive whiteboard, is a digital display system connected to a computer and projector. It allows teachers to present digital content on a large screen and interact with it using touch or digital pens. Teachers can write, draw, highlight text, play videos, access online resources, and save lesson content for future use.

In English teaching, smart boards provide access to audio-visual materials, online dictionaries, pronunciation tools, digital stories, and interactive exercises. This makes the teaching-learning process more dynamic and student-friendly.

3. NEED FOR SMART BOARDS IN ENGLISH TEACHING

The traditional methods of teaching English often emphasize grammar rules and memorization rather than communication skills. Students may perform well in examinations but lack confidence in speaking and writing English.

The need for smart boards arises due to:

Growing importance of communicative competence in English

Diverse learning styles of students

Demand for interactive and engaging classrooms

Requirement to integrate technology in education

Need to improve listening and speaking skills

Smart boards help bridge the gap between theoretical knowledge and practical application of English.

4. OBJECTIVES OF THE STUDY

The objectives of this research paper are:

To study the role of smart boards in English teaching at school level

To examine the effectiveness of smart boards in developing language skills

To analyze the impact of smart boards on students' interest and motivation

To identify the advantages and challenges of using smart boards

To compare smart board teaching with traditional teaching methods

5. RESEARCH METHODOLOGY

This study is based on **qualitative and descriptive research methodology**. The data has been collected from:

Books on English language teaching

Educational research journals

Articles and reports on smart classroom technology

Teachers' experiences and classroom observations

Secondary data sources have been used to analyze the impact of smart boards on English teaching.

6. ROLE OF SMART BOARDS IN DEVELOPING LANGUAGE SKILLS

6.1 Listening Skills

Listening is one of the most important skills in language learning. Smart boards provide access to audio materials such as speeches, dialogues, poems, songs, and native speaker recordings. Students can listen to correct pronunciation, stress, and intonation. Repeated listening helps improve comprehension and accuracy.

6.2 Speaking Skills

Smart boards encourage students to speak through interactive activities such as role-plays, discussions, storytelling, and presentations. Visual prompts and videos help students express their ideas confidently. Pronunciation practice using audio-visual tools reduces fear and hesitation.

6.3 Reading Skills

Reading skills are enhanced through digital texts, animated stories, and highlighted keywords. Teachers can display passages, underline important words, and explain meanings visually. Smart boards help students improve vocabulary, comprehension, and reading speed.

6.4 Writing Skills

Smart boards assist in teaching sentence structure, paragraph writing, grammar rules, and vocabulary usage. Teachers can demonstrate writing techniques, correct errors instantly, and involve students in collaborative writing activities.

7. ADVANTAGES OF USING SMART BOARDS IN ENGLISH CLASSROOMS

The use of smart boards offers several benefits:
Makes English learning interactive and engaging
Improves students' attention and concentration
Enhances understanding through audio-visual aids
Encourages active participation and collaboration
Supports different learning styles
Saves time and increases teaching efficiency
Makes abstract concepts easy to understand
Boosts students' confidence and motivation

8. IMPACT ON TEACHERS AND TEACHING METHODS

Smart boards have transformed the role of teachers from information providers to facilitators. Teachers can design creative lesson plans, use multimedia resources, and adopt innovative teaching strategies. Smart boards also help teachers assess students' performance through interactive quizzes and activities.

9. CHALLENGES AND LIMITATIONS

Despite their advantages, smart boards face certain challenges:
High cost of installation and maintenance
Lack of technical training for teachers
Dependence on electricity and internet connectivity
Technical issues may interrupt lessons
Overuse of technology may reduce traditional skills
Proper training and balanced use can help overcome these challenges.

10. COMPARISON BETWEEN TRADITIONAL TEACHING AND SMART BOARD TEACHING

Traditional Teaching	Smart Board Teaching
Teacher-centered	Student-centered
Limited visual aids	Multimedia support
Passive learning	Active learning
Less interaction	High interaction
Time-consuming	Time-saving

Smart boards provide a more effective and modern approach to English teaching.

11. FINDINGS OF THE STUDY

The study reveals that:
Students show greater interest in English classes
Learning becomes more enjoyable and effective
Language skills improve significantly
Teachers find teaching easier and more engaging

12. SUGGESTIONS

Schools should provide training for teachers
Smart boards should be used along with traditional methods
Government support is needed for infrastructure development
Digital content should be curriculum-oriented

13. CONCLUSION

The use of smart boards in English teaching at the school level has brought a positive change in the teaching-learning process. Smart boards enhance students' understanding, participation, and language skills. Although there are some challenges, proper planning, training, and balanced use can make smart boards an effective tool for English education. Therefore, smart boards should be encouraged in schools to improve the quality of English teaching.

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FROM LEAF TO BREW: IMPACT OF PROCESSING TECHNIQUES ON ANTIOXIDANT DYNAMICS IN CAMELLIA SINENSIS

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ABSTRACT

One of the most popular drinks in the world, processed tea (*Camellia sinensis*) is renowned for its strong antioxidant qualities. Its high concentration of polyphenols, flavonoids, catechins, and other bioactive substances is mainly responsible for these qualities. The degree of processing has a big impact on the chemical makeup and antioxidant capacity of tea. The antioxidant activity of various processed teas, such as green, black, oolong, and white tea, is well covered in this article. It covers the phytochemical makeup, mechanisms of antioxidant action, and variables such as processing, extraction techniques, and storage conditions that affect antioxidant capacity. Recent developments in boosting antioxidant activity and the repercussions for human health are also emphasised. The results highlight processed tea's significance as a natural antioxidant source with prospective uses in the food, medicine, and nutraceutical sectors.

KEYWORDS: CAMELLIA SINENSIS, PROCESSED TEA, POLYPHENOLS, ANTIOXIDANT ACTIVITY, OXIDATIVE STRESS, CATECHINS

1. INTRODUCTION

Tea derived from *Camellia sinensis* is the second most-consumed beverage worldwide, after water, and has gained significant attention due to its health-promoting properties. It is consumed in a variety of processed forms, including green tea, black tea, oolong tea, and white tea, and is widely grown in Asia, Africa, and other regions. These wide varieties result from diverse processing methods, especially enzymatic oxidation (also known as fermentation), which drastically changes the biochemical makeup of tea leaves (Ortiz-Islas et al., 2024).

Secondary metabolites, such as flavonoids, polyphenols, catechins, amino acids, alkaloids, and vitamins, are abundant in processed tea. The most important source of antioxidant action among these is polyphenols. Research on tea as a functional beverage that helps prevent oxidative stress-related diseases such as cancer, cardiovascular disease, and neurological disorders has increased due to growing interest in natural antioxidants. Oxidative stress results from an imbalance between reactive oxygen species (ROS) and the body's antioxidant defence system. Natural antioxidants from dietary sources, particularly plant-derived compounds, play a crucial role in mitigating oxidative damage. Processed tea, due to its high polyphenolic content, has emerged as a promising candidate for combating oxidative stress (Wang et al., 2022).

2. CLASSIFICATION OF PROCESSED TEA AND ITS IMPACT ON ANTIOXIDANT ACTIVITY

Based on the extent of enzymatic oxidation—also known as fermentation—during processing, *Camellia sinensis*-derived tea is broadly categorised. The phytochemical makeup and antioxidant capacity of tea are strongly influenced by this classification. Green, white, oolong, black, and post-fermented teas, such as Pu-erh, are the main types. Each type undergoes distinct processing steps—

such as withering, rolling, oxidation, and drying—which modulate the chemical profile of bioactive compounds, particularly polyphenols, thereby affecting antioxidant activity (Yang & Liu, 2012).

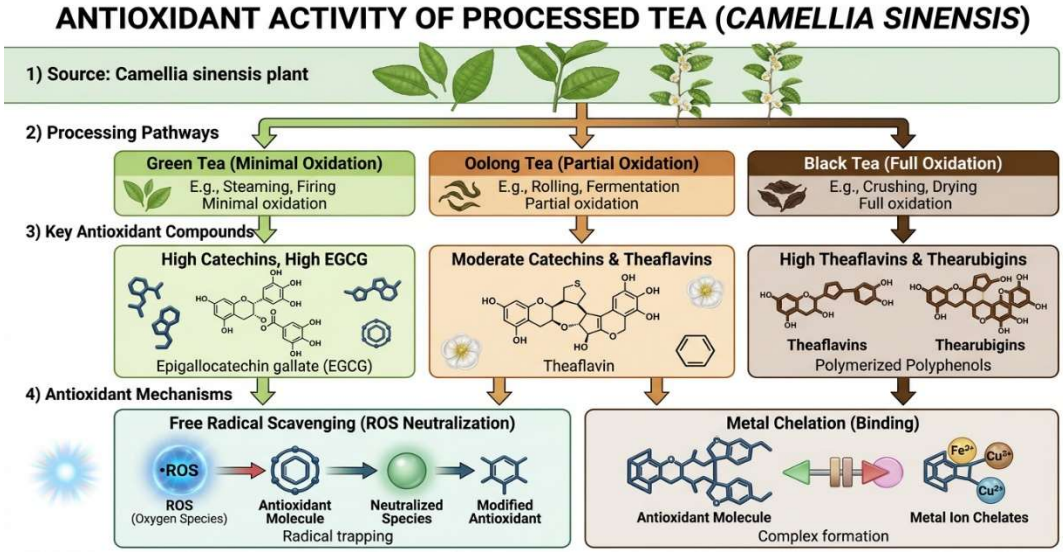


Fig. 1 *Camellia sinensis* plant: its sources, processing pathway, antioxidant compounds, and antioxidant mechanism (Figure is generated by SciSpace).

The trip from the raw source material (*Camellia sinensis* plant) via three different processing processes is shown in Fig. 1 black Tea (complete oxidation via crushing/drying), Oolong Tea (partial oxidation via rolling/fermentation), and Green Tea (minimum oxidation via steaming/firingFrom rich catechins and EGCG in green tea to polymerized polyphenols like theaflavins and thearubigins in black tea, each processing step produces a distinct spectrum of important antioxidant chemicals. The main antioxidant processes, such as metal chelation (complex formation with Fe^{3+}, Cu^{2+}, and Cu^{+}) and free radical scavenging (ROS neutralisation), are highlighted in the bottom panel.

2.1 Green Tea

Green tea is produced by minimal processing, where freshly harvested leaves are subjected to steaming or pan-firing to inactivate polyphenol oxidase enzymes, thereby preventing oxidation. As a result, green tea retains a high concentration of catechins, including epigallocatechin gallate (EGCG), epicatechin, and epigallocatechin. These compounds are potent antioxidants known for their strong free radical scavenging activity and high reducing power. Thus, green tea is frequently noted for demonstrating the highest antioxidant activity among all varieties of tea (Khan & Mukhtar, 2019).

2.2 Black Tea

Black tea, in contrast, is fully oxidised, leading to the extensive conversion of catechins into theaflavins and thearubigins. Although the concentration of catechins decreases significantly, these newly formed compounds also possess antioxidant properties, particularly in inhibiting lipid peroxidation and scavenging reactive oxygen species. However, the overall antioxidant activity of black tea is generally lower than that of green and white tea due to the reduction in catechin content (Stoeva et al., 2025).

2.3 Oolong Tea

Oolong tea falls within the group of partially oxidised tea, with oxidation levels varying from 10% to 70%. This intermediate procedure produces a complicated mixture of oxidised compounds, including flavones and unoxidized catechins. These substances work together to provide a balanced

antioxidant profile by scavenging radicals and chelating metals. Oolong tea, therefore, has a medium to high antioxidant property, depending on the level of oxidation (Wang et al., 2025).

2.4 White Tea

White tea is another minimally processed form, typically prepared from young buds and tender leaves that undergo only withering and drying. Due to limited enzymatic oxidation, white tea preserves a substantial amount of catechins and other delicate phytochemicals. Studies suggest that white tea may exhibit antioxidant activity comparable to or even exceeding that of green tea, owing to the preservation of bioactive compounds during minimal processing (Silveira et al., 2021).

3. PHYTOCHEMICAL COMPOSITION OF PROCESSED TEA

Processed tea derived from *Camellia sinensis* is a complex matrix of bioactive compounds, the composition of which is significantly influenced by the degree of processing and oxidation. Tea leaves are rich in secondary metabolites, particularly carbohydrates, polyphenols, amino acids, alkaloids, vitamins, and volatile compounds, all of which contribute to their biological activities, including antioxidant potential (Wong et al., 2022).

Polyphenols

Polyphenols are the most abundant and biologically significant constituents of processed tea, accounting for approximately 25–40% of the dry weight of fresh tea leaves. These compounds are primarily responsible for the antioxidant activity of tea. The major classes of polyphenols include flavonoids (catechins, flavonols), phenolic acids, and their derivatives.

The main polyphenols found in barely processed teas like white and green tea are called catechins. Epigallocatechin gallate (EGCG), epicatechin (EC), epigallocatechin (EGC), and epicatechin gallate (ECG) are the main catechins (Khan & Mukhtar, 2019). Because these substances may donate hydrogen atoms and stabilise free radicals, they have potent antioxidant qualities. Catechins undergo enzymatic polymerisation during oxidation, as observed in the processing of black tea, to create the flavones and arubigins. While the arubigins give tea its colour and body, the flavones add brightness and astringency. Despite having less radical scavenging activity than catechins, these oxidised polyphenols nevertheless exert notable antioxidant benefits through several pathways (Ding et al., 2022).

Flavonoids and Flavanols

In addition to catechins, tea contains other flavonoids such as quercetin, kaempferol, and myricetin. These flavonols occur mainly as glycosides and contribute to antioxidant, anti-inflammatory, and cardioprotective effects. Their concentration varies depending on processing conditions and leaf maturity. Flavonoids act synergistically with catechins to enhance the overall antioxidant capacity of tea (Sun et al., 2022).

Alkaloids

Alkaloids found in tea include theobromine, theophylline, and caffeine. In addition to contributing to tea's stimulant qualities, caffeine has some moderate antioxidant activity. Alkaloids support the physiological effects and bioavailability of other phytochemicals, even though they are not the main source of antioxidant activity (Rita et al., 2023).

Amino Acids

About 1-4% of the dry weight of tea leaves is made up of amino acids. L-theanine, which is specific to tea and adds to its umami flavour, is the most prevalent amino acid. According to reports, L-theanine possesses antioxidant and neuroprotective qualities. It may work in concert with catechins to lessen oxidative stress (Mao et al., 2022).

Carbohydrates and Polysaccharides

Tea polysaccharides are gaining increasing attention due to their antioxidant, immunomodulatory, and antidiabetic properties. These compounds include cellulose, hemicellulose, pectins, and water-soluble polysaccharides. Studies have demonstrated that tea polysaccharides exhibit significant free radical scavenging activity and may contribute to the overall antioxidant potential of tea extracts (Yu et al., 2023).

Vitamins and Minerals

Processed tea contains essential vitamins such as vitamin C, vitamin E, and B-complex vitamins, although their levels may decrease during processing. Minerals such as potassium, calcium, magnesium, and manganese are also present and contribute to the nutritional value of tea. These micronutrients support antioxidant defense mechanisms by acting as cofactors for enzymatic antioxidant systems (Wang et al., 2022).

Volatile Compounds

Volatile compounds, including aldehydes, alcohols, esters, and terpenoids, are responsible for the aroma and flavor of tea. While they are not major contributors to antioxidant activity, some volatile constituents exhibit mild antioxidant and antimicrobial properties. The composition of volatile compounds varies significantly among different types of processed tea due to changes during oxidation and drying.

Effect of Processing on Phytochemical Composition

Processing plays a crucial role in determining the phytochemical profile of tea. In green and white tea, minimal processing preserves catechins and other sensitive compounds, resulting in higher antioxidant activity. In contrast, black tea processing involves enzymatic oxidation, which transforms catechins into theaflavins and thearubigins, altering both chemical composition and bioactivity. Oolong tea exhibits an intermediate profile due to partial oxidation. Additionally, factors such as temperature, drying methods, and storage conditions can influence the stability and degradation of phytochemicals.

Recent studies (2020–2025) have highlighted that advanced processing techniques, such as controlled fermentation and novel extraction methods, can enhance the yield and stability of bioactive compounds in tea. Furthermore, the interaction among different phytochemicals often leads to synergistic effects, enhancing the overall antioxidant capacity of processed tea (Hasan et al., 2023; Chen et al., 2025).

MECHANISMS OF ANTIOXIDANT ACTIVITY OF PROCESSED TEA

The antioxidant activity of processed tea derived from *Camellia sinensis* is primarily attributed to its rich composition of polyphenolic compounds, including catechins, flavonoids, theaflavins, and other bioactive constituents. These compounds exert their antioxidant effects through multiple complementary mechanisms that collectively reduce oxidative stress and protect biological systems from damage caused by reactive oxygen species (ROS) and reactive nitrogen species (RNS).

1. Free Radical Scavenging Activity

Tea's ability to directly scavenge free radicals is one of its main antioxidant mechanisms. Tea polyphenols, especially catechins like epigallocatechin gallate (EGCG), have hydroxyl groups that can donate electrons or hydrogen atoms to neutralize free radicals and transform them into less reactive and more stable species.

The scavenging activity involves the stabilisation of radicals such as superoxide anion ($O_2^{-}\bullet$), hydroxyl radicals (•OH), and peroxyl radicals (ROO•). The presence of multiple hydroxyl groups

and conjugated double bonds in catechin structures enhances their ability to delocalize unpaired electrons, thus increasing antioxidant efficiency (Kurin et al., 2025).

2. Metal Ion Chelation

Through Fenton and Haber-Weiss reactions, transition metals like iron (Fe^{2+}) and copper (Cu^{2+}) are essential for the production of free radicals. These metal ions can be chelated by tea polyphenols, preventing them from taking part in processes that produce radicals.

Because of their carbonyl and hydroxyl groups, catechins and flavonoids combine with metal ions to create stable complexes. This chelation greatly enhances antioxidant defence by lowering the enzymatic activity of metals and preventing the production of extremely reactive hydroxyl radicals (•OH) (Wnuk, 2025).

3. Inhibition of Lipid Peroxidation

Free radicals begin the chain reaction known as "lipid peroxidation," which causes oxidative lipid breakdown, especially in cell membranes. By scavenging lipid radicals and halting the chain reaction, tea polyphenols prevent lipid peroxidation.

Theaflavins and catechins are particularly effective in protecting polyunsaturated fatty acids from oxidative damage. They stabilise lipid radicals and prevent the formation of malondialdehyde (MDA), a marker of lipid peroxidation. This mechanism is crucial in maintaining membrane integrity and preventing cellular damage (Kurin et al., 2025).

4. Modulation of Antioxidant Enzymes

Tea bioactive compounds enhance the activity of endogenous antioxidant enzymes, thereby strengthening the body's defence system. These enzymes include Superoxide dismutase (SOD), Catalase (CAT), and Glutathione peroxidase (GPx).

Tea polyphenols regulate the expression of these enzymes through signaling pathways such as Nrf2 (nuclear factor erythroid 2–related factor 2). Activation of the Nrf2 pathway leads to the transcription of antioxidant response element (ARE)-driven genes, increasing cellular antioxidant capacity (Yang et al., 2025).

5. Inhibition of Pro-oxidant Enzymes

In addition to enhancing antioxidant enzymes, tea compounds inhibit enzymes that promote oxidative stress, such as Lipoxygenase. Cyclooxygenase and Xanthine oxidase.

By suppressing these enzymes, tea polyphenols reduce the production of reactive species and inflammatory mediators, thereby contributing to antioxidant and anti-inflammatory effects (Khan & Mukhtar, 2019).

6. Regulation of Cellular Signalling Pathways

Tea antioxidants influence various cellular signalling pathways associated with oxidative stress and inflammation. Key pathways include NF-κB (nuclear factor kappa B), MAPK (mitogen-activated protein kinase), and the PI3K/Akt pathway.

Polyphenols such as EGCG inhibit NF-κB activation, thereby reducing the expression of pro-inflammatory cytokines and oxidative stress markers. This regulatory role enhances the overall antioxidant defence system (Kim et al., 2018).

7. Synergistic Effects of Phytochemicals

A variety of phytochemicals, including catechins, flavonoids, amino acids, and polysaccharides, work in concert to produce tea's antioxidant activity rather than a single substance. Beyond the sum of the parts, these interactions improve the total antioxidant capability. For example, polysaccharides add more free radical scavenging activity, while L-theanine may improve the

bioavailability and stability of catechins. For processed tea to have broad-spectrum antioxidant qualities, these synergistic effects are essential (Hasan et al., 2023).

8. Scavenging of Reactive Nitrogen Species (RNS)

Tea polyphenols not only neutralise ROS but also reactive nitrogen species as peroxynitrite ($ONOO^-$) and nitric oxide ($NO\bullet$). These species participate in degenerative and inflammatory processes. Tea antioxidants provide extra defence against oxidative damage by preventing RNS from forming and functioning (Silva, 2021).

5. HEALTH IMPLICATIONS OF ANTIOXIDANT ACTIVITY

The antioxidant activity of processed tea derived from *Camellia sinensis* has significant implications for human health. The presence of bioactive compounds, particularly polyphenols such as catechins, flavonoids, and theaflavins, contributes to the prevention and management of various oxidative stress-related diseases. Oxidative stress arises from an imbalance between reactive oxygen species (ROS) and the body's antioxidant defence system, leading to cellular damage and the progression of chronic diseases. The antioxidant properties of tea help neutralise ROS and modulate biological pathways, thereby exerting protective effects (Fig.2) (Silva, 2021).

5.1 Cardiovascular Health

One of the most extensively studied health benefits of tea antioxidants is their protective effect against cardiovascular diseases. Tea polyphenols reduce oxidative stress by preventing the oxidation of low-density lipoprotein (LDL) cholesterol, a key factor in the development of atherosclerosis. Additionally, they improve endothelial function by enhancing nitric oxide (NO) bioavailability, which promotes vasodilation and reduces blood pressure.

Regular consumption of tea has been associated with reduced risk of coronary heart disease and stroke. Catechins also exhibit anti-inflammatory and antithrombotic effects, further contributing to cardiovascular protection (Khan & Mukhtar, 2019).

5.2 Cancer Prevention

The antioxidant activity of tea plays a crucial role in cancer prevention. Reactive oxygen species can cause DNA damage, mutations, and abnormal cell proliferation. Tea polyphenols, particularly epigallocatechin gallate (EGCG), inhibit carcinogenesis by scavenging free radicals, preventing DNA damage, and modulating signaling pathways involved in cell growth and apoptosis.

Tea compounds have been shown to inhibit tumour initiation, promotion, and progression through mechanisms such as induction of apoptosis, inhibition of angiogenesis, and suppression of cell proliferation. These effects highlight the potential of tea as a chemopreventive agent (Hasan et al., 2023).

5.3 Neuroprotective Effects

One of the main causes of neurodegenerative diseases like Parkinson's and Alzheimer's is oxidative stress. By lowering oxidative damage and preventing neuroinflammation, tea antioxidants safeguard neuronal cells.

By lowering ROS levels in neural tissues, modifying neurotransmitter function, and preventing amyloid-beta aggregation, catechins and L-theanine have been demonstrated to pass the blood–brain barrier and provide protective effects. These characteristics imply that drinking tea regularly may lower the risk of neurodegenerative illnesses and cognitive decline (Chen et al., 2018) .

5.4 Anti-diabetic Effects

By enhancing insulin sensitivity and lowering oxidative stress linked to hyperglycaemia, tea antioxidants help manage diabetes. Polyphenols lower postprandial blood glucose levels by

inhibiting enzymes that break down carbohydrates, such as α-amylase and α-glucosidase. Tea components also control glucose metabolism pathways and shield pancreatic β-cells from oxidative stress. Because of these benefits, tea is a potentially effective dietary intervention for type 2 diabetes prevention and management (Ansari et al., 2022).

5.5 Anti-inflammatory Activity

Oxidative stress and several illnesses are strongly associated with chronic inflammation. By blocking pro-inflammatory mediators and signalling pathways like NF-κB, tea polyphenols have potent anti-inflammatory qualities.

Tea antioxidants help reduce inflammation and prevent associated diseases like arthritis and metabolic problems by lowering the generation of cytokines and inflammatory enzymes(Winiarska-mieczan & Tomaszewska, 2021).

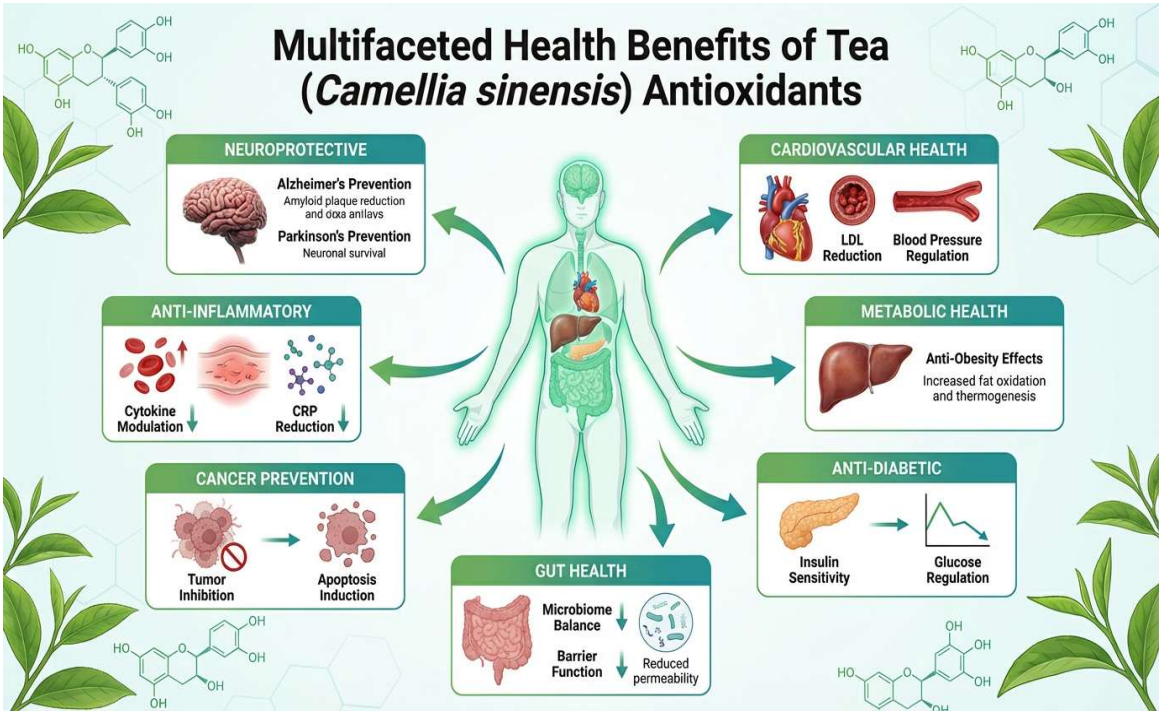


Fig. 2 Multifaceted health benefits of Tea (*Camellia sinensis)* antioxidant (Figure generated by Scispace).

5.6 Antimicrobial and Immune-Boosting Effects

Antioxidants included in tea also support immune system improvement and antibacterial action. Microbial cell membranes, enzyme activity, and microbial DNA replication can all be disrupted by polyphenols.

Additionally, tea ingredients improve immune function by lowering oxidative stress and regulating immune cell activity. The body's defence against illnesses and infections is strengthened by this dual function (Molouki et al., 2021).

5.7 Gut Health and Microbiota Modulation

The importance of tea antioxidants in preserving gut health has been emphasised in recent research (2020–2025). By interacting with the gut microbiota, tea polyphenols encourage the growth of good bacteria while suppressing harmful ones. These interactions lower inflammation, strengthen the intestinal barrier, and improve metabolic health in general. Systemic antioxidant effects are also influenced by the metabolites that the gut flora produces from tea polyphenols (Vamanu et al., 2021).

6. FUTURE PERSPECTIVES

Processed tea made from *Camellia sinensis* is now a viable option for further study and commercial use due to the increased interest in natural antioxidants. To fully realise its promise, more research is needed in a few areas, despite significant advancements in our understanding of its phytochemical composition and antioxidant mechanisms.

Finding and isolating particular bioactive substances that have antioxidant action is one of the most important future approaches. Although polyphenols like catechins and flavonoids have been extensively researched, there is growing evidence that other components, such as polysaccharides and minor flavonoids, also have a major role.

7. CONCLUSION

Processed tea (*Camellia sinensis*) is a rich source of natural antioxidants with significant health benefits. Although processing affects its phytochemical composition, all forms of tea retain considerable antioxidant potential. Advances in extraction and processing technologies continue to enhance its functional properties. The incorporation of tea-derived antioxidants into food and pharmaceutical products holds great promise for improving human health and preventing chronic diseases.

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પર્યાવરણ વિજ્ઞાન

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પરિચય

પર્યાવરણ એટલે આપણા આસપાસનું સમગ્ર કુદરતી અને માનવસર્જિત વાતાવરણ. તેમાં હવા, પાણી, જમીન, પ્રાણી, છોડ, અને માનવ જીવનના બધા તત્વોનો સમાવેશ થાય છે. પર્યાવરણ વિજ્ઞાન એ એક એવો વિષય છે જે પર્યાવરણના ઘટકો, તેમની વચ્ચેના સંબંધો અને માનવ પ્રવૃત્તિઓના પ્રભાવનો અભ્યાસ કરે છે.

આધુનિક યુગમાં વિજ્ઞાન અને ટેકનોલોજીના વિકાસ સાથે માનવ જીવન સરળ બન્યું છે, પરંતુ તેના કારણે પર્યાવરણ પર નકારાત્મક અસર પણ પડી છે. ઉદ્યોગિકરણ, શહેરીકરણ અને વધતી વસ્તી પર્યાવરણ માટે ગંભીર પડકાર બની છે.

પર્યાવરણના ઘટકો

પર્યાવરણને મુખ્યત્વે બે ભાગોમાં વહેંચી શકાય છે:

1. જૈવિક ઘટકો (Biotic Components)

આમાં તમામ જીવંત સજીવો આવે છે જેમ કે માનવ, પ્રાણી, પક્ષીઓ, વૃક્ષો અને છોડ. આ તત્વો પર્યાવરણમાં જીવંત પ્રવૃત્તિઓ માટે જવાબદાર છે.

2. અજૈવિક ઘટકો (Abiotic Components)

આમાં નિર્જીવ તત્વોનો સમાવેશ થાય છે જેમ કે હવા, પાણી, જમીન, પ્રકાશ, તાપમાન વગેરે.

આ બંને ઘટકો પરસ્પર નિર્ભર છે અને પર્યાવરણનું સંતુલન જાળવે છે.

પર્યાવરણ વિજ્ઞાનનું મહત્વ

પર્યાવરણ વિજ્ઞાનનું મહત્વ આજના સમયમાં ખૂબ વધ્યું છે. તે આપણને શીખવે છે:

કુદરતી સંસાધનોનું સંરક્ષણ

પ્રદૂષણને ઘટાડવાના ઉપાયો

જૈવવિવિધતાનું મહત્વ

સ્થિર વિકાસનો માર્ગ

આ વિષય આપણને પર્યાવરણ સાથે સંતુલન રાખીને જીવન જીવવાની પ્રેરણા આપે છે.

પ્રદૂષણ (Pollution)

પ્રદૂષણ એટલે પર્યાવરણમાં હાનિકારક પદાર્થોનું મિશ્રણ. તે ચાર મુખ્ય પ્રકારનું હોય છે:

1. હવા પ્રદૂષણ

વાહનો, કારખાનાઓ અને ધુમાડાથી હવામાં ઝેરી વાયુઓ મિશ્રિત થાય છે. તે શ્વાસરોગ અને અન્ય બીમારીઓનું કારણ બને છે.

2. પાણી પ્રદૂષણ

ઉદ્યોગોના રસાયણો અને ગટરનું પાણી નદીઓ અને તળાવો પ્રદૂષિત કરે છે. તે પીવાના પાણી માટે જોખમરૂપ છે.

3. જમીન પ્રદૂષણ

પ્લાસ્ટિક, કચરો અને રસાયણોથી જમીન બગડે છે અને ખેતી માટે અયોગ્ય બને છે.

4. અવાજ પ્રદૂષણ

વાહનો અને મશીનોના અવાજથી માનસિક તણાવ અને આરોગ્ય સમસ્યાઓ થાય છે.

ગ્લોબલ વોર્મિંગ (Global Warming)

પૃથ્વીનું સરેરાશ તાપમાન વધવાનું ગ્લોબલ વોર્મિંગ કહેવાય છે. તે ગ્રીનહાઉસ વાયુઓ (CO_2, methane)ના વધારા કારણે થાય છે.

અસર:

હિમનદીઓ ઓગળવી

સમુદ્રનું સ્તર વધવું

વાતાવરણમાં અસમાનતા

જંગલોનું મહત્વ

જંગલો પૃથ્વીના "ફેફસા" છે. તે ઓક્સિજન પૂરું પાડે છે અને કાર્બન ડાયોક્સાઇડ શોષે છે.

જંગલોનો નાશ થાય તો:

વરસાદમાં ઘટાડો

જમીન ધોવાણ

જૈવવિવિધતા ખતમ

જૈવવિવિધતા (Biodiversity)

જૈવવિવિધતા એટલે વિવિધ પ્રકારના જીવોનો સમૂહ.

મહત્વ:

ખોરાકની સાંકળ જાળવે

ઔષધિઓ માટે ઉપયોગી

પર્યાવરણનું સંતુલન જાળવે

સ્થિર વિકાસ (Sustainable Development)

સ્થિર વિકાસનો અર્થ છે કે આપણે આજની જરૂરિયાતો પૂરી કરીએ પરંતુ ભવિષ્યની પેઢીને નુકસાન ન પહોંચાડીએ.

ઉદાહરણ:

સોલાર એનર્જી

પાણી સંરક્ષણ

વૃક્ષારોપણ

કુદરતી સંસાધનોનું સંરક્ષણ

કુદરતી સંસાધનો મર્યાદિત છે.

મુખ્ય સંસાધનો:

પાણી

ખનિજ

જંગલો

ઊર્જા

સંરક્ષણ માટે:

રિસાયક્લિંગ

પાણી બચત

વીજળી બચત

પર્યાવરણ સુરક્ષા માટેના ઉપાયો

વધુ વૃક્ષો વાવો

પ્લાસ્ટિકનો ઉપયોગ ઘટાડો

જાહેર પરિવહનનો ઉપયોગ કરો

પાણી બચાવો

સ્વચ્છતા જાળવો

સરકાર અને સમાજની ભૂમિકા

સરકાર:

કાયદા બનાવે

જાગૃતિ ફેલાવે

સમાજ:

નિયમોનું પાલન કરે

પર્યાવરણ પ્રત્યે જવાબદાર બને

નિષ્કર્ષ

પર્યાવરણ વિજ્ઞાન આપણને શીખવે છે કે માનવ જીવન અને પર્યાવરણ એકબીજા સાથે ગાઢ રીતે જોડાયેલા છે. જો આપણે પર્યાવરણને નુકસાન પહોંચાડીએ તો તેનો સીધો અસર આપણા જીવન પર થાય છે.

આથી, દરેક વ્યક્તિએ પર્યાવરણનું રક્ષણ કરવું જોઈએ.

"પ્રકૃતિ બચાવો, ભવિષ્ય બચાવો

દરેક ક્ષેત્રમાં 'AI'

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જેને આપણે સંક્ષેપમાં **'AI'** કહીએ છીએ તેને કૃત્રિમ બુદ્ધિ પણ કહી શકાય.સરળ શબ્દોમાં 'AI' એટલે કોમ્પ્યુટરને માણસની જેમ વિચારતા અને કામ કરતા શીખવવું. જેનો અર્થ થાય છે મશીનોમાં માનવ બુદ્ધિનું અનુકરણ. જે તેમને શીખવા માટે, સમજવા માટે તેમજ સમસ્યા ઉકેલવા અને નિર્ણય લેવા સક્ષમ બનાવે છે. કેન્સરના પરીક્ષણ માટે, હેલ્થકેર, ગૂગલ લેન્સ, વોઈસ આસિસ્ટન્સ અને ઈ-કોમર્સમા પ્રોડકટ ભલામણો જેવી રોજીંદી આર્ટિફિશિયલ ઈન્ટેલિજન્સ ટેકનોલોજીમા થાય છે. ભારતને વૈશ્વિક 'AI' લીડર બનાવવાનું લક્ષ્ય છે. ભારતમાં પણ વિકસતી આ ટેકનોલોજી છે.

પરિચય

મશીન લર્નિંગ **'AI'** સિસ્ટમ્સ અનુભવોમાંથી શીખીને પોતાની કામગીરી સુધારે છે જેમ કે, અલ્ગોરિધમ દ્વારા જ્ઞાનનો સંગ્રહ. ગૂગલ મેપ્સ,ગૂગલ ટ્રાન્સલેટ, એમેઝોન ઉપર પ્રોડકટ ભલામણો, સ્માર્ટફોન,સ્તન કેન્સર જેવી બીમારીઓ શોધવામાં 'AI' ડોક્ટરો કરતાં વધુ સચોટ સાબિત થઈ શકે છે. સમય, પૈસા અને શ્રમ બચાવે છે. **'ચેટજીપીટી'** જેવાં ટૂલ્સ, ઓડીઓ ક્લિયર કરવા માટે **'KRISP AI'.** આપણાં રોજીંદા જીવનમાં આર્ટિફિશિયલ ઈન્ટેલિજન્સ વધુને વધુ મહત્વનું બની રહ્યું છે. ભારતમા 'AI' સરકારી પહેલ જોઈએ તો ભારત સરકાર **'INDIA AI'** મશીન દ્વારા કરી રહી છે તેમજ 'AI' ક્રાંતિ દ્વારા નવા વ્યક્તિઓને પ્રોત્સાહન આપી રહી છે. દેશમાં 'AI' – સંચાલિત ગેજેટ્સના ઉત્પાદન પર ભાર મૂક્યો છે.

દરેક વસ્તુના હકારાત્મક તેમજ નકારાતાત્મક પાસાં હોય છે. 'AI' મશીન અથવા સોફ્ટવેરની બુદ્ધિ છે. તે જીવનને સરળ બનાવશે,અવનવી તકો ઉભી કરશે અને જટિલ સમસ્યાઓનું સમાધાન પણ કરશે. તો, બીજી તરફ **'ડીપ ફેક'** જેવી સમસ્યાઓ અને નૈતિક ચિંતાઓ પણ છે જે વિષય પર ધ્યાન આપવું જરૂરી છે. 'AI' એ ભવિષ્યની ટેકનોલોજી છે જે આપણું વિશ્વ બદલી રહ્યું છે જેમાં, ભારત પણ સક્રિય ભૂમિકા ભજવી રહ્યું છે.'AI' જે મનુષ્યો તેમજ પ્રાણીઓની બુદ્ધિથી વિપરીત છે. તે કોમ્પુટર વિજ્ઞાનમાં અભ્યાસનું ક્ષેત્ર છે જે મશીનોનો વિકાસ અને અભ્યાસ કરે છે.આવા મશીનોને **'AIS'** કહેવાય છે. છેલ્લા કેટલાંક મહિનાઓમાં 'ડીપ ફેક' ના કેસ જોયા છે. જેમાં અભિનેત્રી 'રશ્મિકા મંદાના'થી લઈને 'આલિયા ભટ્ટ' પણ તેનો ભોગ બની છે. જે એક ખતરાની ઘંટડી છે. તેથી આ ટેકનોલોજીનો ઉપયોગ સતર્કતાથી થાય તે આવશ્યક છે. **'ડીપ ફેક', 'ડીપ ન્યુડસ'** જેને લઈને ખુબજ મોટી સમસ્યાઓ ઉભી કરી શકે છે તેથી ગવર્મેન્ટ અને ઓર્ગેનાઈઝેશન જેમકે, **'OPEN AI'** ખાતરી કરે છે કે આ ટેકનોલોજીનો દુરુપયોગ ન થાય તેમજ વ્યક્તિની ગોપનીયતા જળવાઈ રહે.

ભારતમાં બનેલ ટેકનોલોજી

ઈન્ડિયન એક્સપ્રેસના એડિટર **'નંદગોપાલ રાજન'** એ કહ્યું કે, આર્ટિફિશિયલ ઈન્ટેલિજન્સ સામૂહિક બુદ્ધિ છે કે જે મનુષ્યોએ બનાવી છે. જે ખૂબજ વેગથી વિસ્તરી રહી છે. આ ઉપરાંત તેમણે 'AI' ને **'જાયન્ટ માઈક્રો ઓર્ગેનીઝમ'** પણ કહ્યું કે, "ઈન્ડિયામાં વર્ષ **'૨૦૨૪'** માં લોકસભાની ચૂંટણીઓ આવી રહી છે ત્યારે એક શબ્દ આપણે વ્યાપકપણે સાંભળીશું તે છે; **"મેક ઈન ઈન્ડિયા"** અને **"મેડ ઈન ઈન્ડિયા"** એટલે કે, ભારતની મોટાભાગની કંપનીઓ તેમની પ્રોડકટ અને સર્વિસ માટે તેનો ઉપયોગ

કરે છે.'AI' ટેકનોલોજી આવ્યા પછી કામ સુગમ થઈ ગયું છે. ગ્રાહકોને તેમની સર્ચ ક્વેરી, બ્રાઉઝિંગહિસ્ટ્રી અને અન્ય માહિતીના આધારે 'AI' નો ઉપયોગ કરીને એમેઝોને જેવી સાઈટ્સ દ્વારા પ્રોડક્ટની ભલામણ આપવામાં આવે છે. પરિણામે વેચાણમાં વધારો થાય છે અને ગ્રાહકોનો સંતોષ વધે છે. જે 'AI' ના ઉપયોગને આભારી છે.

આ ઉપરાંત વર્ષ **'૨૦૨૩'** ના આરંભે પણ **'નંદગોપાલજી'એ** કહ્યું હતું કે, "આ વર્ષથી 'મેટાવર્ષ' ટેકનોલોજી વ્યાપક પ્રમાણમાં વિકસિત થશે પરંતુ આવતા વર્ષોમાં આપણે કદાચ આ ટેકનોલોજી વધુ ડીટેલ્સમાં જેમ કે, કોઈ એડીશનલ હાર્ડવેર સપોર્ટ વિના સ્માર્ટફોનનો કલેક્ટિવ ડેટા 'ઓગમેન્ટેડ રીયાલીટી' માં બદલી શકાય તેવા ફેરફાર આવી શકે છે." ભવિષ્યમાં 'AI' અને માનવ બુદ્ધિમત્તાનું સંયોજન આપણને વધુ સારા સમાજ તરફ દોરી જશે જ્યાં, આ તકનીક્ માનવ કલ્યાણ અને પ્રગતિમાં મહત્વપૂર્ણ ભૂમિકા ભજવશે. આ માટે સરકાર, ઉદ્યોગવર્ગ અને સમાજે સાથે મડીને 'AI' ના જવાબદાર વિકાસ અને ઉપયોગ માટે કામ કરવું પડશે. 'AI' નો સફળ ઉપયોગ માનવમૂલ્યો અને નૈતિક સિદ્ધાંતોનાં સંતુલન પર આધારિત હશે.ઈન્ટરનેશનલ ડેટા કોર્પોરેશન (IDC) અનુસાર ભારતમાં 'AI' માર્કેટ **'૨૦૨૦'** માં **'3.૧'** બિલિયનથી વધીને **'૨૦૨૫'** સુધીમાં **'7.૮'** બિલિયન સુધી પહોંચવાનો અંદાજ છે. **'૨૦૩૫'** માં સમાપ્ત થશે લીપ સેકન્ડ પ્રણાલી **'૫૦'** વર્ષ પહેલા શરૂ થઈ હતી પૃથ્વીના સમયને એક સેકન્ડ આગળ વધારવાની આ ટેકનોલોજી.

ગ્રીન ટેકનોલોજી ચળવળ

ઘણી કંપની ગ્રીન ટેકનોલોજીના અમલીકરણ અંગે વિચારી રહ્યાં છે. ગ્રીન ટેકનોલોજી એ એક અમ્બ્રેલા ટર્મ છે જે, કુદરતી પર્યાવરણ પર માનવીય પ્રભાવોને ઘટાડવા માટે ટેકનોલોજી અને વિજ્ઞાનના ઉપયોગનું વર્ણન કરે છે જેમ કે, રિસાઈકલ, રિયુઝ, ટકાઉ અને ઓછામાં ઓછી કાર્બનફૂટ પ્રિન્ટનો ઉપયોગ વગેરે લાભ જોઈ શકાય છે. આ ટેકનોલોજી આપણી જીવનશૈલી, કાર્યપદ્ધતિ અને વિચારસરણીને નવો આકાર આપી રહી છે.

'AI' નો ઈતિહાસ

'૧૯૫૦' ના દશકમાં, બ્રિટીશ ગણિતશાસ્ત્રી અને કમ્પ્યુટર વિજ્ઞાની 'એલન ટ્યુરિંગે' પ્રસિદ્ધ **'ટ્યુરીંગ ટેસ્ટ'** રજૂ કર્યો જે મશીનની બુદ્ધિમત્તાને માપવાનો એક માપદંડ બની ગયો.**'૧૯૫૬'**માં **'ડાર્ટમાઉથ'** કૉલેજમાં એક ઐતિહાસિક સંમેલન યોજાયું. જ્યાં, આર્ટિફિશિયલ ઈન્ટેલિજન્સ શબ્દનો ઔપચારિક રીતે સૌ પ્રથમ વખત ઉપયોગ કરવામાં આવ્યો. **'૧૯૮૦'** અને **'૧૯૯૦'** માં 'AI' એ વ્યવસાયિક અને ઔદ્યોગિક ઉપયોગોમાં પ્રવેશ કર્યો.

૨૧ મી સદીની શરૂઆતથી, 'AI' એ નોંધપાત્ર પ્રગતિ સાધી છે. ડેટા પ્રોસેસિંગ ક્ષમતામાં વધારો, મોટા 'ડેટાસેટ' ની ઉપલબ્ધતા અને નવી અલ્ગોરિધ્મ્સના વિકાસને 'AI' એ નવી ઉંચાઈઓ પર લઈ જવામાં સહાયતા કરી છે.

'AI' કેવી રીતે કાર્ય કરે છે ?

મશીનોને ડેટામાંથી શીખવા અને તેમાં પેટર્ન ઓળખવા 'AI' ને સક્ષમ બનાવે છે.

જેનાથી દરેક કાર્ય વધુ કાર્યક્ષમ અને અસરકારક રીતે કરી શકાય 'AI' પાંચ તબક્કામાં કાર્ય કરે છે જે નીચે પ્રમાણે છે:

ઈનપુટ: વિભિન્ન ક્ષેત્રોમાંથી ડેટા સંગ્રહિત કરવામાં આવે છે. આ ડેટાને પછી શ્રેણીયોમાં વિભક્ત કરવામાં આવે છે.

પ્રોસેસિંગ: 'AI' એવા પેટર્નનો ઉપયોગ કરીને ડેટાને વર્ગીકૃત અને સમજે છે જે તેના શીખવા માટેના પ્રોગ્રામ કરવામાં આવ્યા છે. જ્યાંસુધી તે ડેટામાં સમાન પેટર્ન ઓળખી ના લે. 'AI' પછી તે પેટર્નનો ઉપયોગ પરિણામોની આગાહી કરવામાં કરી શકે છે.

સમાયોજન: જો 'ડેટા સેટસ' ને નિષ્ફળ ગણવામાં આવે,તો 'AI' તે ભૂલમાંથી શીખે છે. અને તે પ્રક્રિયા અલગ પરિસ્થિઓ હેઠળ ફરીથી પુનરાવર્તિત થાય છે.

મૂલ્યાંકન: આ રીતે 'AI' સતત શીખતું અને સુધરતું રહે છે.

નેચરલ લેંગ્વેજ પ્રોસેસિંગ (NLP)

આ એક એવી શાખા છે જે કોમ્પુટરને માનવભાષા સમજવા અને પ્રોસેસ કરવામાં સક્ષમ બનાવે છે. **'NLP'** નો ઉપયોગ વિવિધ ભાષાઓ વચ્ચે અનુવાદ કરવા માટે થાય છે. આ ટેકનોલોજી, ઈમેલ ફીલ્ટરીંગ, સોશિયલ મીડિયા મોનિટરીંગ અને માર્કેટ રિસર્ચમાં મદદ કરે છે. આ તકનીક્ મેડીકલ રીકોર્ડ્સ અને કાનૂની દસ્તાવેજોના વિશ્લેષણ ઉપયોગી છે.

'NLP' મોડેલ્સમાં બાયસ ઘટાડવો એક મોટો પડકાર છે. ભાષાના સંસ્કૃતિક સંદર્ભો

અને વ્યંગ્ય સમજવા મુશ્કેલ છે. બહુભાષી 'NLP' સિસ્ટમ્સ વિકસાવવા માટે દરેક ભાષાનો પૂરતો ડેટા જરૂરી છે. ભવિષ્યમાં માનવ કોમપ્યુટર ઈન્ટરેકશનને વધુ સહજ બનાવશે. આ તકનીક્ ડિજિટલ સહાયકો અને ચેટબોટ્સને વધુ બુદ્ધિશાળી બનાવશે.

ન્યુરલ નેટ્વર્ક્સ (Neural Networks)

ન્યુરલ નેટ્વર્ક્સ કમ્યુટેશનલ મોડેલ્સ છે. જે માનવ મગજની રચના પર આધારિત છે. આ નેટ્વર્ક્સ કૃત્રિમ ન્યુરોન્સના પરસ્પર જોડાયેલા લેયર્સથી બનેલાં છે. દરેક ન્યુરોન ડેટાને પ્રોસેસ કરે છે અને તેની આઉટપુટ અન્ય ન્યુરોન્સને મોકલે છે. ન્યુરલ નેટવર્ક્સ

પેટર્ન **'રિકગ્નીશન'** અને **'ફંક્સન એપ્રોક્ષિમેશન'**માં સારી કામગીરી કરે છે. કોન્વોન્યુશનલ ન્યુરલ નેટ્વર્ક્સ **'ઈમ પ્રોસેસિંગ'**માં વપરાય છે. રિકરન્ટ ન્યુરલ નેટ્વર્ક્સ સિક્વન્સ ડેટા માટે યોગ્ય છે. ન્યુરલ નેટ્વર્ક્સ **'બેકપ્રોપેગેશન'** એલ્ગોરિધમ દ્વારા શીખે છે. આ નેટ્વર્ક્સની આર્ટિટેક્ચર ટાસ્ક પ્રમાણે ડીઝાઈન કરવામાં આવે છ ન્યુરલ નેટવર્ક્સ ગેમિંગ અને રોબોટિક્સમા વપરાય છે. આ મોડેલ્સ ફાઈનાન્શિયલ ફોરકાસ્ટિન્ગ અને રિસ્ક એસેસમેન્ટમાં મદદ કરે છે. ન્યુરલ નેટવર્ક્સની ક્ષમતાઓ હાર્ડવેર અને સોફ્ટ્વેરના વિકાસ સાથે વધી રહી છે. આ તકનીક્ 'AI' રીસર્ચનો મહત્વપૂર્ણ ભાગ છે.

સુપર આર્ટીફ્રિશિયલ ઈન્ટેલિજન્સ (ASI)

'AI' સિસ્ટમ માનવ બુદ્ધિને વટાવી જાય તેવી સિસ્ટમ છે. આ કાલ્પનિક સિસ્ટમ જનરલ વિઝડમ, સાયન્સ, ક્રિએટીવિટી, સોશિઅલ સ્કીલ્સમા માનવથી આગળ હશે. આ પ્રકારની 'AI' માનવતા માટે આશીર્વાદ કે જોખમ સ્વરૂપ બની શકે છે. તેથી તેના વિકાસમાં નૈતિક અને સુરક્ષા માર્ગદર્શિકાઓનું પાલન કરવું અગત્યનું છે.

રિએકટીવ મશીન્સ

રિએક્ટીવ એ સૌથી સરળ 'AI' સિસ્ટમ છે. જે કેવળ સામ્પ્રંત પરિસ્થિતિઓ પર પ્રતિક્રિયા આપે છે. આ સિસ્ટમ્સ ભૂતકાળના અનુભવોનો ઉપયોગ કરતી નથી કે ભવિષ્ય માટે યોજના બનાવતી નથી. **IBM** નું **'ડીપ બ્લ્યુ'**, જે ચેસમાં વિશ્વ ચેમ્પિયનને હરાવી શક્યું તે રીએકટીવ મશીનનું ઉદાહરણ છે. આ સિસ્ટમ્સ તેના નિર્ધારિત કાર્યમાં ખૂબ કુશળ હોય છે પરંતુ તેમની ક્ષમતાઓ ઘણી મર્યાદિત હોય છે.

લિમિટેડ મેમરી 'AI'

આ સિસ્ટમ્સ મર્યાદિત સમય માટે માહિતી સંગ્રહિત કરી શકે છે અને તેનો ઉપયોગ કરી શકે છે. સ્વયં સંચાલિત કાર્સ આ પ્રકારના 'AI' નું ઉદાહરણ છે, જે ટ્રાફિક વ્યવસ્થા, રોડની સ્થિતિ અને અન્ય વાહનોની ગતિવિધિઓને ધ્યાનમાં રાખીને નિર્ણયો લે છે. આ સિસ્ટમ્સ સામ્પ્રંત સમયમાં સૌથી વ્યાપક રીતે ઉપયોગમાં લેવાતી ટેકનોલોજી છે.

આરોગ્ય સેવાઓમાં 'AI'

હેલ્થકેર ક્ષેત્રમા 'AI' નો ઉપયોગ રોગોનાં પરીક્ષણ માટે,દર્દીઓની સારવાર તેમજ દવાઓની શોધ માટે થાય છે. મેડિકલ ઈમેઝીંગ કેન્દ્રો દ્વારા કેન્સર જેવી -બીમારીઓનું પણ પરીક્ષણ થાય છે આ પ્રકારના જીવલેણ રોગોની વહેલી ઓળખ થાય છે. દવાખાનાનાં સાધનોનું સંચાલન કરવા અને દર્દીઓની સારવાર યોજના બનાવવામાં પણ મદદરૂપ થાય છે.

નાણાંકીય ક્ષેત્રમા 'AI'

'AI' આધારિત ચેટબોટ્સ ગ્રાહકસેવા અને નાણાંકીય સલાહ પ્રદાન કરે છે. વિવિધ બેન્કિંગ અને ફાઈનાન્સમાં **'ફ્રોડડીટેક્શન'**માં તેમજ જોખમ મૂલ્યાંકન અને રોકાણ માટે 'AI' ઉપયોગી થાય છે. 'AI' મોડેલ્સ બજાર વલણોની આગાહી કરવામાં અને નિર્ણયોમાં માર્ગદર્શન આપવા માટે વિશાળ માત્રામાં નાણાંકીય ડેટાનું વિશ્લેષણ કરે છે.

શિક્ષણ ક્ષેત્રમાં 'AI'

આ તકનીક્ ઓટોમેટેડ ગ્રેડિંગ અને વિદ્યાર્થીઓની પ્રગતિનું વિશ્લેષણ કરવામાં મદદ કરે છે. શિક્ષણમાં 'AI' વ્યક્તિગત શીખવાના અનુભવો પ્રદાન કરવા અને શિક્ષકોને વહીવટી કાર્યોમાંથી મુક્ત કરવા માટે ઉપયોગમાં લેવાય છે. આ તકનીક્ વિદ્યાર્થીની શૈલી અને શીખવાની ગતિને અનુકૂડ અભ્યાસ સામગ્રી પ્રદાન કરે છે.

ઉત્પાદન ક્ષેત્રમાં 'AI'

મેન્યુફેક્ચરીંગમા 'AI' રોબોટિક્સ, ગુણવત્તામાં સુધારા અને 'સપ્લાયચેન ઓપ્ટિમાઈઝેશન' માટે વપરાય છે. આ રોબોટ્સ જોખમી અને પુનરાવર્તિત કાર્યો કરે છે. આ તકનીક્ ઉત્પાદન પ્રક્રિયાઓમાં ખામીઓની આગોતરી ઓળખ કરીને ડાઉનટાઈમ ઘટાડે છે.

વાહનવ્યવહાર અને લોજિસ્ટિક્સમાં 'AI'

'AI' અલ્ગોરિધ્મ્સન ડિલિવરી રૂટ્સને ઓપ્ટિમાઈઝ કરે છે અને **'શિપમેન્ટ ટ્રેકિંગ'**મા સહાય કરે છે. તે સાચા સમયે 'ટ્રાફિક ડેટા'ના આધારે માર્ગ આયોજનમાં પણ મદદ કરે છે. ટ્રાન્સપોર્ટેશન ક્ષેત્રમા 'AI' સ્વયં-સંચાલિત વાહનો તેમજ ટ્રાફિકના આયોજનમાં મદદરૂપ બને છે.

રિટેલ ક્ષેત્રમા 'AI'

'AI' સિસ્ટમ્સ માંગની આગાહી કરે છે. તે ગ્રાહકોને પોતાની પસંદગી મુજબ પ્રોડક્સની ભલામણ કરે છે. રિટેલમાં 'AI' ગ્રાહકોના વર્તણુંકનું વિશ્લેષણ કરવા ઈન્વેન્ટરી મેનેજમેન્ટ અને વ્યક્તિગત ભલામણો પ્રદાન કરવા માટે વપરાય છે.

કલા અને નૃત્યમાં 'AI' નું યોગદાન

કલા અને નૃત્ય માનવ મનોવિજ્ઞાન ભાવના અને સાંસ્કૃતિક અભિવ્યક્તિનું પ્રતિબિંબ બની રહ્યું છે. આ ક્ષેત્રોમાં સર્જનાત્મકતા, અભિવ્યક્તિ અને શક્તિનો વિશાળ પ્રભાવ હોય છે જે માનવ સંસ્કૃતિના અતિ મહત્વના ક્ષેત્રો છે. આજના ટેક્નોલોજી અને ક્રાંતિકારી સમયના પરિપ્રેક્ષ્યમાં આર્ટિફિશિયલ ઈન્ટેલિજન્સે આ ક્ષેત્રમાં નવો અને રાહતપૂર્ણ આયામ ઉમેર્યો છે. તંત્ર અને મશીન દ્વારા કલા બનાવવી એ એક અનોખો અને નવા વિચારોનો અભ્યાસ છે. કલા સર્જન માટે વિવિધ અલ્ગોરિધમ્સ અને મશીન લર્નિંગ મોડેલ્સનો ઉપયોગ કરવામાં આવે છે. જેમ કે,પેઈન્ટિંગ, ડિઝિટલ આર્ટ,મ્યુઝિક,ફોટોગ્રાફી અને વિડીયો પ્રોડક્શન જેવા ઉદાહરણોમાં 'AI' નો ઉપયોગ કરી રહ્યા છે. 'AI' અનેક જુદી જુદી શૈલીઓ અને પેન્ટિંગનો અભ્યાસ કરીને નવી પેન્ટિંગ્સ બનાવી શકે છે. ઉદાહરણ તરીકે, ' DEEP ART' અને 'DEEP DREAM' જેવા પ્લેટફોર્મનો ઉપયોગ કરીને અવધિ પ્રકારની કલા પેન્ટિંગ્સ બની શકે છે. 'AI' દ્વારા સંગીતના પ્રકારોને શીખીને અને નવા સંગીત ટૂકડા તૈયાર

કરે છે. ચિત્રો અને ફોટાઓની ઘોર ગૌણતાઓને ઓળખી શકે છે ફોટોગ્રાફી એડિટિંગ અને પોસ્ટ પ્રોસેસિંગમાં 'AI' મહત્વની ભૂમિકા ભજવી રહ્યો છે. માનવ મગજના સર્જનાત્મક પ્રતિબિંબ તરીકે કામ કરી રહી છે. મશીનો કલા બનાવતી વખતે માનવ મગજની રૂપક કે લાગણી વિના પણ વિચાર અને મૌલિક ચિંતનને જીવન આપે છે.

નૃત્ય એ માનવ શરીર દ્વારા આદર અને ભાવનાવિહાર વ્યક્ત થાય છે. દરેક નૃત્ય પ્રકારને માત્ર શારીરિક પરિપ્રેક્ષ્યથી નહીં પરંતુ આદર અને લાગણીથી પણ રજૂ કરવામાં આવે છે. 'AI' આ ક્ષેત્રમાં પણ નવો દ્રષ્ટિકોણ આપે છે. જે નૃત્યકળાની વૃદ્ધિ અને વિસ્તરણ માટે ખૂબ જ લાભદાયી નીવડે છે.

'AI' ના પ્રકારો

રીએક્ટીવ મશીન
લિમિટેડ મેમરી
થિયરી ઓફ માઈન્ડ
સ્વ-સભાન

'AI' ના ઉપયોગો

'AI' હેલ્થકેર

એગ્રીકલ્ચર

ફાઈનાન્સ માણસોને આપવામાં આવેલ કાર્યો મશીનો દ્વારા ઝડપથી પૂર્ણ કરી શકાય છે

આમાં ભૂલો અને ખામીઓ ઓછી છે.

તેની મદદથી જટિલ સોફ્ટવેર સરળતાથી સમજી શકાય તેવું બનાવી શકાય છે.

આર્ટિફિશિયલ ઈન્ટેલિજન્સ સંસાધન અને સમયનો દુરુપયોગ કરતી નથી પરંતુ ઓછા સમયમાં લક્ષ્ય પ્રાપ્ત કરી શકે છે.

આર્ટિફિશિયલ ઈન્ટેલિજન્સનાં ગેર-ફાયદા

મનુષ્યની ગુણવત્તાને અવગણવામાં આવે છે.

આ તકનીક આવનારી પેઢી માટે ખતરનાક સાબિત થઈ શકે છે. તે નવીન પેઢીને સંપૂર્ણ રીતે ભ્રષ્ટ પણ કરી શકે છે.

આ તકનીકમાં માહિતીનું કોઈ ફિલ્ટરીંગ નથી.

'AI' નો ઉપયોગ વિદ્યાર્થી, શિક્ષક અને શાળાની ગોપનીયતા અને સુરક્ષા માટે જોખમ

ઉત્પન્ન કરી શકે છે. કારણ કે, ડેટા પર વ્યક્તિનું કોઈ નિયંત્રણ નથી. જેમાં તેઓના ડેટા કે ખાનગી માહિતી સંવેદનશીલ પણ હોઈ શકે છે. આ બધી બાબતોનો ઉપયોગ નકારાત્મક રીતે થવાની સંભાવના છે. આર્ટિફિશિયલ ઈન્ટેલિજન્સ ખર્ચાળ છે જે નાના વ્યવસાયોને પરવડે તેમ નથી. આ ટેક્નોલોજી બેરોજગારીને આમંત્રણ આપશે કારણ કે માણસનું કામ મશીન કરશે. આ ટેક્નોલોજીમા સંવેદનશીલતા ન હોવાના કારણે સામાજિક અને કલાત્મક ક્ષેત્રોમાં જે નાવીન્ય અને સહાનુભૂતિ માણસનું મગજ લાવી શકતું હોય છે તે 'AI' કરી શકતું નથી. તેની કાર્યક્ષમતા સમય જતાં ઘટી શકે છે. એના **'હાર્ડવેર'** અને **'સોફ્ટવેર'** ને અપગ્રેડેશન કરતાં રહેવું પડે છે જે ખર્ચાળ છે. જો તે ન થાય તો કામ પર પ્રતિકૂળ અસર પડતી હોય છે.

આમ, 'AI' માં નૈતિક પ્રશ્નો ઊભાં થઈ શકે છે. જે ના થાય તેની માટે 'AI' ને મજબૂત નિયમનકારી માળખું અને નૈતિક માર્ગદર્શિકા પૂરાં પાડવા જોઈએ.

'AI' ની એપ્લિકેશનો નીચે મુજબ છે:

દાખલાઓ ઓળખવામાં

આ તકનીક્ નો ઉપયોગ કૉમ્પુટર વિઝન વર્ચ્યુઅલ રિયાલિટીઈમેઝ પ્રોસેસિંગમા થાય છે.

કૃત્રિમ બુદ્ધિ કે નિદાન

ગેમ 'AI' અને કૉમ્પુટર ગેમ બોટ

ઓપ્ટિકલ કેરેક્ટર રેક્ગ્નિશન

હસ્તક્ષાર ઓળખ

ચહેરા અથવા મુખની ઓળખ.

ઉપસંહાર

આમ, આર્ટિફિશિયલ ઈન્ટેલિજન્સનો સદુપયોગ વરદાન સ્વરૂપ છે જયારે તેનો દુરુપયોગ અભિશાપ સ્વરૂપ બની શકે છે.'AI' ના વિકાસની સાથે સાથે નૈતિક માર્ગદર્શિકાઓ અને નિયમની જરૂરિયાત પણ જરૂરી છે. આ તકનીક્ નો ઉદ્દેશ્ય માનવ ક્ષમતાઓને વિસ્થાપિત કરવાનો નહીં પરંતુ તેને વધારવાનો અને સહાય કરવાનો હોવો જોઈએ. 'AI'માનવજીવનના દરેક ક્ષેત્રને પ્રભાવિત કરી રહી છે અને વિવિધ ક્ષેત્રોમાં નવી શક્યતાઓ ખોલી રહી છે. જેના જવાબદારીભર્યા વિકાસ માટે સરકાર, ઉદ્યોગો અને સમાજે સાથે મડીને કાર્ય કરવું જોઈએ. આમ, 'AI'નો સફ્ડતાપૂર્વકનો ઉપયોગ માનવમૂલ્યો અને નૈતિક સિદ્ધાંતોના સંતુલન પર આધારિત હશે.

સંદર્ભ ગ્રંથ સૂચિ

Artificial Intelligence -10

Author: Professor Ashok Arora

Publication: Viva Education

Year: 2023

Artificial Intelligence

A Textbook of class – X

Author: Sumita Arora

Publisher: Dhanpat Rai And Co.

A Classical Approach to Artificial Intelligence

Author: Munesh Chandra Trivedi

Publisher: Khanna Publishing House

Editon: Second

Year: 2025

AI FOR EVERYONE

Authors: Saptarshi Goswami

Amit Kumar Das

Amlan Chakrabarti

Publisher: Pearson Education India

Edition: First

Year:2024

Complete A.I,

Machine

Learning and

Data Science

Author: Julian Blackwood

Publisher: Martin Chavez

Edition: First

Year: 7 october,2025

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મધુસૂદન પારેખના હાસ્યલેખનોનું AI આધારિત ડિજિટલ વિશ્લેષણ

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પરિચય :

આજના ડિજીટલ યુગમાં કૃત્રિમ બુદ્ધિ (Artificial Intelligence - AI) સાહિત્ય અને ભાષા સંશોધનના ક્ષેત્રમાં મહત્વપૂર્ણ સાધન બની રહી છે. ગુજરાતી હાસ્ય સાહિત્યમાં પણ AI દ્વારા ડિજિટલ વિશ્લેષણ એક નવી દિશા દર્શાવી રહી છે.હાસ્ય, જેમાં સમાજની વિવિધ પરિસ્થિતિઓ પરના જુક અને તીખી ટિપ્પણીઓ હોય છે, તેનું વિશ્લેષણ જટિલ અને રસપ્રદ હોય છે.મધુસૂદન પારેખ, ગુજરાતી હાસ્ય સાહિત્યના પ્રખ્યાત લેખક, તેમના અંકણીઓમાં સમકાલીન સમાજના વિવિધપાસાઓને હાસ્યમય પ્રસ્તુત કરીને વાંચકને મનોરંજન સાથે વિચાર કરવા માટે પ્રેરણા આપતા રહ્યા છે.

આ પેપરમાં, આપણે મધુસૂદન પારેખના હાસ્ય લેખનોનું AI આધારિત ડિજિટલ વિશ્લેષણ કરીને ગુજરાતી હાસ્યના નવા પરિપ્રેક્ષ્યને સમજવા પ્રયાસ કરીશું. આ અભ્યાસથી AI અને ગુજરાતી હાસ્ય સાહિત્ય વચ્ચેના સંબંધો અને AI ના ઉપયોગથી હાસ્ય સાહિત્યના વિશ્લેષણમાં થતી નવી શોધોને ઉજાગર કરવાનો હેતુ છે.

પૃષ્ઠભૂમિ :

ગુજરાતી હાસ્ય સાહિત્યનું એક સમૃદ્ધ ઐતિહાસિક પરંપરા છે, જેમાં સામાજિક, સાંસ્કૃતિક અને રાજકીય વિષયો પર ટીકા અને મજાક દ્વારા ચર્ચા કરવામાં આવે છે .હાસ્ય સાહિત્યમાં લેખકો પોતાના નિબંધો,અંકણીઓ, નાટકો અને વાર્તાઓ દ્વારા સમાજના વિકારોને હળવી અને રસપ્રદ રીતે રજૂ કરે છે. મધુસૂદન પારેખ આપરંપરાના એક મહત્વપૂર્ણ પ્રતિનિધિ હતા, જેમણે તેમના એકાંકીઓમાં સામાન્ય માણસની દૈનિક જીંદગી અને સમાજની વિમર્શાત્મક પરિસ્થિતિઓને હાસ્યમય શૈલીમાં વ્યકત કર્યું. મધુસૂદન પારેખના એકાંકીઓમાં ભાષાનું સરળ અને પ્રભાવશાળી ઉપયોગ જોવા મળે છે, જે હાસ્યને વધુ અસરકારક બનાવે છે. તેમના લખાણોમાં સમયાંતરે સમાજની રાજકીય અને સામાજિક સમસ્યાઓનો ઉલ્લેખ અને હાસ્યમય ટિપ્પણીઓ જોવા મળે છે, જે ગુજરાતી હાસ્ય સાહિત્યને નવી ઊંચાઈઓ પર લઈ ગયા છે.

આ પેપરમાં, મે મધુસૂદન પારેખના કેટલાક પ્રખ્યાત એકાંકીઓ પર ધ્યાન કેન્દ્રિત કરીને , AI આધારિત ડિજિટલ વિશ્લેષણ દ્વારા તેમની હાસ્ય શૈલી અને સામાજિક સંદેશાઓને સમજવાની કોશિશ કરીશું.

સાહિત્યસમીક્ષા :

ગુજરાતી હાસ્ય સાહિત્ય પર થયેલા સંશોધનોમાં મધુસૂદન પારેખને એક પ્રતિષ્ઠિત હાસ્યકાર તરીકે ઓળખવામાં આવે છે, અભ્યાસોમાં હાસ્યના સામાજિક અને ભાષાકીય પાસાઓનું વિગતવાર વિશ્લેષણ કરવામાં આવ્યું છે.તેમનું માનવું છે કે હાસ્ય માત્ર મનોરંજન નથી, પરંતુ તે સમાજના ન્યાય અને વિમર્શ માટે એક મજબૂત સાધન છે.આધુનિક યુગમાં, AI અને નેચરલ લેંગ્વેજ પ્રોસેસિંગ (NLP) દ્વારા ભાષા અને સાહિત્યના વિશ્લેષણને નવી દિશા મળી છે. ટેકનિક્સ ખાસ કરીને મોટા

ડેટાસેટમાંથી ઢાંચાગત માહિતી અને ભાવનાત્મક તત્વોને ઓળખવામાં મદદરૂપ થાય છે. પરંતુ, ગુજરાતી હાસ્ય સાહિત્યમાં AI આધારિત વિશ્લેષણ હજી અપ્રચલિત છે અને આ ક્ષેત્રમાં સંશોધનની જરૂરિયાત છે.

આ સંદર્ભમાં, મધુસૂદન પારેખના હાસ્ય લેખનોનું AI આધારિત ડિજિટલ વિશ્લેષણ ગુજરાતી હાસ્ય સાહિત્યમાં એક નવીન અભ્યાસ દિશા પ્રદાન કરે છે.

AI અને ડિજિટલ વિશ્લેષણ :

કૃત્રિમ બુદ્ધિ (Artificial Intelligence) એ તાજેતરના વર્ષોમાં ભાષા અને સાહિત્યના વિશ્લેષણ માટે એક શક્તિશાળી સાધન તરીકે ઉભરી છે.ખાસ કરીને નેચરલ લેંગ્વેજ પ્રોસેસિંગ અને મશીન લર્નિંગ ટેકનિક્સ દ્વારા મોટા પ્રમાણમાં લખાણના ડેટાનું વિશ્લેષણ કરી શકાય છે. આ ટેકનોલોજી હાસ્ય સાહિત્યના સંદર્ભમાં પણ ઉપયોગી સાબિત થઈ રહી છે, જ્યાં ભાષાના સંદર્ભ, ઉદ્દેશ્ય અને ભાવનાત્મક સ્તરોનું વિશ્લેષણ જરૂરી હોય છે.

ડિજિટલ વિશ્લેષણ માટે ક્સ્ટમાઈનિંગ, સેન્ટિમેન્ટ એનાલિસિસ, અને વિષયવાર વર્ગીકરણ જેવી પદ્ધતિઓનો ઉપયોગ થાય છે. આ પદ્ધતિઓથી હાસ્યલેખનોમાં છુપાયેલા સામાજિક સંદેશાઓ અને ભાષાકીય વિશેષતાઓને ઊંડાણ પૂર્વક સમજવા મદદ મળે છે.

આઅભ્યાસમાં, મધુસૂદન પારેખના એકાંકીઓના ડિજિટલ ટેક્સ્ટ ડેટા પર AI આધારિત વિશ્લેષણ કરવામાં આવશે, જેમાં કી-વર્ડ્સ, ભાષાકીય નમૂનાઓ અને હાસ્યના તત્વોનું નિરીક્ષણ શામેલ રહેશે. આથી, ગુજરાતી હાસ્ય સાહિત્યમાં AI ના ઉપયોગની નવી સંભાવનાઓ અને પડકારો પર પ્રકાશ પાડવામાં આવશે.

મધુસૂદન પારેખના અંકણીઓનું વિગતવાર વિશ્લેષણ :

આ અભ્યાસમાં, મધુસૂદન પારેખના હાસ્ય લેખોનું AI આધારિત ડિજિટલ વિશ્લેષણ વિશ્લેષક રુપે અમલ કરવામાં આવ્યું છે. વિશ્લેષણમાં પારેખની વિવિધ એકાંકીઓમાંથી ટેક્સ્ટ ડેટા એકત્રિત કરી તેને નેચરલ લેંગ્વેજ પ્રોસેસિંગ અને મશીન લર્નિંગ ટેકનિક્સ દ્વારા સમજવાનો પ્રયાસ કરવામાં આવ્યો. મુખ્યરૂપે કી-વર્ડ એનાલિસિસ, સેન્ટિમેન્ટ એનાલિસિસ, અને ભાષાકીય માળખાનું મૂલ્યાંકન કરવામાં આવ્યું.

પ્રથમ, કી-વર્ડ એનાલિસિસ દ્વારા પારેખની એકાંકીઓમાં વારંવાર આવતા શબ્દો અને વાક્ય રચનાઓનું નિરીક્ષણ થયું.આથી સ્પષ્ટ થયું કે તે સમાજના વિવિધ મેદાનોમાં થતી ઘટનાઓ, જેવી કે રાજકારણ , સામાજિક અસમાનતા, અને માનવીય વ્યવહાર પર વિશેષ ધ્યાન કેન્દ્રિત કરે છે. તેમના હાસ્યમાં સામાન્ય લોકોની દૈનિક જિંદગી અને તેમના સંઘર્ષને ખાસ સ્થાન મળ્યું છે. આ કી-વર્ડ
એનાલિસિસથી મળેલ માહિતી પરથી પારેખની ભાષા સરળ હોવા છતાં અસરકારક અને તીખી ટિપ્પણીઓ માટે તૈયાર છે તે નોંધાઈ.

બીજુ સેન્ટિમેન્ટ એનાલિસિસ દ્વારા મધુસૂદન પારેખના લેખનમાં હાસ્યનું ભાવનાત્મક સ્તર અને તેના વિવિધરૂપોની ઓળખ થઈ.વિશ્લેષણમાં જોવા મળ્યું કે પારેખનું હાસ્ય માત્ર મજાક પૂરતું ન રહી, પણ તેમાં વ્યંગ્ય અને વિમર્શાત્મક તત્વો પણ

ઊંડાણથી વણાયેલા છે .AI દ્વારા આ તત્વોની ઓળખ કરવામાં આવી અને તે હાસ્યને માત્ર મનોરંજનથી આગળ લઈ જઈને સામાજિક સંદેશા આપતું સાધન તરીકે વ્યક્ત કરે છે.

ત્રીજુ ભાષાકીય માળખાનું વિશ્લેષણ પણ AI મોડેલ દ્વારા થયું, જેમાં વાક્યરચના, શબ્દચયન અને ભાષાકીય શૈલીઓની તુલના પારંપરિક ગુજરાતી હાસ્ય સાહિત્ય સાથે કરવામાં આવી. આ વિશ્લેષણમાં મધુસૂદન પારેખની ભાષા પ્રવાહી, સ્પષ્ટ અને સહજ હોવા છતાં, તે હાસ્ય માટે પૂરતું તીખું અને તદ્દન અનોખુંછે તે જણાયું.આ ડિજિટલ વિશ્લેષણથી સ્પષ્ટ થયું કે, મધુસૂદન પારેખના એકાંકીઓમાં હાસ્ય સાહિત્યના પરંપરાગત તત્વો સાથે સાથે આધુનિક સામાજિક અને સાંસ્કૃતિક મુદ્દાઓનો પણ સંકલન છે. AI આધારિત વિશ્લેષણ પદ્ધતિએ આ એકાંકીઓના વિવિધ પાસાઓને એક નવી અને ઊંડા દૃષ્ટિકોણથી સમજવાની તક આપી છે, જે માનવ વિશ્લેષણ કરતાં વધુ વિગતવાર અને તટસ્થ બની શકે છે.આ રીતે, મદુસુદન પારેખના હાસ્ય લેખનનું ડિજિટલ વિશ્લેષણ ગુજરાતી હાસ્ય સાહિત્યમાં AI ના સંભવિત ઉપયોગો અને તેમના ફાયદાઓને પ્રકાશમાં લાવતું એક મજબૂત ઉદાહરણ બની શકે છે.

ચર્ચા :

આ અભ્યાસમાં કરવામાં આવેલ AI આધારિત ડિજિટલ વિશ્લેષણથી સ્પષ્ટ થાય છે કે કૃત્રિમ બુદ્ધિ હાસ્ય સાહિત્યના વિશ્લેષણમાં એક શક્તિશાળી અને નવીન સાધન તરીકે ઉપયોગી સાબિત થઈ શકે છે. મધુસૂદન પારેખના એકાંકીઓમાં જોવા મળેલ વિવિધ હાસ્ય તત્વો, જેમ કે વ્યંગ્ય, વિમર્શ, અને સામાજિક ટિપ્પણીઓ, AI દ્વારા વધુ વિસ્તૃત અને તટસ્થ રીતે ઓળખાઈ શક્યા. પરંતુ, AI આધારિત વિશ્લેષણમાં કેટલીક મર્યાદાઓ પણ જોવા મળી.હાસ્યમાં લાગણીઓ, સંદર્ભ અને સંસ્કૃતિના નાજુક પાસાઓને સંપૂર્ણ રીતે સમજવીએ AI માટે મુશ્કેલ કાર્ય છે. ખાસ કરીને ભાષાના વિવિધ સ્તરો અને હાસ્યના અવિરત સંદર્ભોને સમજવામાં માનવીય સમજ ગહન અને વ્યાપક હોય છે, જે હજુ પણ AI માટે એક પડકાર છે.આ ઉપરાંત, ગુજરાતી ભાષાના પ્રાકૃતિક અને સાંસ્કૃતિક વિશેષતાઓને AI મોડેલો સંપૂર્ણ રીતે સમજી શકતા નથી.તેથી, AI આધારિત વિશ્લેષણને વધુ અસરકારક બનાવવા માટે ભાષા અને સાહિત્યના નિષ્ણાતો સાથે સહયોગ આવશ્યક છે.

આ અભ્યાસ દર્શાવે છે કે ગુજરાતી હાસ્ય સાહિત્યમાં AI નો ઉપયોગ સંશોધનના ક્ષેત્રમાં નવો દિશા સૂચક બની શકે છે, પણ તેને પૂર્ણ પણે સક્ષમ બનાવવા માટે ટેકનિકલ અને સંસ્કૃતિક બંને સ્તરે વધુ મજબૂત વિકાસની જરૂર છે.

નિષ્કર્ષ :

આ પેપરમાં, મધુસૂદન પારેખના હાસ્યલેખનોનું AI આધારિત ડિજિટલ વિશ્લેષણ કરીને ગુજરાતી હાસ્ય સાહિત્યની એક નવી દિશા શોધવાનો પ્રયાસ કરવામાં આવ્યો. વિશ્લેષણથી સ્પષ્ટ થયું કે AI ટેકનોલોજી હાસ્ય લેખનના ભાષાકીય અને સામાજિક તત્વોને વધુ ગહન રીતે સમજવામાં મદદરૂપ થઈ શકે છે.સાથે જ, આ અભ્યાસે બતાવ્યું કે હાસ્યમાં લાગણીઓ અને સંસ્કૃતિક સંદર્ભોની જટિલતા AI માટે પડકાર રૂપ છે, જેના કારણે માનવ નિષ્ણાતોની ભૂમિકા મહત્વપૂર્ણ રહે છે. ભવિષ્યમાં , AI અને માનવીય સમજણ વચ્ચેના સંયોજનથી ગુજરાતી હાસ્ય સાહિત્યના સંશોધનમાં વધુ પ્રગતિ શક્ય છે.

આ રીતે, AI અને ગુજરાતી હાસ્ય સાહિત્ય વચ્ચેનો સંવાદ નવી સંશોધન દિશાઓ ખોલશે અને સાહિત્યના વિશ્લેષણ માટે નવી ટેકનિક્સને પ્રોત્સાહન આપશે.

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EMRS સ્કૂલ લાઈબ્રેરી: શૈક્ષણિક વિકાસમાં ભૂમિકા અને સુવિધાઓ

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એબ્સ્ટ્રેક્ટ (Abstract)

શૈક્ષણિક સંસ્થાઓના ક્ષેત્રમાં, પુસ્તકાલય મૂળભૂત સંસાધન કેન્દ્ર તરીકે સેવા આપે છે જે વિદ્યાર્થીઓની બૌદ્ધિક અને શૈક્ષણિક પ્રગતિમાં નોંધપાત્ર ફાળો આપે છે. એકલવ્ય મોડેલ રેસિડેન્શિયલ સ્કૂલો (ઈએમઆરએસ) ની અંદર પુસ્તકાલય સેવાઓ અને સુવિધાઓની જોગવાઈ ખાસ કરીને આદિવાસી અને અન્ય માર્જિનલ વિદ્યાર્થી વસ્તી માટે મહત્વપૂર્ણ છે. આ સંશોધન નિબંધ ઈએમઆરએસ શાળાઓમાં ઉપલબ્ધ પુસ્તકાલય સેવાઓ, તેમની સાથેની સુવિધાઓ અને વિદ્યાર્થીઓ માટે પરિણામી શૈક્ષણિક પરિણામોની વિસ્તૃત પરીક્ષા પ્રદાન કરે છે. સમકાલીન સંદર્ભોમાં, ડિજિટલ સંસાધનો, માહિતી સાક્ષરતાની પહેલ અને તકનીકી પ્રગતિનું એકીકરણ પુસ્તકાલયોની અસરકારકતા અને અસરકારકતામાં વધારો કરી રહ્યું છે. આ તપાસમાં પુસ્તકાલય સંસાધનો, માહિતી સાક્ષરતા, ડિજિટલ સેવાઓ અને વાંચનની સંસ્કૃતિની તપાસ કરવામાં આવી. સંશોધનના તારણો સૂચવે છે કે સારી રીતે માળખાગત પુસ્તકાલય સુવિધાઓ અને સક્રિય સેવાઓ વિદ્યાર્થીઓની સંશોધન ક્ષમતાઓ, વાંચન પદ્ધતિઓ અને એકંદર શૈક્ષણિક સિદ્ધિને નોંધપાત્ર રીતે વધારે છે. તદુપરાંત, આ નિબંધ ઈએમઆરએસ શાળાઓમાં પુસ્તકાલય સેવાઓના જથ્થા અને ગુણવત્તા બંનેને વધારવા માટે વ્યવહારિક ભલામણો રજૂ કરે છે, જેનાથી વિદ્યાર્થીઓના શૈક્ષણિક અધિકારોની સુરક્ષા કરવામાં આવે છે.

KEYWORDS: EMRS SCHOOLS, SCHOOL LIBRARY SERVICES, EDUCATIONAL DEVELOPMENT, TRIBAL EDUCATION, લાઈબ્રેરી સુવિધાઓ, માહિતી સાક્ષરતા

૧. પરિચય

ભારત સરકાર દ્વારા ઈએમઆરએસ શાળાઓની સ્થાપનાનો હેતુ દેશભરમાં આદિવાસી અને આર્થિક રીતે અછતગ્રસ્ત વિદ્યાર્થીઓને ઉચ્ચ ગુણવત્તાવાળા રહેણાંક શિક્ષણ પૂરું પાડવાનો છે. એકલવ્ય મોડેલ રેસિડેન્શિયલ સ્કૂલ્સ (EMRS) યોજના 1997–98માં શરૂ કરવામાં આવી હતી. ગુજરાત રાજ્યમાં 2026 સુધી કુલ 47 EMRS શાળાઓ મંજૂર થયેલ છે અને 44 કાર્યરત છે

આ શૈક્ષણિક સંસ્થાઓની અંદર પુસ્તકાલય સેવાઓ વિદ્યાર્થીઓના વ્યાપક શૈક્ષણિક અને વ્યક્તિગત વિકાસને પ્રોત્સાહન આપવા માટે મહત્વપૂર્ણ ભૂમિકા ભજવે છે. સમકાલીન સમાજમાં, શૈક્ષણિક સંસ્થાઓમાં પુસ્તકાલયો ફક્ત પુસ્તકોના ભંડાર તરીકે જ નહીં, પરંતુ મહત્વપૂર્ણ શૈક્ષણિક સંસાધન કેન્દ્રો તરીકે કાર્ય કરે છે. પુસ્તકાલય સેવાઓ વિદ્યાર્થીઓને માહિતીને ઉજાગર કરવાની, પુરાવા આધારિત પૂછપરછ કુશળતા વધારવા અને આજીવન શિક્ષણની સંસ્કૃતિ કેળવવાની મૂલ્યવાન તક આપે

છે. આ સંશોધન નિબંધ ઈએમઆરએસ શાળાઓમાં ઉપલબ્ધ લાઈબ્રેરી સેવાઓ અને તેમના પરિણામી શૈક્ષણિક પરિણામોનું વ્યાપક વિશ્લેષણ પ્રદાન કરે છે.

સાહિત્ય સમીક્ષા (Literature Review)

શાળા લાઈબ્રેરીના શૈક્ષણિક વિકાસમાં ભૂમિકાશાળા લાઈબ્રેરીઓ આધુનિક શિક્ષણ પ્રણાલીમાં અગ્રણી ભૂમિકા ભજવે છે. એક અધ્યયનમાં નોધવામાં આવ્યું છે કે લાઈબ્રેરીનો ઉપયોગ કરતા વિદ્યાર્થીઓ વધુ સારી શૈક્ષણિક પ્રવૃત્તિ પ્રદર્શિત કરે છે (Otubelu et al., 2026). વાસ્તવમાં, હાલના સંશોધનમાં જાણવા મળ્યું છે કે જ્યાં લાઈબ્રેરી સેવાઓ સમ્પૂર્ણ અને સુવ્યવસ્થિત છે, ત્યાં શીખવાનો માર્જ બીજા બધા પરિબળો કરતાં વધુ ઊર્જાવાન હોય છે (Guterres et al., 2024).

લાઈબ્રેરી સુવિધાઓ અને શૈક્ષણિક પરિણામોશાળાના ભૌતિક અને ડિજિટલ ઘટકો, જેમાં આધુનિક સંસાધનો, પર્યાપ્ત સ્થાન અને તકનીક સમાવિષ્ટ હોય, તે શિક્ષણમાં નોલખીય ફેરફાર લાવે છે (Mom et al., 2025). વિશ્લેષણે નિર્દેશન કર્યું છે કે સારી તૈયાર લાઈબ્રેરી સુવિધાવાળી શાળાઓમાં વાંચન અભ્યાસ વધુ હોય છે (Ali et al., 2023). બીજી તરફ, અપૂર્ણ સુવિધાવાળી લાઈબ્રેરીઓ તો વિદ્યાર્થીઓને નુકસાન પહોંચાડે છે (Ahmed et al., 2024).

લાઈબ્રેરી સંચાલન અને નેતૃત્ત્વશાળા લાઈબ્રેરીના સફળ પરિચાલનમાં પેશાદાર લાઈબ્રેરિયનો અથવા તાલીમ પ્રાપ્ત કર્મચારીઓની નિર્ણાયક ભૂમિકા છે (Darling-Hammond, 2000).

આધુનિક લાઈબ્રેરી વ્યવસ્થાપન પણ પ્રણાલીશીલતા, પણ્યતાર અને સહયોગી પ્રણાલીઓ સમાવે છે (Costa, 2025). ગુણવત્તાશીલ લાઈબ્રેરી મેનેજમેન્ટ સિસ્ટમ્ સ્કૂલ, શીક્ષક અને સમુદાય તમામને એક સાથે લાવે છે.

ડિજિટલ રૂપાંતર અને ટેકનોલોજી ઈન્ટિગ્રેશનસમકાલીન શાળા લાઈબ્રેરીઓમાં ડીજીટલીકરણ અપરિહાર્ય બની ગયું છે (Lampaza et al., 2025). (Gunawan et al., 2024). ડીજીટલ લાઈબ્રેરી યુગમાં, માહિતી પ્રવેશ અને સેવા વહિવટ પણ બુદ્ધિમાન અને શક્તિશાળી બની જાય છે (Yuniarti et al., 2026).

ભવિષ્યતના સંશોધનોની દિશાહાલમાં, એ સ્પષ્ટ છે કે કૃત્રિમ બુદ્ધિમત્તા (AI), ઈ-લર્નિંગ પ્લેટફોર્મ્સ, અને વર્ચુઅલ લર્નિંગ વાતાવરણો શાળા લાઈબ્રેરીના ભવિષ્યતમાં વધુ મહત્તવપૂર્ણ ભૂમિકા ભજવશે (Larisu, 2025). આધુનિક લાઈબ્રેરીઓને આ તમામ નવી પ્રણાલીઓને સમર્થન આપવી જોઈએ અને વિદ્યાર્થીઓને બીજીબીજ માધ્યમો વાપર કરવાની તાલીમ આપવી જોઈએ.

૨. લાઈબ્રેરી સેવાઓ અને તેમનું વર્ગીકરણ

ઈએમઆરએસ શૈક્ષણિક સંસ્થાઓમાં આપવામાં આવતી પુસ્તકાલય સેવાઓ વૈવિધ્યસભર અને વ્યાપક છે, જે વિદ્યાર્થી વસ્તીની બહુમુખી શૈક્ષણિક આવશ્યકતાઓને પૂર્ણ કરે છે. પુસ્તકોની આસપાસ કેન્દ્રિત સેવાઓ પુસ્તક પરિચય, ધીમે ધીમે ઉધાર વિકલ્પો, સંદર્ભ સહાય અને આંતર-પુસ્તકાલય ધિરાણ પદ્ધતિઓની જોગવાઈનો સમાવેશ કરે છે. માહિતી સાક્ષરતાની પહેલ વિદ્યાર્થીઓને ઉચ્ચ ગુણવત્તાની માહિતીને શોધવા, વિવેચનાત્મક રીતે મૂલ્યાંકન કરવા અને તેને અસરકારક રીતે લાગુ કરવા માટે જરૂરી કુશળતા સાથે સજ્જ કરવા માટે રચાયેલ છે. ડિજિટલ ઓફરિંગમાં ઈ-પુસ્તકો, ઓનલાઈન ડેટાબેસેસ અને ડિજિટલ સંગ્રહનો સમાવેશ થાય છે જે વિદ્યાર્થીઓને ચોવીસ કલાક માહિતી સંસાધનોની અવિરત ઍક્સેસ પ્રદાન કરે છે. સાહિત્ય ક્લબો, વર્તમાન પુસ્તક ચર્ચાઓ અને વાંચન હિમાયત કાર્યક્રમો વાંચનની ટેવોની ખેતી અને સાહિત્યની આસપાસ કેન્દ્રિત સંસ્કૃતિના મજબૂતીકરણમાં ફાળો આપે છે.

3. લાઈબ્રેરી સુવિધાઓ અને ભૌતિક સંસાધનો

ઈએમઆરએસ શૈક્ષણિક સંસ્થાઓમાં લાઈબ્રેરી સુવિધાઓ આરામદાયક અને વૈવિધ્યસભર વાંચન જગ્યાઓ, અત્યાધુનિક કમ્પ્યુટર સુવિધાઓ અને વિશ્વસનીય ઈન્ટરનેટ કનેક્ટિવિટીને પુસ્તક સંગ્રહમાં પાઠ્યપુસ્તકો, સંદર્ભ સામગ્રી, વૈજ્ઞાનિક બ્રોશર્સ અને શૈક્ષણિક ફિલ્મોનો સમાવેશ થાય છે, જે બધા શીખવા માટે બહુ-વિષયક અભિગમને ટેકો આપે છે. ઑડિઓ-વિઝ્યુઅલ સ્રોતો અને ઈન્ટરેક્ટિવ શૈક્ષણિક સાધનો વિદ્યાર્થીઓ માટે વિવિધ શીખવાના અનુભવોના સ્પેક્ટ્રમને સરળ બનાવે છે. અદ્યતન લાઈબ્રેરી સ્ટોરેજ સિસ્ટમ્સ જેવા સમકાલીન ડિજિટલ સંસાધનો, લાઈબ્રેરી કામગીરીની કાર્યક્ષમતામાં વધારો કરે છે અને વૈજ્ઞાનિક સામગ્રીના વ્યવસ્થિત સંગઠનને પ્રોત્સાહન આપે છે

4. માહિતી સાક્ષરતા અને સંશોધન કુશળતા

વિપુલ પ્રમાણમાં ડિજિટલ સંસાધનો અને માહિતી દ્વારા વર્ગીકૃત થયેલા સમકાલીન યુગમાં માહિતી સાક્ષરતા શીખનારાઓ માટે એક મૂળભૂત ક્ષમતાની રચના કરે ઈએમઆરએસ માળખાની અંદરની શૈક્ષણિક સંસ્થાઓ વિદ્યાર્થીઓને માહિતીને અર્થપૂર્ણ રીતે સ્થિત કરવાની ક્ષમતાથી સજ્જ કરે છે, તેનું વિવેચનાત્મક રીતે વિશ્લેષણ કરે છે, તેની માન્યતાનું મૂલ્યાંકન કરે છે અને રેટરિકલ સંદર્ભોમાં તેને અસરકારક રીતે લાગુ કરે છે. સંશોધન પધ્ધતિઓમાં સૂચના, ડેટાબેઝ શોધખોળ માટેની તકનીકો અને માહિતીનું મૂલ્યાંકન કરવા માટેની કુશળતા અમારા વિદ્યાર્થીઓને વ્યાપક સર્વેક્ષણ કરવા માટે મજબૂત માળખું આપે છે. આ ક્ષમતાઓ શીખનારાઓ માટે ફક્ત શૈક્ષણિક સેટિંગ્સમાં નહીં પરંતુ તેમના સંભવિત વ્યાવસાયિક પ્રયાસો અને કારકિર્દીના માર્ગમાં પણ ફાયદાકારક છે.

5. ડિજિટલ સંસાધનો અને તકનીકી એકીકરણ

શૈક્ષણિક મેનેજમેન્ટ એન્ડ રિસર્ચ સિસ્ટમ્સ (ઈએમઆરએસ) ની અંદર સમકાલીન પુસ્તકાલયો તકનીકી પ્રગતિ સાથે સંરેખિત કરીને તેમની સેવા વિતરણમાં વધારો કરી રહી છે. ઈલેક્ટ્રોનિક પુસ્તકાલયો અને ડિજિટલ ડેટાબેસેસ શીખનારાઓને વૈશ્વિક જ્ઞાન ભંડારોની વ્યાપક એરેની ઍક્સેસ દૂરસ્થ મોબાઈલ લાઈબ્રેરી એપ્લિકેશન્સ અને ડિજિટલ કેટલોગ સહિત સુસંસ્કૃત લાઈબ્રેરી મેનેજમેન્ટ સિસ્ટમ્સ, સ્ટોરેજ વહીવટ અને વપરાશ મોનિટરિંગને ઓપ્ વર્ચ્યુઅલ સંદર્ભ સેવાઓ અને ઓનલાઈન સંશોધન આધાર વિદ્યાર્થીઓને ટેમ્પોરલ અવરોધો અને અવકાશી મર્યાદાઓથી મુક્ત કરે છે સુવ્યવસ્થિત ઈ-લર્નિંગ પ્લેટફોર્મ અને વર્ચ્યુઅલ વર્ગખંડનું એકીકરણ પુસ્તકાલયને શૈક્ષણિક અનુભવનો આવશ્યક ઘટક બનાવે છે.

6. શીખવાના પરિણામો અને શૈક્ષણિક સિદ્ધિ

લાઈબ્રેરી સેવાઓ ઈએમઆરએસ શાળાઓમાં વિદ્યાર્થીઓના શૈક્ષણિક પ્રદર્શન પર નોંધપાત્ર અને નોંધપાત્ર પ્રભાવ પાડે છે, જેનાથી એકંદર શિક્ષણ પરિણામોને અસર થાય છે. સર્વેક્ષણ આધારિત તપાસમાંથી મેળવેલા પ્રયોગમૂલક પુરાવા સૂચવે છે કે જે વિદ્યાર્થીઓ સક્રિય પુસ્તકાલય સેવાઓ અને સારી રીતે સજ્જ સુવિધાઓ સાથે જોડાય છે તે વાંચવામાં ચઢિયાતી નિપુણતા દર્શાવે છે અને સંશોધન પધ્ધતિઓમાં ઉન્નત ક્ષમતાઓ દર્શાવે તદુપરાંત, લોજિકલ તર્ક, નિર્ણાયક વિશ્લેષણ અને સમસ્યા ઉકેલવાની કુશળતાનો વિકાસ પુસ્તકાલય કેન્દ્રિત શૈક્ષણિક અનુભવો સાથે સંકળાયેલા મુખ્ય પરિણામોનું પ્રતિનિધિત્વ કરે છે. વધુમાં, લાઈબ્રેરી સેવાઓ વિદ્યાર્થીઓની સ્વ-અસરકારકતા, શૈક્ષણિક આકાંક્ષાઓ અને સંભવિત કારકિર્દીની મહત્વાકાંક્ષાઓમાં નોંધપાત્ર વૃદ્ધિ

7. પડકારો અને મર્યાદાઓ

ઈએમઆરએસ શાળાઓમાં લાઈબ્રેરી સેવાઓ અસંખ્ય પડકારોનો સામનો કરે નાણાકીય સંસાધનોની મર્યાદાથી ડેટા સંગ્રહ અને તકનીકી અપગ્રેડના ઉન્નતીકરણમાં અવરોધો ઊભા થાય છે. શહેરી વિસ્તારોમાં આધુનિક ટેકનોલોજીકલ

સુવિધાઓથી સજ્જ પુસ્તકાલયો ગ્રામીણ ઈએમઆરએસ શાળાઓમાં ઉપલબ્ધ નથી, જેના પરિણામે ડિજિટલ વિભાજનમાં વધારો થયો છે. લાઈબ્રેરી સ્ટાફની અછત છે અને તેમને આધુનિક તકનીકો અને સેવાઓમાં તાલીમ આપવામાં પડકારો છે. શિક્ષકો અને ગ્રંથપાલયો વચ્ચે સહયોગ અને વાંચન સાક્ષરતા વધારવાના પ્રયાસો પણ કેટલીક ઈએમઆરએસ શાળાઓમાં નબળા છે.

8. ભલામણો અને ભાવિ દિશાઓ

ઈએમઆરએસ શાળાઓમાં પુસ્તકાલય સેવાઓને વધારવા અને વ્યાપક બનાવવા માટેની દરખાસ્તો નીચે પ્રમાણે છે: (1) ઈલેક્ટ્રોનિક સંસાધનોની વધુ નોંધપાત્ર ફાળવણી સાથે પુસ્તક સંગ્રહમાં સતત વધારો; (2) પુસ્તકાલય કર્મચારીઓ માટે નિયમિત વ્યાવસાયિક વિકાસ પહેલોની ડિઝાઈન અને અમલીકરણ; (3) શૈક્ષણિક અભ્યાસક્રમમાં માહિતી સાક્ષરતા કાર્યક્રમોનું એકીકરણ; (4) શિક્ષકો અને પુસ્તકાલયો વચ્ચે સહયોગી પહેલને મજબૂત બનાવવું; (5) ડિજિટલ અને બુદ્ધિધશાળી સ્થાપના પુસ્તકાલય ઈન્ફ્રાસ્ટ્રક્ચર; અને (6) પુસ્તક ચર્ચાઓ, સાહિત્ય ક્લબોની સુવિધા, અને વાંચનની પહેલ સહિત સશક્ત પુસ્તકાલય પ્રવૃત્તિઓના પ્રોત્સાહન.

9. નિષ્કર્ષ

ઈએમઆરએસ (એકલવ્ય મોડેલ રેસિડેન્શિયલ સ્કૂલ્સ) ની અંદર સ્થિત પુસ્તકાલયો વંચિત વિદ્યાર્થીઓ, ખાસ કરીને સ્વદેશી અને સીમાંચિત સમુદાયો સાથે સંકળાયેલા વિદ્યાર્થીઓની શૈક્ષણિક ઉન્નતિ અને જ્ઞાનાત્મક ઉન્નતિ માટે આવશ્યક સંસાધન બનાવે છે. પર્યાપ્ત સેવાઓ, ઈન્ફ્રાસ્ટ્રક્ચરલ સંસાધનો અને તકનીકી સહાય પ્રદાન કરીને, આ પુસ્તકાલયો વંચિત શીખનારાઓને તેમની શૈક્ષણિક આકાંક્ષાઓને સાકાર કરવા અને તેમના વાયદા માટે વધુ આશાસ્પદ માર્ગની રચના કરવા માટે સશક્ત બનાવી શકે છે. વાંચન નિપુણતાને પ્રોત્સાહન આપવા, માહિતી-સાક્ષર નાગરિકોને કેળવવા અને શૈક્ષણિક સમાનતાને પ્રોત્સાહન આપવા લાઈબ્રેરીનું કાર્ય સુવિધાજનક અને નિર્ણાયક બંને છે. પરિણામે, ઈએમઆરએસ સંસ્થાઓમાં લાઈબ્રેરી સેવાઓની વધતી ફાળવણી, તકનીકી નવીનતાઓ અને સક્રિય સંસાધન વ્યવસ્થાપન સાથે, ભારતીય શૈક્ષણિક માળખામાં સમાનતા, શ્રેષ્ઠતા અને સર્વગ્રાહી બાળ વિકાસ ઉત્પન્ન કરવાનો પ્રયત્ન કરે છે.

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ડિજિટલ સંસ્કૃતિ અને સાંસ્કૃતિક વિલંબના

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સારાંશ (Abstract):-

પ્રસ્તુત શોધપત્રમાં વિલિયમ ઓગબર્નના 'સાંસ્કૃતિક વિલંબના' (Cultural Lag) ના સિદ્ધાંતને આધુનિક સાયબર યુગના સંદર્ભમાં તપાસવાનો એક નમ્ર પ્રયાસ છે. જે સમાજશાસ્ત્રીય દ્રષ્ટિકોણથી જોતા, સંસ્કૃતિના બે પ્રકાર છે,1_ભૌતિક (ટેક્નોલોજી, સાધનો) અને 2_અભૌતિક (વિચારો, મૂલ્યો, પરંપરાઓ). વર્તમાન સમયમાં સાયબર ટેક્નોલોજી, સ્માર્ટફોન અને ઈન્ટરનેટ જેવી 'ભૌતિક સંસ્કૃતિ' અત્યંત ઝડપથી આગળ વધી રહી છે, પરંતુ તેની સામે આપણી નૈતિકતા, સામાજિક શિષ્ટાચાર અને કાયદાકીય સમજ જેવી 'અભૌતિક સંસ્કૃતિ' પછાત રહી ગઈ છે. આ બે પાસાંઓ વચ્ચે સર્જાયેલું અંતર જ સાયબર અપરાધ, ડિજિટલ હિંસા અને નૈતિક પતનનું મુખ્ય કારણ બને છે

અહીં વિશ્લેષણ કરવામાં આવ્યું છે કે કેવી રીતે સમાજ પાસે આધુનિક ગેજેટ્સ તો આવી ગયા છે, પરંતુ તેનો સુરક્ષિત અને નૈતિક ઉપયોગ કરવા માટેના સામાજિક મૂલ્યો હજુ વિકસ્યા નથી. ઉદાહરણ તરીકે, સોશિયલ મીડિયાનો ઉપયોગ આપણે કરીએ છીએ પણ 'સાયબર એથિક્સ' (નૈતિકતા) બાબતે આપણે હજુ અજાણ છીએ. અહીં અંતે, આ સાંસ્કૃતિક વિલંબનાને દૂર કરવા માટે ટેક્નોલોજીની સાથે-સાથે સામાજિક જાગૃતિ અને નૈતિક શિક્ષણની અનિવાર્યતા પર ભાર મૂકવામાં આવ્યો છે.

ચાવીરૂપ શબ્દો: સાંસ્કૃતિક વિલંબના (Cultural Lag), ભૌતિક અને અભૌતિક સંસ્કૃતિ, સાયબર યુગ, ડિજિટલ નૈતિકતા (Cyber Ethics), સામાજિક મૂલ્યો, સાયબર અપરાધ.

પ્રસ્તાવના:-

૨૧મી સદી એ માહિતી અને ટેક્નોલોજીની સદી છે. માનવ ઈતિહાસમાં ક્યારેય ન આવ્યો હોય એટલો ઝડપી પરિવર્તનનો વેગ સાયબર સ્પેસે આપ્યો છે. સમાજશાસ્ત્રીય દ્રષ્ટિકોણથી જ્યારે આપણે આ પરિવર્તનને જોઈએ છીએ ત્યારે વિલિયમ એફ. ઓગબર્નનો 'સાંસ્કૃતિક વિલંબના' (Cultural Lag) નો સિદ્ધાંત અત્યંત પ્રસ્તુત જણાય છે. ઓગબર્નના મતે, સંસ્કૃતિના બે પાસાં છેઃ ભૌતિક અને અભૌતિક. જ્યારે ભૌતિક સંસ્કૃતિ (ટેક્નોલોજી, સાધનો, ગેજેટ્સ) ખૂબ જ ઝડપથી પ્રગતિ કરે છે, પરંતુ તેની સાપેક્ષમાં અભૌતિક સંસ્કૃતિ (નૈતિકતા, સામાજિક મૂલ્યો, વિશ્વાસ, કાયદા અને વર્તન) પાછળ રહી જાય છે, ત્યારે સમાજમાં એક પ્રકારનું અસંતુલન પેદા થાય છે. આ અસંતુલનને જ 'સાંસ્કૃતિક વિલંબના' કહેવામાં આવે છે

વર્તમાન સાયબર યુગમાં આપણી પાસે 5G ટેક્નોલોજી અને આર્ટિફિશિયલ ઈન્ટેલિજન્સ (AI) જેવા અત્યાધુનિક સાધનો તો ઉપલબ્ધ છે, પરંતુ તેનો ઉપયોગ કરવા માટે જે સામાજિક પરિપક્વતા અને ડિજિટલ નૈતિકતા હોવી જોઈએ, તેનો સમાજમાં અભાવ વર્તાય છે. સાયબર બુલિંગ, ઓનલાઈન છેતરપિંડી અને પ્રાઈવસીનું હનન એ આ જ વિલંબનાનું પરિણામ છે. પ્રસ્તુત અહીં શોધપત્રમાં ટેક્નોલોજીની આ આંધળી દોટ અને તેની સામે હાંફતા માનવીય મૂલ્યો વચ્ચેના સંઘર્ષનો વિગતે અભ્યાસ કરવામાં આવ્યો છે.

સંશોધન લેખન ના હેતુઓ

ભૌતિક અને અભૌતિક સંસ્કૃતિ વચ્ચેનો તફાવત

સાયબર સ્પેસમાં સાંસ્કૃતિક વિલંબના: વ્યવહારુ ઉદાહરણોનું વિશ્લેષણ

સાંસ્કૃતિક વિલંબના અને ઉદભવતી સામાજિક સમસ્યાઓ
આ અંતરને દૂર કરવાના અસરકારક ઉપાયો

સંશોધન પદ્ધતિ :-

આ શોધપત્ર ગ્રંથાલય તેમજ google માધ્યમ દ્વારા એકત્ર કરીને હેતુ પૂર્વકના નિદર્શન નો ઉપયોગ કરવામાં આવ્યો છે. માહિતીના સ્ત્રોત તરીકે ગૌણ પ્રકારની માહિતીનો ઉપયોગ કરી વિષય વસ્તુ વિશ્લેષણ અને વર્ણાત્મક પદ્ધતિના ઉપયોગ દ્વારા અભ્યાસ કરવામાં આવે છે.

માહિતીનું વર્ગીકરણ અને વિશ્લેષણ

ભૌતિક અને અભૌતિક સંસ્કૃતિ વચ્ચેનો તફાવત:-

સમાજશાસ્ત્રી વિલિયમ ઓગબર્નના મતે, સંસ્કૃતિના બે મુખ્ય પાસાંઓ છે જે માનવ જીવનને ઘડે છે. **ભૌતિક સંસ્કૃતિ**માં એવી તમામ ચીજોનો સમાવેશ થાય છે જેને આપણે જોઈ શકીએ છીએ, સ્પર્શી શકીએ છીએ અને જેનો ઉપયોગ સાધન તરીકે કરીએ છીએ. આજના સંદર્ભમાં સ્માર્ટફોન, હાઈ-સ્પીડ ઈન્ટરનેટ, લેપટોપ, સોશિયલ મીડિયા પ્લેટફોર્મ્સ અને આર્ટિફિશિયલ ઈન્ટેલિજન્સ (AI) એ ભૌતિક સંસ્કૃતિના પ્રબળ ઉદાહરણો છે. આ પાસું વિજ્ઞાન અને ટેક્નોલોજીની પ્રગતિ સાથે અત્યંત ઝડપથી બદલાય છે. દાખલા તરીકે, દર 6 મહિને નવો સ્માર્ટફોન કે નવી એપ્લિકેશન બજારમાં આવી જાય છે અને લોકો તેને તરત જ અપનાવી લે છે. જેમ કે. Mx Player, Dream11, kishan.. વગેરે.

જ્યારે બીજી તરફ, **અભૌતિક સંસ્કૃતિ** એ માનવ મન, વિચારો અને સામાજિક વ્યવસ્થા સાથે જોડાયેલી છે. તેમાં આપણાં મૂલ્યો, નૈતિકતા, પરંપરાઓ, કાયદાઓ અને વર્તન કરવાની રીતોનો સમાવેશ થાય છે. ભૌતિક સંસ્કૃતિની સરખામણીમાં અભૌતિક સંસ્કૃતિમાં પરિવર્તન ખૂબ જ ધીમી ગતિએ આવે છે. કારણ કે લોકોના વિચારો, માન્યતાઓ અને જૂના સંસ્કારો રાતોરાત બદલાતા નથી. સાયબર સુરક્ષાના ક્ષેત્રમાં આ તફાવત સ્પષ્ટ દેખાય છે, લોકો પાસે 5G ઈન્ટરનેટ (ભૌતિક) તો આવી ગયું છે, પરંતુ ઓનલાઈન કોની સાથે કેવું વર્તન કરવું, અજાણી લિંક પર ક્લિક ન કરવી કે કોઈની ગોપનીયતાનું સન્માન કરવું (અભૌતિક) જેવા નૈતિક મૂલ્યો હજુ કેળવાયા નથી.

આમ, જ્યારે ભૌતિક સંસ્કૃતિ (ટેક્નોલોજી) બુલેટ ટ્રેનની ઝડપે દોડે છે અને અભૌતિક સંસ્કૃતિ (નૈતિકતા અને જાગૃતિ) ગોકળગાયની ગતિએ પાછળ રહી જાય છે, ત્યારે સમાજમાં 'સાંસ્કૃતિક વિલંબના' (Cultural Lag) સર્જાય છે. આ અંતર જ સાયબર ક્રાઈમ અને સામાજિક અરાજકતા માટે જવાબદાર છે. જ્યાં સુધી માનવીની વિચારવાની પદ્ધતિ ટેક્નોલોજીની ઝડપ સાથે તાલ મિલાવી નહીં શકે, ત્યાં સુધી સુરક્ષિત ડિજિટલ સમાજનું નિર્માણ કરવું મુશ્કેલ છે.

સાયબર સ્પેસમાં સાંસ્કૃતિક વિલંબના: વ્યવહારુ ઉદાહરણોનું વિશ્લેષણ

સાયબર સ્પેસમાં સાંસ્કૃતિક વિલંબના ત્યારે સ્પષ્ટપણે જોવા મળે છે જ્યારે આપણી તકનીકી ક્ષમતા આપણી સામાજિક સમજણ કરતાં વધી જાય છે. તેનું પ્રથમ અને પ્રબળ ઉદાહરણ 'ડિજિટલ ગોપનીયતા' (Privacy) છે. આજે લોકો પાસે હાઈ-રિઝોલ્યુશન કેમેરાવાળા સ્માર્ટફોન અને સોશિયલ મીડિયા પ્લેટફોર્મ્સ ઉપલબ્ધ છે, જે ભૌતિક સંસ્કૃતિનો ભાગ છે. લોકો પળવારમાં પોતાની કે અન્યની અંગત વિગતો ઓનલાઈન શેર કરી દે છે, પરંતુ 'ડિજિટલ ફૂટપ્રિન્ટ' અને તેનાથી થતા જોખમો વિશેની સભાનતા હજુ કેળવાઈ નથી. ટેક્નોલોજીએ આપણને ફોટો ક્લિક કરવાની શક્તિ આપી, પણ 'બીજાની પ્રાઈવસીનું સન્માન' કરવાની નૈતિકતા હજુ પણ જૂના જમાનાની જ રહી ગઈ છે, જેના કારણે સાયબર સ્ટોકિંગ અને બ્લેકમેલિંગની ઘટનાઓ વધે છે. બીજું ઉદાહરણ 'ડિજિટલ ટ્રાન્ઝેક્શન અને ફ્રોડ' માં જોવા મળે છે. ભારતમાં યુપીઆઈ (UPI) જેવી અત્યાધુનિક પેમેન્ટ સિસ્ટમ ગામડે-ગામડે પહોંચી ગઈ છે. ટેક્નોલોજી ખૂબ ઝડપથી સ્વીકારી લેવામાં આવી, પરંતુ 'સાયબર

હાઈજીન' એટલે કે પાસવર્ડ સુરક્ષા અને અજાણી લિંક્સથી બચવાની સમજ હજુ પણ ઘણા વર્ગોમાં પછાત છે. લોકો લોભમાં આવીને કે ડરના માર્યા પોતાની બેંકિંગ વિગતો આપી દે છે, કારણ કે તેમની પાસે નાણાકીય ટેક્નોલોજી છે પણ તે સુરક્ષિત રાખવા માટેની 'ડિજિટલ સાક્ષરતા' કે બુદ્ધિચાતુર્ય હજુ વિકસ્યું નથી. આ અંતર જ સાયબર ગુનેગારો માટે મોટું મેદાન પૂરું પાડે છે.

છેલ્લે, 'સોશિયલ મીડિયા એથિક્સ' બાબતે પણ મોટી વિલંબના જોવા મળે છે. ફેક ન્યૂઝ (ખોટી માહિતી) અને ડીપફેક ટેક્નોલોજીએ સમાજમાં પ્રવેશ કરી લીધો છે, પરંતુ માહિતીની સત્યતા તપાસવાના સામાજિક ધોરણો હજુ નબળા છે. લોકો કોઈપણ ખરાઈ કર્યા વગર સંવેદનશીલ વિગતો ફોરવર્ડ કરે છે, જે સામાજિક અરાજકતા પેદા કરે છે. આ તમામ ઉદાહરણો સાબિત કરે છે કે ટેક્નોલોજીકલ સાધનો (ભૌતિક) આપણા હાથમાં આવી ગયા છે, પરંતુ તેનો સભ્ય અને જવાબદાર ઉપયોગ કરવાની રીતભાત (અભૌતિક) હજુ પણ ધીમી ગતિએ પાછળ ચાલી રહી છે.

સાંસ્કૃતિક વિલંબના અને ઉદભવતી સામાજિક સમસ્યાઓ

જ્યારે ટેક્નોલોજી અને સામાજિક મૂલ્યો વચ્ચેનું અંતર વધે છે, ત્યારે સમાજમાં અનેક જટિલ સમસ્યાઓ જન્મે છે, જેમાં **'પેઢીઓ વચ્ચેનું અંતર' (Generation Gap)** સૌથી મુખ્ય છે. આજના યુવાનો ટેક્નોલોજીમાં અત્યંત ઝડપી છે, જ્યારે વડીલ પેઢી પાસે અનુભવ હોવા છતાં ડિજિટલ સાક્ષરતાનો અભાવ છે. આના પરિણામે કુટુંબમાં સંવાદિતા ઘટે છે અને વડીલો સાયબર છેતરપિંડીનો સરળતાથી ભોગ બને છે. વળી, ભૌતિક રીતે લોકો સોશિયલ મીડિયા દ્વારા જોડાયેલા છે, પરંતુ સામાજિક રીતે 'ડિજિટલ આઈસોલેશન'નો ભોગ બની રહ્યા છે, જેનાથી એકલતા અને માનસિક તણાવ જેવી સમસ્યાઓ સમાજમાં વ્યાપક બની રહી છે.

બીજી ગંભીર સમસ્યા "સાયબર બુલિંગ અને નૈતિક પતન" છે. ટેક્નોલોજીએ દરેક વ્યક્તિને અભિવ્યક્તિનું પ્લેટફોર્મ પૂરું પાડ્યું છે, પરંતુ 'બીજાના સન્માન' અને 'નૈતિક મર્યાદા' જેવા અભૌતિક મૂલ્યો પાછળ રહી ગયા છે. આથી, ઓનલાઈન પ્લેટફોર્મ પર અપશબ્દોનો ઉપયોગ, ટ્રોલિંગ અને કોઈની છબી ખરડવાની પ્રવૃત્તિઓ વધી છે. આ ઉપરાંત, 'ડિજિટલ વિભાજન' **(Digital Divide)** ના કારણે સમાજમાં એક નવો ભેદભાવ ઊભો થયો છે; જેની પાસે ટેક્નોલોજી છે તે વર્ગ વધુ સક્ષમ બન્યો છે, જ્યારે ટેક્નોલોજીથી વંચિત વર્ગ સામાજિક અને આર્થિક રીતે પછાત રહી જાય છે. આમ, આ વિલંબના માત્ર ગુનાઓ જ નહીં, પણ સામાજિક અસમાનતા અને માનસિક અશાંતિ માટે પણ જવાબદાર છે.

આ અંતરને દૂર કરવાના અસરકારક ઉપાયો:-

ડિજિટલ સાક્ષરતા અને નૈતિકતાનું એકીકરણ વર્તમાન સમયમાં માત્ર ડિજિટલ સાધનો વાપરતા આવડવું એ પૂરતું નથી, કારણ કે ટેકનિકલ જ્ઞાનની સાથે જો નૈતિકતા (Ethics) ન હોય તો તે સામાજિક અરાજકતા પેદા કરી શકે છે. સાયબર એથિક્સ પર ભાર મૂકવાનો અર્થ એ છે કે વ્યક્તિને ઓનલાઈન પ્લેટફોર્મ પર અન્યોના ડેટાની ગોપનીયતા જાળવવા, ખોટી માહિતી ફેલાવતા અટકાવવા અને ડિજિટલ દુનિયામાં સભ્યતાપૂર્વક વર્તન કરવા માટે પ્રેરિત કરવી. જ્યારે યુઝરને એ ખબર હોય કે તેની એક નાની ભૂલ કે 'શેર' કરવાની આદત કોઈની સુરક્ષા જોખમાવી શકે છે, ત્યારે જ સાચો ડિજિટલ સુધારો આવશે.

શૈક્ષણિક અભિગમમાં પરિવર્તન શૈક્ષણિક સંસ્થાઓએ સાયબર સુરક્ષાને માત્ર આઈ.ટી. (IT) ના એક પ્રકરણ તરીકે જોવાને બદલે તેને 'મૂલ્ય શિક્ષણ' અથવા 'સામાજિક જવાબદારી' તરીકે સ્વીકારવી જોઈએ. વિદ્યાર્થીઓ નાનપણથી જ ઈન્ટરનેટનો ઉપયોગ કરે છે, તેથી જો શાળાના વાતાવરણમાં જ તેમને સાયબર ક્રાઈમના જોખમો અને કાયદાકીય પાસાઓ વિશે માહિતગાર કરવામાં આવે, તો તેઓ જવાબદાર ડિજિટલ નાગરિક બની શકે છે. આ વિષયને ટેકનિકલ જટિલતામાંથી બહાર લાવીને માનવીય સંવેદના અને સુરક્ષા સાથે જોડવો અનિવાર્ય છે.

વ્યાપક સામાજિક જાગૃતિની જરૂરિયાત ટેકનોલોજીનો ઉપયોગ કરનાર દરેક વ્યક્તિ શિક્ષિત કે ટેક-સેવી હોતી નથી, ખાસ કરીને ગ્રામીણ વિસ્તારો અને વડીલોમાં આ જ્ઞાનનો અભાવ વધુ જોવા મળે છે. તેથી સાયબર જાગૃતિના કાર્યક્રમોને લોકશાહી ઢબે દરેક સ્તર સુધી પહોંચાડવા જોઈએ. જાગૃતિ અભિયાનો દ્વારા જ્યારે સામાન્ય માણસ પાસવર્ડ મેનેજમેન્ટ, ટુ-ફેક્ટર ઓથેન્ટિકેશન અને ફિશિંગ લિંક્સ જેવા પાયાના સુરક્ષાના નિયમોથી વાકેફ થશે, ત્યારે જ સાયબર ગુનેગારોની સફળતાનો દર ઘટશે. અંતે, ટેકનોલોજીની તાકાત અને માનવીય સમજણ વચ્ચેનો સમન્વય જ આ અંતરને દૂર કરવાનો શ્રેષ્ઠ માર્ગ છે.

ઉપસંહાર :-

૨૧મી સદીમાં ટેક્નોલોજી એ માનવ જીવનનું અભિન્ન અંગ બની ગઈ છે, પરંતુ વિલિયમ ઓગબર્નનો 'સાંસ્કૃતિક વિલંબના'નો સિદ્ધાંત આજે પણ એટલો જ પ્રસ્તુત છે. ભૌતિક સંસ્કૃતિ (સ્માર્ટફોન, AI, 5G) જે ગતિએ પરિવર્તિત થઈ રહી છે, તેની સામે આપણી અભૌતિક સંસ્કૃતિ (વિચારો, મૂલ્યો અને ડિજિટલ શિષ્ટાચાર) ઘણી પાછળ રહી ગઈ છે. આ તફાવત માત્ર ટેકનિકલ સમસ્યા નથી, પરંતુ એક ગંભીર સામાજિક પડકાર છે, જે સાયબર અપરાધ અને નૈતિક પતન તરીકે આપણી સામે આવે છે.

માત્ર કાયદાઓ ઘડવાથી કે ટેક્નોલોજીને મર્યાદિત કરવાથી આ સમસ્યાનો ઉકેલ શક્ય નથી. સાચો ઉકેલ ટેક્નોલોજીના સ્વીકારની સાથે 'ડિજિટલ નૈતિકતા'ના વિકાસમાં રહેલો છે. જ્યારે સમાજમાં ટેક્નોલોજીનો ઉપયોગ કરવાની 'આવડત' અને તેને વાપરવાની 'સમજણ' વચ્ચેનું અંતર ઘટશે, ત્યારે જ આપણે એક સુરક્ષિત અને સ્વસ્થ ડિજિટલ સંસ્કૃતિનું નિર્માણ કરી શકીશું. અંતે, માનવીય મૂલ્યો અને આધુનિક ગેજેટ્સ વચ્ચેનો સમન્વય જ આ 'સાંસ્કૃતિક વિલંબના'ને દૂર કરવાની એકમાત્ર ચાવી છે.

સંદર્ભ સૂચિ:-

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ATTITUDES TOWARD LEARNING ENGLISH THROUGH MOVIES AND WEB SERIES: A PRIMARY SURVEY IN NORTH GUJARAT

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ABSTRACT

This paper will look at the customer awareness and customer satisfaction with the risk mitigation strategies implemented by textile companies in Gujarat. The textile industry is highly vulnerable to operational, supply chain, environmental, and market risks; therefore, it is a sector that is turning into more structured approaches in its risk mitigation to stabilize and gain customer confidence. As the expectations of customers towards reliability, quality assurance, and ethical compliances change, it has become critical to know how customers perceive such strategies. Primary survey of 70 customers represents textile firms in Gujarat is used to base the study. The one-sample t-tests were employed to test the hypothesis that the level of customer awareness and customer satisfaction is significantly increased; compared to a neutral level, and the simple linear regression was employed to determine the effect of customer awareness on customer satisfaction. The results indicate that the awareness and satisfaction levels of the customers with respect to the risk mitigation strategies are very high. The regression outcomes however show that customer awareness is not a significant factor on customer satisfaction. In the study, most of the satisfaction motivation is practical rather than awareness.

KEY WORDS: CUSTOMER AWARENESS, CUSTOMER SATISFACTION, RISK MITIGATION STRATEGIES, TEXTILE INDUSTRY, OPERATIONAL RISK, SUPPLY CHAIN RISK, GUJARAT

INTRODUCTION

One of the greatest beneficiaries of the industrial development of India, job creation, and foreign exchange earnings is the textile industry, and Gujarat has become one of the major textile manufacturing and processing centers. The industry includes spinning, weaving, processing, garment, and technical textiles, which renders it very complicated and vulnerable to various types of risk. The number of risks textile companies in Gujarat encounter is quite large; they are exposed to the fluctuation of the prices of raw materials, the disruption of the supply chain, quality breakdowns, environmental compliance, labor shortage, technological obsolescence, and market demand fluctuations. To cope with these uncertainties, textile companies tend to adopt systematic risk management plans that would guarantee operational stability, financial viability and customer confidence.

Over the past few years, the customer demands in the cloth market have changed to be more than just the price and the quality of the product. Reliability, delivery assurances, ethical practices, environmental safety and consistency of product standards are more conscious areas to the customers. The risk reduction strategies like quality control system, diversification of supply chain, inventory, adherence to environmental regulations, and openness in communication are important in the development of customer perceptions. These strategies will increase customer satisfaction

and confidence when well implemented and communicated, as there is less uncertainty and perceived risk in business transactions.

The awareness of the customer as to the risk mitigation strategies that are embraced by the textile companies has become a significant factor in determining customer satisfaction and future loyalty. Informed customers in business-to-business and business-to-consumer markets are more likely to favor companies that are seen to be prepared in case of disruption and continuity of supply. The perception and assessment of these strategies by customers in Gujarat textile industry will help it to be more competitive and maintain growth.

This research is aimed at analysing the degree of customer knowledge and satisfaction with risk mitigation measures of textile companies in Gujarat. With the help of the analysis of customer responses, the research will help to obtain the information about the efficiency of the current practices and the potential areas where the firms can improve the risk management strategy to increase customer satisfaction and trust.

LITERATURE REVIEW

Ejiogu, Tasie, and Chimaobi (2024) also show that customer satisfaction in fast-food companies in Nigeria is highly achieved through the competitive positioning that builds customer loyalty and retention, which indicates that positioning is a major source of competitive advantage. Adding to this strategic perspective, Benjamin (2025) points out that business strategy should be aligned with the changes in customer expectations in terms of technology, personalization and data analytics to achieve long-lasting customer satisfaction and organizational development.

A number of studies emphasize emotional, perceptual and brand related aspects of satisfaction. Subramaniam and Rathnapriya (2025) disclose that nostalgic products are known to create a lot of customer satisfaction since they produce positive feelings and also strengthen brand loyalty (especially among the middle-aged consumers). Likewise, Mwakajinga and Mtega (2024) and Mwaifyusi and Magobe (2025) affirm that brand awareness, attitude, and reputation have a positive impact on the firm performance, and customer satisfaction is a reinforcer of the relationship between the brand and performance.

The key role of customer satisfaction strategies is also supported by sector-specific evidence. Okeke and Eze (2024) and Nebo and Okolo (2016) conclude that service quality, timely settlement of claims, communication and complaint management are important in enhancing performance and retention in insurance companies. In the online setting, Akinfala, Muo, and Akintolu (2025) refer to the e-service quality (in particular, information quality) when it comes to online customer satisfaction, whereas Jasmine Anitha and Rosaline (2025) emphasize the importance of reminder notifications in increasing customer satisfaction in e-pharmacy platforms.

Besides, Ogan, Akani, and Agbogunleri (2022) and Putra and Sari (2023) determine that awareness of employee service and customer awareness play a significant role in satisfaction and loyalty. According to the studies by Kamalesh and Tamilmani (2024) and Chandrashekhar and Parameshwari (2025), the affordability, awareness, and tailored service strategies determine satisfaction in both mobility and NBFC services. Lastly, Durmaz and Öcal (2025) contribute to the

discussion by proving the intermediate role played by environmental awareness between sustainable marketing and customer satisfaction and supports the increased relevance of sustainability-focused strategies.

RESEARCH GAP

Although the literature on the topic of risk management and operational risk mitigation in the textile industry is substantial, the existing sources are firm-based and concentrate on financial performance, supply chain efficiency, or internal controls. There is a lack of empirical studies on customer-oriented risk mitigation strategies as well as on the risk mitigation strategies in the context of awareness and satisfaction. Besides, there is dearth of region specific research on the textile industry in Gujarat. The gap in understanding the customer perception towards these strategies and its effects on their satisfaction and trust has a significant difference. This research fills this gap by carrying out a primary study using customers as the basis of the study.

RESEARCH OBJECTIVES

To examine whether the mean level of customer awareness regarding risk mitigation strategies adopted by textile firms in Gujarat is significantly higher than the neutral level of awareness.
To examine whether the mean level of customer satisfaction towards risk mitigation strategies adopted by textile firms in Gujarat is significantly higher than the neutral level of satisfaction.
To examine whether customer awareness regarding risk mitigation strategies significantly influences customer satisfaction towards such strategies adopted by textile firms in Gujarat.

RESEARCH METHODOLOGY

Research Design: Descriptive and analytical research design
Nature of Study: Empirical and quantitative
Source of Data: Primary data collected through a structured questionnaire
Sampling Unit: Customers of textile firms in Gujarat
Sample Size: 70 respondents
Sampling Technique: Convenience sampling
Measurement Scale: Five-point Likert scale

Variables Studied:

Customer Awareness
Customer Satisfaction

Statistical Tools Used:

Descriptive statistics
One-Sample t-test
Simple Linear Regression Analysis
Software Used: SPSS
Scope of Study: Textile firms operating in Gujarat
Purpose of Analysis: To evaluate awareness, satisfaction, and their relationship regarding risk mitigation strategies

DATA ANALYSIS AND INTERPRETATION

H_0 (Null Hypothesis): The mean customer awareness score regarding risk mitigation strategies adopted by textile firms in Gujarat is equal to the neutral value ($\mu = 3$), indicating no significant level of awareness.

H_1 (Alternative Hypothesis): The mean customer awareness score regarding risk mitigation strategies adopted by textile firms in Gujarat is significantly greater than the neutral value ($\mu > 3$), indicating a significant level of awareness.

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Awareness Mean Score	70	3.9750	.40188	.04803

One-Sample Test						
	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Awareness Mean Score	20.298	69	.000	.97500	.8792	1.0708

The One-Sample t-test was done to determine whether the level of awareness of the customers on the risk mitigation strategies implemented by textile companies in Gujarat is significantly different as compared to the neutral value of 3. The findings suggest that the sample size is 70 customers and the mean awareness of the customer is 3.975 and standard deviation of 0.40188. Also, t-value of 20.298 with 69 degrees of freedom is significant at the 5 percent level ($p = 0.000$) which is a clear indication that the mean score is significantly greater than test value. More so, the mean difference of 0.975 and a 95 percent confidence interval of 0.8792 to 1.0708 prove the strength of the result. Therefore, the null hypothesis is rejected and it is ascertained that the level of awareness among the customers on the risk mitigation measures taken by the textile companies in Gujarat is significantly high.

H_0 (Null Hypothesis): The mean customer satisfaction score towards risk mitigation strategies adopted by textile firms in Gujarat is equal to the neutral value ($\mu = 3$), indicating no significant level of satisfaction.

H_1 (Alternative Hypothesis): The mean customer satisfaction score towards risk mitigation strategies adopted by textile firms in Gujarat is significantly greater than the neutral value ($\mu > 3$), indicating a significant level of satisfaction.

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Satisfaction Mean Score	70	3.9750	.43645	.05217

One-Sample Test						
	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Satisfaction Mean Score	18.690	69	.000	.97500	.8709	1.0791

The One-Sample t-test was used to test the hypothesis of whether the customer satisfaction of the contingency measures towards the risk reduction strategies taken by the textile companies located in Gujarat has a significant difference with the neutral level of 3. The descriptive analysis, which is done through the responses of 70 customers, indicates that they had a mean satisfaction of 3.975 with a standard deviation of 0.43645. The t-value of 18.690 at 69 degrees of freedom is statistically significant at the 5 percent level (p = 0.000) which means that the measured mean is significantly larger than the test value. Also, the difference of means of 0.975 and the 95 percent interval between 0.8709 and 1.0791 are another support of the consistency and reliability of the result. So null hypothesis is rejected as the conclusion is made that the customers are highly satisfied with the risk mitigation measures implemented by the textile industries in Gujarat.

H_0 (Null Hypothesis): Customer awareness regarding risk mitigation strategies adopted by textile firms in Gujarat does not have a significant influence on customer satisfaction.

H_1 (Alternative Hypothesis): Customer awareness regarding risk mitigation strategies adopted by textile firms in Gujarat has a significant influence on customer satisfaction.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.079[a]	.006	-.008	.43827

a. Predictors: (Constant), Awareness Mean Score

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.082	1	.082	.427	.516[b]
	Residual	13.062	68	.192		
	Total	13.144	69			

a. Dependent Variable: Satisfaction Mean Score

b. Predictors: (Constant), Awareness Mean Score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.634	.524		6.928	.000
	Awareness Mean Score	.086	.131	.079	.654	.516

a. Dependent Variable: Satisfaction Mean Score

The study used simple linear regression analysis to determine the effect of customer awareness on customer satisfaction with risk mitigation strategies of textile firms in Gujarat. The model summary shows that the correlation (R) between the two variables is very low (0.079) and the explanatory

power (R^2) is also very low (0.006), which means that customer awareness is associated with less than 0.6 percent of customer satisfaction variation. Further, the results of the ANOVA indicate that there is no statistical significance in the regression model (F = 0.427, p = 0.516), which implies that the data does not fit the model. Furthermore, customer awareness regression coefficient (β= 0.079, = 0.654, = 0.516) is not significant meaning that customer satisfaction does not change significantly due to the change in customer awareness. Therefore, the null hypothesis is accepted and it is assumed that customer awareness does not play any important role in customer satisfaction in risk mitigation strategies implemented by textile companies in Gujarat.

CONCLUSION

The current research looked at customer awareness and customer satisfaction and interaction between awareness and customer satisfaction in relation to risk mitigation measures embraced by textile companies in Gujarat. The empirical results are clear on the fact that customers have a high degree of awareness concerning the risk mitigation measures taken by the textile companies. Results of One-Sample t-test reveal that the average awareness score is significantly above the neutral mean, which shows that customers are highly knowledgeable about safety measures, quality management, compliance measures and risk mitigations efforts made by textile companies. This is an indicator of the efficiency of the industry activities and communication process in creating knowledge and confidence among customers.

On the same note, the analysis indicates that the level of customer satisfaction with the risk mitigation strategies is also very high. The customers were found to be highly satisfied with precautionary and contingency measures that were embraced by the textile firms, indicating that the strategies play a positive role in ensuring trust, reliability, and perceived operational responsibility. The high satisfaction rates show that the textile companies in Gujarat are in most ways successful to satisfy the customer expectations in terms of risk management and stability.

Nevertheless, the regression analysis makes an essential point: in this regard, customer awareness is not a significant factor in customer satisfaction. Although the level of awareness is high, satisfaction seems to be motivated with other factors rather than the level of awareness as regularity in product quality, timely supply, stability in prices, after-sale service, and reliability over a long period. This means that awareness though a necessity is not the only factor of satisfaction.

In general, the research findings reveal that textile companies in Gujarat have made reputable performances in adopting and sustaining the risk mitigation measures. The customers are satisfied and they are aware, however, the outcomes of satisfaction depend more on the practical results than on the level of awareness only.

RECOMMENDATIONS

Gujarat textile companies should keep empowering their risk management models so that they maintain high customer confidence and satisfaction levels. Although the level of awareness has been high, companies ought to pay more attention to operational excellence, quality consistency, and transparency in the execution of risk control procedures. Customer confidence can be further improved by regular audits, resiliency of the supply chain and proactive crisis management. Also, companies are advised to incorporate customer feedback systems in order to determine the

satisfaction source beyond awareness. Awareness should be better aligned with the experience by having targeted communication with an emphasis on the tangible results of the risk mitigation process, including enhanced reliability and fewer disruptions.

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TAXATION AND FISCAL FEDERALISM IN INDIA

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ABSTRACT

Taxation forms the fiscal foundation of a sovereign State and represents the lifeblood of governance. In India, the power to levy and collect taxes is not merely an economic prerogative but a constitutional function that reflects the federal distribution of authority. The Indian Constitution establishes a complex yet balanced framework for taxation through a meticulous division of powers between the Union and the States, primarily under **Articles 245–265** and the **Seventh Schedule**. Over the years, the judiciary has played a vital role in interpreting the constitutional contours of fiscal federalism, ensuring that neither level of government transgresses its jurisdiction.

This paper examines the legal and institutional dimensions of India's taxation framework and fiscal federalism. It traces the constitutional structure of taxing powers, explores the principles of federal balance, and evaluates landmark judicial pronouncements that have shaped India's fiscal jurisprudence. The paper also analyzes the transformative impact of the **Goods and Services Tax (GST)**—India's most significant fiscal reform since independence—on cooperative federalism and fiscal autonomy. It concludes that while judicial interpretation has largely upheld the equilibrium between central and state taxation powers, continuous institutional cooperation remains essential to preserve India's federal spirit in an evolving fiscal landscape.

KEYWORDS: TAXATION LAW, FISCAL FEDERALISM, CONSTITUTION, JUDICIAL REVIEW, GOODS AND SERVICES TAX, FEDERAL BALANCE, REVENUE SHARING, COOPERATIVE FEDERALISM

INTRODUCTION

Taxation represents the legal expression of a State's sovereignty and its ability to mobilize resources for public welfare. In a federal system like India's, taxation also embodies the delicate balance between unity and regional autonomy. The framers of the Indian Constitution envisaged a **quasi-federal fiscal structure** that combined centralization of key tax powers with adequate financial independence for the States.

India's fiscal federalism thus operates within a **constitutional matrix**—allocating taxing powers through legislative lists, regulating intergovernmental transfers through Finance Commissions, and subjecting taxation statutes to judicial scrutiny under fundamental rights and federal principles.

This paper analyzes India's taxation law and fiscal federalism from a **constitutional–institutional perspective**, focusing on the structure of taxing powers, judicial interpretation of tax statutes, and the evolving dynamics of cooperative fiscal relations after the introduction of the **GST regime** in 2017.

CONSTITUTIONAL FRAMEWORK OF TAXATION

1. Constitutional Basis

The power to levy and collect taxes in India is governed by:

Articles 245–265 (legislative competence and financial provisions).

Seventh Schedule (distribution of taxing subjects).

Articles 268–281 (revenue sharing and Finance Commission).

Article 265 embodies the rule of legality in taxation:

"No tax shall be levied or collected except by authority of law."

This clause ensures that taxation is a **legislative function**, subject to parliamentary or state legislative approval, and not an executive prerogative.

2. Division of Taxing Powers

The **Seventh Schedule** classifies subjects into:

List I (Union List) – confers exclusive power on Parliament for taxes such as income tax (other than agricultural income), customs, excise on manufactured goods, corporation tax, etc.

List II (State List) – empowers States to levy taxes on land, agricultural income, and entry of goods, among others.

List III (Concurrent List) – does not include tax subjects, preventing overlap.

This distribution maintains fiscal balance while avoiding duplication.

3. Constitutional Limitations

Certain constitutional doctrines constrain taxing powers:

Non-Discrimination (Article 303): Prevents discriminatory taxation that favors one State over another.

Inter-State Trade Freedom (Article 301): Ensures that tax policies do not hinder free trade and commerce.

Fundamental Rights: Taxation laws are subject to Articles 14, 19, and 21, ensuring fairness and non-arbitrariness.

PRINCIPLES OF FISCAL FEDERALISM

Fiscal federalism refers to the financial relationship between the Union and State governments, balancing revenue generation with expenditure responsibilities.

1. Vertical and Horizontal Balance

Vertical balance deals with the equitable sharing of revenues between the Centre and States.

Horizontal balance addresses disparities among States in revenue capacity.

The **Finance Commission (Article 280)** plays a pivotal role in ensuring both through formula-based devolution and grants-in-aid.

2. Constitutional Mechanisms

India's fiscal federalism operates through:

Finance Commission: Periodic constitutional body recommending distribution of tax revenues.

Inter-State Council (Article 263): Facilitates coordination in fiscal and policy matters.

Consolidated Funds and Public Accounts: Separate funds for Union and State finances ensure fiscal autonomy.

3. Cooperative Federalism

The Indian Constitution envisages a cooperative model where fiscal coordination strengthens national unity. The introduction of the **GST Council (Article 279A)** epitomizes this shift from competitive to cooperative fiscal federalism.

JUDICIAL INTERPRETATION OF TAXATION POWERS

Judicial interpretation has been central to defining and safeguarding the constitutional distribution of tax powers.

1. Union of India v. H.S. Dhillon (1972)

The Supreme Court upheld the **residuary power of taxation** under Article 248 and Entry 97 of the Union List, establishing that Parliament can levy taxes not enumerated in either List I or List II. This case cemented central supremacy in fiscal matters.

2. Atiabari Tea Co. Ltd. v. State of Assam (1961)

The Court struck down a state tax on inter-state transport of goods as violative of **Article 301** (freedom of trade). However, in **Automobile Transport (Rajasthan) Ltd. v. State of Rajasthan (1962)**, it clarified that regulatory taxes do not violate Article 301 if they facilitate rather than restrict trade.

3. State of West Bengal v. Kesoram Industries Ltd. (2004)

This case clarified the distinction between **taxes** and **fees**, emphasizing that a tax is imposed for revenue purposes while a fee is linked to specific services rendered. The decision reinforced that taxing powers are subject to strict interpretation.

4. M.P.V. Sundararamier & Co. v. State of Andhra Pradesh (1958)

The Court upheld the principle of mutual exclusivity between Union and State taxation powers, holding that legislative entries must be read in a manner that avoids overlap.

5. Jindal Stainless Ltd. v. State of Haryana (2016)

The Court, in a landmark nine-judge bench decision, reaffirmed that **taxation on inter-state trade** must comply with the principle of **free commerce under Article 301**, but permissible restrictions can be justified under Article 304(b) if sanctioned by Parliament.

TAXATION AND FUNDAMENTAL RIGHTS

Although taxation is primarily an economic policy matter, courts have subjected tax laws to constitutional scrutiny to prevent arbitrariness.

1. Article 14: Equality in Taxation

In **Kunnathat Thathunni Moopil Nair v. State of Kerala (1961)**, the Supreme Court struck down a land tax for being arbitrary and violating Article 14, holding that **equality in taxation is a constitutional requirement**.

2. Article 19(1)(g): Freedom of Trade

Tax laws that unreasonably restrict business are subject to challenge under Article 19(1)(g). However, courts uphold legitimate regulatory taxation as reasonable.

3. Article 265: Rule of Law

The principle that **no tax shall be levied or collected except by law** embodies the rule of legality in fiscal governance. In **Chhotabhai Jethabhai Patel v. Union of India (1962)**, the Court reiterated that taxation must have clear statutory authority.

THE GOODS AND SERVICES TAX (GST): TRANSFORMING FISCAL FEDERALISM

1. Genesis and Objectives

Implemented on **July 1, 2017**, the **Goods and Services Tax (GST)** unified India's fragmented indirect tax regime into a single national market. It subsumed multiple central and state taxes, including excise, VAT, and service tax.

The **101st Constitutional Amendment Act (2016)** introduced:

Article 246A: Concurrent taxing power for Centre and States over GST.

Article 269A: Levy and collection of IGST on inter-state trade.
Article 279A: Constitution of the **GST Council** for cooperative decision-making.

2. Cooperative Federalism through the GST Council

The **GST Council** is the most significant innovation in India's fiscal architecture. Comprising representatives from the Centre and all States, it promotes **collaborative fiscal policy-making**. Decisions are based on consensus, reflecting cooperative federalism in practice.

3. Challenges to Federal Autonomy

While GST fosters uniformity, it has raised concerns about erosion of state autonomy:
States lost independent taxing powers on goods and services.
Fiscal dependence on central compensation has increased.
The pandemic-induced delay in compensation payments strained state finances.
In **Union of India v. Mohit Minerals Pvt. Ltd. (2022)**, the Supreme Court upheld the GST Council's recommendations as non-binding, reinforcing **federal flexibility** within cooperative structures.

4. Judicial Approach to GST

The judiciary has adopted a balanced stance—acknowledging the GST's cooperative intent while safeguarding constitutional distribution of powers. Courts continue to clarify issues like **input tax credits**, **classification disputes**, and **jurisdictional overlaps** under GST law.

FISCAL TRANSFERS AND THE FINANCE COMMISSION

1. Constitutional Role

Under **Article 280**, the Finance Commission is constituted every five years to recommend:
Distribution of tax revenues between Centre and States.
Grants-in-aid from the Consolidated Fund of India.
Measures for fiscal consolidation and equity.

2. Evolution of Devolution

From the **First Finance Commission (1951)** to the **Fifteenth Finance Commission (2020)**, the devolution formula has evolved to incorporate factors like population, income distance, forest cover, and tax effort.

3. Fiscal Equity and Accountability

The Finance Commission's recommendations ensure fiscal equity by addressing disparities between resource-rich and resource-poor states, thereby strengthening the cooperative federal framework.

JUDICIAL REVIEW OF TAXATION: PRINCIPLES AND TRENDS

1. Judicial Deference to Economic Policy

Courts generally defer to legislative wisdom in taxation matters, intervening only when laws are arbitrary or discriminatory. In **R.K. Garg v. Union of India (1981)**, the Supreme Court emphasized that fiscal legislation must enjoy greater judicial latitude, recognizing the complexities of economic policy.

2. Interpretation of Tax Statutes

The golden rule of tax interpretation—**no taxation without clear words**—has been consistently upheld. In **Cape Brandy Syndicate v. IRC (1921)**, quoted approvingly in Indian judgments, it was held that tax statutes must be strictly construed in favor of the taxpayer.

3. Judicial Protection Against Double Taxation

In **Hoechst Pharmaceuticals Ltd. v. State of Bihar (1983)**, the Court clarified that double taxation is not inherently unconstitutional unless expressly prohibited or oppressive.

4. Doctrine of Colourable Legislation

The judiciary ensures that neither the Centre nor the States encroach upon each other's taxation fields. In **State of Rajasthan v. G. Chawla (1959)**, the Court applied the doctrine of **pith and substance** to validate legislative competence.

CHALLENGES TO FISCAL FEDERALISM IN INDIA

1. Centralization of Resources

The Union retains control over the most productive taxes (income, customs, excise), leading to **vertical fiscal imbalance** and dependence of States on central transfers.

2. Declining Fiscal Autonomy

The GST has constrained States' ability to adjust tax rates independently, raising concerns over fiscal sovereignty.

3. Compensation and Trust Deficit

Delays in GST compensation and unilateral central decisions occasionally strain Centre–State relations.

4. Administrative Complexity

The multi-tiered structure of tax administration and compliance under GST has created interpretive and procedural challenges for businesses and tax authorities alike.

5. Fiscal Discipline and Accountability

Frequent fiscal slippages by States and increasing public debt require better monitoring mechanisms and cooperative fiscal discipline.

ANALYSIS AND DISCUSSION

India's fiscal federalism represents an intricate balance between **constitutional design and economic pragmatism**. Judicial interpretation has reinforced federal principles while permitting necessary centralization for fiscal efficiency.

The GST Council marks a constitutional innovation—transforming India from a hierarchical federation into a **negotiated fiscal union**. Yet, cooperative federalism must remain genuine, not symbolic. Institutional cooperation must be sustained through transparency, equitable transfers, and mutual trust.

Ultimately, taxation in India is not merely a legal function but a constitutional dialogue between unity and diversity—mediated through judicial interpretation and institutional evolution.

FINDINGS

The Constitution of India establishes a detailed and balanced framework for taxation and fiscal federalism. Judicial interpretation has consistently upheld federal equilibrium while respecting economic realities.

The GST has transformed India's fiscal structure, institutionalizing cooperative federalism.
Fiscal autonomy of States requires protection through transparent mechanisms and judicial oversight.

The success of India's fiscal federalism depends on continuous institutional dialogue and adaptability.

SUGGESTIONS

Strengthen GST Council Governance: Formalize dispute resolution mechanisms and enhance state participation.
Revise Finance Commission Formula: Incorporate real-time fiscal indicators and incentivize tax effort.
Codify Fiscal Responsibility: Enact a comprehensive Fiscal Responsibility and Budget Management (FRBM) law applicable to both Centre and States.
Promote Taxpayer Rights: Introduce a Taxpayers' Bill of Rights ensuring fairness, transparency, and accountability.
Empower State Revenues: Expand non-tax revenue sources and allow flexibility in local taxation.
Judicial and Administrative Training: Enhance capacity in tax adjudication and alternative dispute resolution (ADR).

CONCLUSION

Taxation in India is both a legal and constitutional enterprise—anchored in federalism, democracy, and economic justice. The Constitution's fiscal design ensures that the Union and the States function as **cooperative partners in governance**, not adversaries. Judicial interpretation has been instrumental in maintaining this equilibrium by upholding legality, equality, and accountability in taxation.

The introduction of the **Goods and Services Tax (GST)** has redefined India's fiscal landscape, institutionalizing cooperative federalism through shared decision-making. Yet, the long-term success of India's fiscal federalism depends on strengthening institutional trust, ensuring transparency, and preserving constitutional autonomy in fiscal policymaking.

As India advances toward becoming a $5-trillion economy, the constitutional principles of **equity, accountability, and cooperation** must guide its fiscal evolution—ensuring that taxation remains not a burden but an instrument of justice and national integration.

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MEDIA LAW AND FREE EXPRESSION IN INDIA

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ABSTRACT

Freedom of expression is the lifeblood of democracy, and the media serves as its vital organ. In India, this freedom finds its constitutional foundation in **Article 19(1)(a)** of the Constitution, guaranteeing the right to freedom of speech and expression. Though the Constitution does not explicitly confer separate "freedom of the press," judicial interpretation has consistently recognized it as an intrinsic part of this fundamental right. Over the decades, Indian courts have navigated the delicate balance between liberty and restraint, defining the scope of permissible restrictions under **Article 19(2)**.

This paper examines the constitutional and judicial evolution of media law and freedom of expression in India. It explores seminal judgments that have shaped media jurisprudence, from the early constitutional cases (*Romesh Thappar v. State of Madras*, *Brij Bhushan v. State of Delhi*) to modern digital age challenges (*Shreya Singhal v. Union of India*). The paper also evaluates how the judiciary has interpreted "reasonable restrictions" in the context of national security, defamation, contempt, morality, and public order. It argues that while Indian jurisprudence robustly protects press freedom, emerging regulatory frameworks and technological transformations demand renewed judicial vigilance to preserve media's democratic function.

KEYWORDS: FREEDOM OF SPEECH, ARTICLE 19, PRESS FREEDOM, MEDIA LAW, JUDICIAL REVIEW, REASONABLE RESTRICTIONS, DEMOCRATIC ACCOUNTABILITY, DIGITAL MEDIA

INTRODUCTION

The media is often described as the "fourth pillar" of democracy, complementing the legislature, executive, and judiciary in promoting transparency and accountability. In India, media freedom is not merely a civil liberty but a constitutional value—an essential instrument for the realization of public participation, informed citizenship, and democratic legitimacy.

While **Article 19(1)(a)** guarantees freedom of speech and expression, it is **Article 19(2)** that delineates the contours of state control by permitting reasonable restrictions in the interests of sovereignty, integrity, security, public order, decency, morality, contempt of court, defamation, and incitement to offense. The tension between these provisions constitutes the central dialectic of Indian media jurisprudence.

This paper traces the judicial evolution of media law in India, focusing on how the Supreme Court and High Courts have defined, expanded, and occasionally circumscribed media freedom. It highlights constitutional interpretation as the principal vehicle for balancing press autonomy with societal responsibility.

CONSTITUTIONAL FOUNDATIONS OF FREEDOM OF EXPRESSION

1. Article 19(1)(a): Guarantee of Free Speech

Article 19(1)(a) confers upon all citizens the right to freedom of speech and expression. This right encompasses the freedom to:

Express opinions and ideas through words, writing, printing, and images;

Disseminate information through press, broadcasting, or digital media;

Access and receive information as an aspect of participatory democracy.

In **Indian Express Newspapers v. Union of India (1985)**, the Supreme Court held that freedom of expression includes not just the right to express but also the right to publish and circulate information.

2. Article 19(2): Reasonable Restrictions

Freedom under Article 19(1)(a) is not absolute. Article 19(2) authorizes the State to impose **reasonable restrictions** on grounds such as:

Sovereignty and integrity of India;

Security of the State;

Friendly relations with foreign States;

Public order, decency, or morality;

Contempt of court, defamation, or incitement to an offense.

Judicial scrutiny ensures that such restrictions are both **reasonable and proportionate**, thereby preserving the essential core of liberty.

JUDICIAL RECOGNITION OF PRESS FREEDOM

The framers of the Constitution did not explicitly mention "freedom of the press." During the Constituent Assembly Debates, K.M. Munshi and Dr. B.R. Ambedkar clarified that press freedom was subsumed within freedom of expression. However, its contours were defined through early constitutional litigation.

1. Romesh Thappar v. State of Madras (1950)

This landmark case was the first to strike down state-imposed pre-censorship on a political journal. The Supreme Court held that freedom of speech and expression includes the right to propagate ideas, and any restriction not covered by Article 19(2) is unconstitutional. The judgment emphasized that "public order" could not justify censorship unless it endangered the security of the State.

2. Brij Bhushan v. State of Delhi (1950)

Here, the Court invalidated pre-censorship orders on a newspaper, holding them violative of Article 19(1)(a). Together, *Romesh Thappar* and *Brij Bhushan* established that prior restraint on publication is presumptively unconstitutional.

3. Express Newspapers (1958) and Sakal Papers (1962)

In **Express Newspapers Ltd. v. Union of India (1958)**, the Court held that freedom of the press includes the right to manage its business and determine circulation policy without governmental interference.

In **Sakal Papers Pvt. Ltd. v. Union of India (1962)**, price-page regulations were struck down as they indirectly curtailed press freedom. The Court ruled that economic restrictions that impair circulation amount to violation of Article 19(1)(a).

4. Bennett Coleman & Co. v. Union of India (1973)

The Supreme Court reaffirmed that government policies controlling newsprint allocation violated freedom of the press. The Court observed that "freedom of the press is both qualitative and quantitative—it includes the right to print and the right to reach readers."

FREEDOM OF THE PRESS AND REASONABLE RESTRICTIONS: JUDICIAL APPROACH

1. National Security and Public Order

Balancing liberty with security has been a recurrent judicial theme.
In **Virendra v. State of Punjab (1958)**, the Court upheld limited pre-censorship during emergencies but warned against excessive discretion.
In **Kedar Nath Singh v. State of Bihar (1962)**, the Court read down sedition (Section 124A IPC) to apply only when speech incites violence or public disorder—thus preserving legitimate dissent.
The **1975–77 Emergency** marked the darkest chapter for press freedom, with mass censorship justified under Article 352. Post-Emergency jurisprudence, however, restored judicial vigilance, emphasizing that **free speech is the essence of liberty**.

2. Defamation and Contempt

Defamation (civil and criminal) remains a valid ground for restriction. In **Subramanian Swamy v. Union of India (2016)**, the Supreme Court upheld the constitutionality of criminal defamation under Sections 499–500 IPC, reasoning that reputation is a component of Article 21. Critics argue this judgment tilted the balance toward protection of personality rights over press freedom.
In **Re: Arundhati Roy (2002)**, the Court clarified that contempt of court should not be used to stifle fair criticism, reaffirming the need for judicial tolerance in a free society.

3. Morality and Obscenity

The boundaries of morality have evolved with societal change. In **Aveek Sarkar v. State of West Bengal (2014)**, the Supreme Court adopted the "community standards test" to assess obscenity, holding that nudity per se is not obscene if intended for art or public good.

4. Reasonableness and Proportionality

In **Chintaman Rao v. State of Madhya Pradesh (1951)** and **State of Madras v. V.G. Row (1952)**, the Court formulated the test of reasonableness: restrictions must not be arbitrary or excessive relative to the purpose sought. The principle of **proportionality** now guides judicial review under Article 19(2).

FREEDOM OF EXPRESSION BEYOND PRINT: BROADCASTING AND DIGITAL MEDIA

1. Doordarshan and State Monopoly

In **Secretary, Ministry of Information and Broadcasting v. Cricket Association of Bengal (1995)**, the Supreme Court held that airwaves are public property, and their use must promote free speech and diversity. The judgment dismantled the state monopoly over broadcasting and paved the way for private channels and the **Cable Television Networks (Regulation) Act, 1995**.

2. Regulation of Television and Cinema

While film censorship under the **Cinematograph Act, 1952** has been judicially upheld, courts have insisted on procedural fairness. In **K.A. Abbas v. Union of India (1971)**, the Court recognized that film is a powerful medium requiring regulation but cautioned that classification must be reasonable and non-arbitrary.

3. Freedom and Responsibility in Digital Space

The rise of social media and digital platforms has redefined freedom of expression. The **Information Technology Act, 2000**, particularly **Section 66A**, criminalized "offensive" online

speech but was struck down in **Shreya Singhal v. Union of India (2015)**. The Court ruled that vague and subjective restrictions on digital expression violate Articles 19(1)(a) and 19(2), reaffirming that online speech enjoys the same protection as traditional media.

EVOLVING DOCTRINES IN FREE SPEECH JURISPRUDENCE

1. Prior Restraint

The doctrine of prior restraint prohibits pre-publication censorship. The Supreme Court consistently invalidates such restraints unless justified by exceptional circumstances, such as wartime secrecy or judicial orders safeguarding fair trial rights (e.g., *Sahara India v. SEBI*, 2012).

2. Public Interest and Right to Know

In **State of U.P. v. Raj Narain (1975)**, the Court recognized the **right to information** as an aspect of Article 19(1)(a), forming the philosophical basis for the **Right to Information Act, 2005**. Freedom of the press includes the public's right to receive information, ensuring informed participation in democracy.

3. Commercial Speech

In **Tata Press Ltd. v. MTNL (1995)**, the Supreme Court extended Article 19(1)(a) protection to **commercial advertisements**, recognizing them as expressions of economic freedom that facilitate consumer choice.

4. Hate Speech and Responsible Expression

In **Pravasi Bhalai Sangathan v. Union of India (2014)**, the Court condemned hate speech as antithetical to constitutional morality but refrained from judicial legislation, urging the legislature to frame guidelines. Courts thus maintain a cautious balance between free expression and social harmony.

DEMOCRATIC ACCOUNTABILITY AND THE ROLE OF THE MEDIA

The judiciary has frequently acknowledged media's role as the "public watchdog." In **Indian Express Newspapers v. Union of India (1985)**, Justice Venkataramiah observed that "the press has a solemn duty to serve as the guardian of public interest."

1. Investigative and Trial Reporting

While investigative journalism is constitutionally protected, trial reporting must not prejudice judicial proceedings. The Court in **Sahara India Real Estate Corp. Ltd. v. SEBI (2012)** evolved the doctrine of **postponement orders**, balancing freedom of the press with the right to a fair trial under Article 21.

2. Media Ethics and Self-Regulation

The **Press Council of India (PCI)**, established under the **Press Council Act, 1978**, functions as a quasi-judicial body promoting press ethics and independence. However, its powers are recommendatory, lacking enforcement mechanisms.

3. Judicial Oversight

Courts have intervened to prevent "media trials" that prejudice justice. In **R.K. Anand v. Registrar, Delhi High Court (2009)**, the Supreme Court cautioned against sensationalism undermining judicial process. The balance between media freedom and judicial restraint remains delicate.

FREEDOM OF EXPRESSION AND EMERGING CHALLENGES

1. Fake News and Misinformation

The digital revolution has facilitated the spread of misinformation, posing challenges to electoral integrity and public order. Courts emphasize that state regulation must target harm, not dissent.

The **IT (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021**, aim to regulate digital publishers, but concerns persist over vagueness and chilling effects on free speech.

2. Surveillance and Privacy

In **K.S. Puttaswamy v. Union of India (2017)**, the Supreme Court declared privacy a fundamental right, holding that surveillance measures must satisfy legality, necessity, and proportionality. This decision significantly impacts media freedom, particularly the protection of journalistic sources.

3. Censorship and OTT Platforms

The exponential rise of online streaming content has led to debates over censorship. Courts continue to balance artistic freedom with societal sensitivity, underscoring the principle that **creative expression cannot be suppressed merely because it offends** certain groups.

4. Freedom of the Internet

Digital access is now integral to free expression. In **Anuradha Bhasin v. Union of India (2020)**, the Supreme Court held that indefinite internet shutdowns violate constitutional principles of proportionality and due process, affirming that the internet is essential for exercising free speech.

ANALYSIS AND DISCUSSION

The evolution of media law in India reveals a **judicially driven expansion of free speech**. From the early rejection of censorship in *Romesh Thappar* to the digital rights affirmed in *Shreya Singhal* and *Anuradha Bhasin*, courts have consistently upheld expressive liberty as central to democracy.

However, the judiciary also recognizes that freedom entails responsibility. The application of Article 19(2) ensures that liberty does not degenerate into license. Yet, judicial restraint must coexist with state tolerance, as excessive regulation risks transforming democracy into paternalism.

In the digital age, the judiciary's challenge lies in extending constitutional principles to algorithmic governance, social media regulation, and transnational digital speech. Constitutional interpretation must evolve to safeguard freedom without undermining accountability.

FINDINGS

Freedom of expression under Article 19(1)(a) is the constitutional foundation of media freedom.
Judicial interpretation has expanded the scope of press and digital freedoms.
Reasonable restrictions under Article 19(2) must satisfy tests of necessity and proportionality.
Courts have balanced freedom with accountability in cases of contempt, defamation, and national security.
Digital transformation necessitates renewed jurisprudential approaches to protect speech in cyberspace.

SUGGESTIONS

Codify Media Freedom Standards: Enact a comprehensive media freedom law harmonizing print, broadcast, and digital regulation.
Strengthen Self-Regulation: Enhance autonomy and powers of the Press Council and digital media boards.
Judicial Oversight of Censorship: Mandate prior judicial approval for content restrictions affecting free expression.

Media Literacy and Ethics: Promote education on responsible journalism and public information verification.
Privacy Protection for Journalists: Institutionalize source confidentiality and protection against surveillance.
Periodic Review of IT Rules: Ensure digital regulations align with constitutional standards of free speech.

CONCLUSION

Freedom of expression in India stands as the cornerstone of its democratic identity. Through decades of constitutional evolution, the judiciary has elevated this freedom into a living guarantee—dynamic, inclusive, and resilient. The media, as both the conduit and custodian of this liberty, bears the responsibility of truth-telling and accountability.

The Supreme Court's jurisprudence—from *Romesh Thappar* to *Shreya Singhal*—reflects a consistent affirmation that free speech is not a privilege but a **democratic necessity**. Yet, the task of preserving this liberty is perpetual, especially as technology transforms the nature of communication.

The future of media freedom in India will depend on the delicate equilibrium between **constitutional fidelity and technological adaptation**, ensuring that the voice of the citizen remains both free and responsible within the world's largest democracy.

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