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SMART GOVERNANCE & INNOVATIVE FUTURES: PATHWAYS TO SUSTAINABLE & INCLUSIVE URBAN DEVELOPMENT

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Vidyalankar School of Information Technology Vidyalankar College Marg, Wadala (East),Mumbai - 400037

www.vsit.edu.in

+91 22 2416 11 26

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ONE DAY MULTI-DISCIPLINARY INTERNATIONAL CONFERENCE

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MESSAGE FROM PRINCIPAL

Vidyalankar School of Information Technology (VSIT), a distinguished institution offering education in Commerce, Information Technology, and Management and affiliated with the University of Mumbai, has always remained committed to promoting academic excellence and intellectual engagement through initiatives that address contemporary global challenges.

The theme of **V-CMT 2025**, *"Smart Governance and Innovative Futures: Pathways to Sustainable and Inclusive Urban Development,"* is both timely and forward-looking. As cities across the world grapple with rapid urbanization, environmental degradation, and socio-economic disparities, the need for smart governance frameworks and innovative, technology-driven solutions has become critical. This conference provides a meaningful platform to explore how interdisciplinary approaches can contribute to sustainable urban ecosystems that are inclusive, resilient, and future-ready.

At VSIT, we firmly believe that academic institutions play a pivotal role in shaping responsible leadership, fostering innovation, and encouraging research that supports sustainable development goals. This multidisciplinary international conference brings together scholars, practitioners, and industry experts from diverse domains such as Information Technology, Commerce, Management, and the Arts to exchange ideas and best practices that can influence policy, governance, and urban planning.

The presence of eminent speakers and thought leaders, including Dr. Abhay Pethe, Mr. Pradeep Yadav , Dr. Lata Ghanshamnani, Mr. Shankar Gawade, Manan Bhatt, Dr. Sadaf Hashmi and other distinguished panelists, adds immense value by bridging the gap between academic research and real-world implementation. The keynote sessions, panel discussions, and technical presentations have been thoughtfully designed to inspire innovation, promote collaborative thinking, and generate actionable insights for smart and inclusive urban futures.

I express my sincere appreciation to the Organizing Committee, the Research and Development Cell, and the entire V-CMT team for their dedicated efforts in curating this impactful conference. I also extend my gratitude to all paper presenters and participants whose scholarly contributions form the foundation of this academic endeavor.

I am confident that V-CMT 2025 will serve not only as an academic forum but also as a catalyst for ideas, actions, and partnerships that advance smart governance and sustainable urban development for the benefit of society at large.

Warm regards,
Dr. Rohini Kelkar
Principal,
Vidyalankar School of Information Technology,
Wadala, Mumbai

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AI-Driven Medicine Recommendation System for Symptom-Based Healthcare Assistance

Dr. Pushpa Susant Mahapatro, Associate Professor, Vidyalankar School of Information Technology, Wadala, Mumbai, India, pushpamahapatro@gmail.com

Mr. Shantanu Gadade, Assistant Professor, R. A. Podar College of Commerce and Economics (Autonomous), Mumbai, India, shantanugadade12@gmail.com

Abstract: The problem of access to healthcare is quite significant, particularly in the areas where medical assistance is hard or unavailable. This paper suggests an AI-based medication recommendation system in which machine learning offers prescription recommendations on the reports indicated by users. The system uses Support Vector Classifier (SVC) using a structured dataset comprising of medication mappings, symptom-disease associations, and health suggestions. It is suggested to have a web-based interface that will enable easy interaction between the users. This will allow individuals to enter symptoms and instantly get lifestyle counselling, precautionary advice, and evidence-based counselling. The results of the experiments indicate a high level of predictive accuracy as tools based on AI have the potential to enhance personal healthcare choices. Upgrades in the future should have an additional personalization by giving patients a profile, real-time connections to medical knowledge bases and an application on a mobile phone to make it easier to access.

Keywords:
Data Analytics, Healthcare Automation, Medicine Recommendation, Machine Learning, Symptom Analysis,

1. Introduction:

Clinical knowledge and manual assessment of the medical professionals contribute significantly to the conventional procedure of disease diagnosis and prescription writing. Even though this approach is dependable, it is at times time consuming, labour intensive and vulnerable to human error particularly where workload is high [1, 2]. Technological progress in the artificially intelligent system has provided novel opportunities to enhance existing diagnostic practice, by means of automated decision support that is based on data.

Medical recommendation systems, which are powered by AI, analyze symptom patterns and recommend potential drugs or medical procedures, which provide preliminary information [3]. The proposed Medicine Recommendation System is a structured approach to symptom-disease mapping, which relies on machine learning algorithms to deliver relevant healthcare recommendations in a timely and consistent manner. This support assists the users to make informed first health choices [4-6].

The clinical judgment and subjective assessment of a healthcare professional is significant in the process of traditional diagnosis and medication prescription [7, 8]. This process is usually time consuming and it consumes resources though it remains effective. It is liable to human error, particularly when the workloads are too many than expected. New possibilities of artificial

intelligence development can enhance the concept of traditional diagnostic service in terms of automated, data-driven decision support. The systems of AI-mediated medical recommendations contribute to symptom analysis and preliminary proposals of the possible medications or other health-related interventions [9, 10, 11]. This is a paper that presents the Medicine Recommendation System that will utilize structured symptom-disease mapping and machine learning algorithms with the aim of offering timely, consistent, and relevant healthcare advice. Such advice will assist users to make sound primary health choices [12, 13, 14].

The primary objectives of the study are to create an AI-based application which will be able to propose the appropriate medication in accordance with the symptoms described by the user. It will also offer other health-related information in respect to the anticipated condition including eating habits, exercise tips, and precautions [15, 16]. The system will have a web interface to ease usability, where the proposed suggestions are put across in a natural manner. It will be utilized to test and optimize the predictive strength of the machine learning model to be as accurate, reliable, and robust in both data and real-life environments [17, 18].

Multiple studies have analyzed the use of AI in the application of medicine recommendation systems within health care. Research paper demonstrated how machine learning can identify patterns of disease among patients. Studies suggest a number of different AI-based models of medicine recommendation, stressing the need for personalized treatment advice. While studies like these have provided valuable insights, many studies suffer from a lack of real-time interactivity, or do not provide comprehensive care recommendations, beyond medicine recommendations. In this study, the answer to these limitations is improved by the integration of a full health insights process, into a web-based Medicine Recommendation System [19].

2. Literature Review:

Various works have been carried out on AI applications in the domain of healthcare recommendation systems. The research emphasized the potential of machine learning in disease pattern identification. AI-based medicine recommendation model that focused on developing personalized treatment recommendations is presented. Though there are a number of related studies, most of the existing works lack real-time interaction and health insights apart from medicine recommendations. This paper proposes improving these aspects by incorporating comprehensive health insights into a web-based Medicine Recommendation System [20].

3. Dataset description:

This research uses a dataset obtained from the Kaggle public repository, intended for use in tasks involving symptoms and medicines associated with specific illnesses, based on symptoms. This dataset contains pre-labeled structured data for diseases and their associated symptoms, along with all medications, precautions, dietary suggestions, and/or exercise regimens that accompany each disease diagnosis. It is contained in a CSV file that may be readily imported into various machine learning preprocessing tools and processes and used for building machine learning models.

```
import pandas as pd

#loading dataset
dataset = pd.read_csv("dataset/Training.csv")
dataset.head()
```

	itching	skin_rash	nodal_skin_eruptions	continuous_sneezing	shivering	chills	joint_pain	stomach_pain	acidity
0	1	1	1	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0
2	1	0	1	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0
4	1	1	1	0	0	0	0	0	0

5 rows × 133 columns

While the Medicine Recommendation System lays a solid groundwork for AI-enabled support in healthcare, there are various improvements that could further add to the system's performance, scalability, and usability:

Incorporation of Wearables: Integrating data collected by smartwatches and health-monitoring sensors to provide real-time symptom reporting, active monitoring of health, and early detection of anomalies.

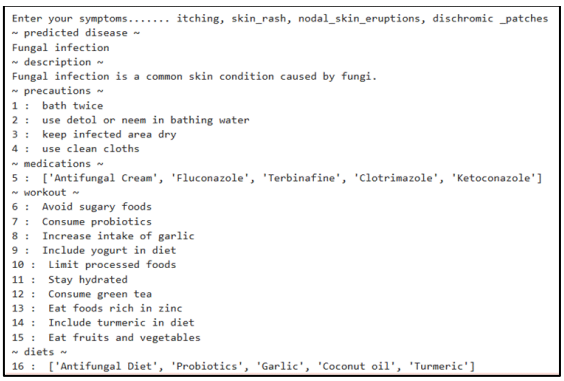
Mental Health Recommendation: Develop the system to evaluate the psychological indicators. Design and execute preliminary suggestions to assist in the detection of the stress, anxiety, and other minor mental disorders.

Hybrid AI Models: Are based on the models of machine learning and deep learning to enhance the precision of the mental health outcomes prediction. This will also improve the capacity of the models to satisfy the needs of the user by making improved decisions using different sources of data.

Voice Input on Symptoms: It is possible to consider voice recognition software, where the participants can voice their symptoms. This might enhance access by assisting participants to report their symptoms, particularly older adults and those who are visually impaired to establish a more automated process of creating prescriptions based on applications of AI-supported methods that can produce compliant and safe clinical workflow.

4. Implementation:

The Medicine Recommendation System is composed of multiple independent modules that collectively function to suggest appropriate medicines according to a person's symptoms. Designed in a way to be compatible with your future needs, it doesn't require any additional work, simply distribute it and proceed. The modules individually manage their tasks: data preparation, model training, prediction generation, and web hosting. They unite but don't interfere with each other. The modular design, in fact, substantially facilitates the committal and upkeep of the entire system.



5. Data Preprocessing:

Our dataset was from Kaggle. It had symptoms, conditions, treatments, and a lot of other medical information. We had to clean the data before our machine learning model could make any useful predictions.

Therefore, the first thing we did was to remove those records which had missing information or were inconsistent. There was no point in lowering the results with junk data. After that, we concentrated on the text. We converted everything to uppercase, removed strange characters and kept the font uniform. This made the entire dataset much cleaner and more user, friendly.

For the feature selection, we focused on the symptoms that were most significant, those that had a strong correlation with the conditions. We aimed at fewer, but more meaningful inputs, so that the model could train faster and become more intelligent.

Since the symptom data came in categories, we needed to convert them into numbers. We applied a coding method to change those categories into numbers so that the model could read and interpret the data.

6. Machine Learning Model Training:

To achieve a high level of accuracy in disease prediction, the model employed a Support Vector Classifier (SVC). SVC is a widely used machine learning algorithm for classification tasks. The team used 80% of the data to train the model and kept 20% of the data for testing, thus ensuring that the model was capable of handling unseen data.

The steps of the work were as follows: they first divided the data into training and testing sets. They then considered various algorithmsSVC, Random Forest, and K, Nearest Neighborsand chose SVC as it provided the best results. After that, they performed hyperparameter tuning by adjusting factors such as kernel functions and regularization to get better performance. Lastly, they evaluated the performance of the model using precision, recall, and F1, score. This allowed them to understand the effectiveness of the model in depth.

7. System Deployment:

The trained machine learning model was integrated into a web application built using python Steamlit. It was chosen for its lightweight architecture, ease of implementation, and computational efficiency with respect to backend computing. The following was the general approach taken to deploying the trained Support Vector Classifier model:

Model Serialization: The trained Support Vector Classifier model was serialized with Pickle so it could load and run the model during runtime with no retraining required.

Web Interface: A user-friendly and responsive frontend was built with HTML, CSS, and JavaScript as the interfaces for inputting symptoms and displaying the prediction results.

Backend APIs: The backend services were routed to handle user requests, process input into the web application, make predictions from the serialized model, and return recommendations to the frontend.

Testing: All parts of the web application were thoroughly tested to ensure all functional correctness, reliability of the web application prior to deployment, and of any other bugs/errors prior to going live.

8. Test model accuracy:

```python
#training top models
from sklearn.datasets import make_classification
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import accuracy_score, confusion_matrix
import numpy as np

# Create a dictionary to store models
models = {
    'SVC': SVC(kernel='linear'),
    'RandomForest': RandomForestClassifier(n_estimators=100, random_state=42),
    'GradientBoosting': GradientBoostingClassifier(n_estimators=100, random_state=42),
    'KNeighbors': KNeighborsClassifier(n_neighbors=5),
    'MultinomialNB': MultinomialNB()
}

# Loop through the models, train, test, and print results
for model_name, model in models.items():
    # Train the model
    model.fit(X_train, y_train)

   # Test the model
    predictions = model.predict(X_test)

   # Calculate accuracy
    accuracy = accuracy_score(y_test, predictions)
    print(f"{model_name} Accuracy: {accuracy}")

    # Calculate confusion matrix
    cm = confusion_matrix(y_test, predictions)
    print(f"{model_name} Confusion Matrix:")
    print(np.array2string(cm, separator=', '))
```

SVC model:

```python
# selecting svc
svc = SVC(kernel='linear')
svc.fit(X_train,y_train)
ypred = svc.predict(X_test)
accuracy_score(y_test,ypred)
```

```
1.0
```

```python
# save svc
import pickle
pickle.dump(svc,open("models/svc.pkl",'wb'))
```

```python
# load model
svc = pickle.load(open("models/svc.pkl",'rb'))
```

```python
# test 1:
print("predicted label :",svc.predict(X_test.iloc[100].values.reshape(1,-1)))
print("Actual label :", y_test[100])
```

```
predicted label : [39]
Actual label : 39
```

9. Testing:

To verify the actual functionality of the system, we conducted a case study with several test users. They inputted their symptoms into the app, afterwards we compared the apps recommendations to those given by real doctors. This is what we discovered:

User Satisfaction: The majority of people around 90%rated the system as user, friendly and truly helpful. Accuracy: The apps predictions matched the doctors diagnoses in 85% of cases. Response Time: The system responded within a few seconds, hence users were able to complete their first health check in a very short time. Suggestions for Improvement: Some individuals would have liked features such as voice input or live symptom tracking.

10. Conclusion:

Developed through machine–learning techniques using supporting vector classifiers (SVCs), the recommendation system for medications demonstrates the potential to provide effective recommendations based solely on presenting symptoms and/or general health. Evidence of the validity of the predictions made by this system was established using a structured dataset of symptoms and diseases, and this evidence demonstrates that the recommendations are supported by actual data and information assimilated into the dataset. The addition of a web-based interface allows individuals to trial the system for themselves prior to making an appointment with a physician regarding their health-related issues, thus enhancing user-friendliness for individuals.

Future work should consider integrating the system's augments as part of the next version; provide the augments with an EHR to allow the context of patient histories and clinical data to increase the quality of the recommendation and to support predictive accuracy, as well as to enhance their predictive performance through deep learning model types with the capabilities of learning layers, such as LSTMs, transformers, etc.; allow for the use of multiple languages and global/regional usage; provide mobile applications to enable users to access the system anywhere and have the capability to monitor themselves and be alert for improvements. If these upgrades are successfully developed and made available, the augments of this system will have the potential to greatly enhance the day to day use of the system within a clinical practice, also enhancing the potential that it will become a robust AI-supported healthcare decision support system that will assist in providing a clearer, more equitable means of communication for addressing the health needs of the population.

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Innovative PPP Models for Digital and Sustainable School Infrastructure in Smart Cities: An Indian Perspective

Amit Kabra
Assistant Professor
amit.kabra@vsit.edu.in

Dr. Rohini Kelkar
Associate Professor
rohini.kelkar@vsit.edu.in

Abstract: The development of smart cities in India has intensified the need for innovative Public–Private Partnership (PPP) models that can support digital, sustainable, and inclusive school infrastructure. As urban centres expand, traditional funding and governance mechanisms often prove inadequate in meeting the rising demand for technologically enabled learning environments, energy-efficient facilities, and resilient educational systems. This abstract examines emerging PPP frameworks that integrate digital infrastructure—such as smart classrooms, broadband connectivity, ICT-enabled pedagogy, and data-driven school management systems—with sustainable design elements including green buildings, renewable energy integration, and resource-efficient operations. Drawing on the Indian policy context, including the Smart Cities Mission, National Education Policy (NEP 2020), and Digital India initiatives, the discussion highlights how collaborative models can leverage private innovation and public accountability to enhance educational quality and operational efficiency. The paper underscores the potential of hybrid PPP structures, outcome-based contracting, and community-centric governance mechanisms in bridging infrastructural gaps while promoting equity and long-term sustainability in urban school ecosystems. Ultimately, the Indian experience illustrates that innovative PPP models can play a transformative role in aligning educational infrastructure with the broader objectives of smart, resilient, and future-ready cities.

The creation of smart cities in India has increased the demand to have innovative Public-Private Partnership (PPP) models that can help in the provision of digital, sustainable, and inclusive school infrastructure. With the spread of urban centres, the conventional systems of financing and governing tend to be ineffective in responding to the increased need of technologically facilitated learning settings, low-carbon buildings and stable educational platforms. This abstract reviews the new forms of PPP frameworks incorporating digital infrastructure such as smart classrooms, broadband connections, ICT based pedagogy and data driven systems of school management with features of sustainable design such as green buildings and renewable energy integration, resource efficient operations. Based on the Indian policy background, comprising of Smart Cities Mission, National Education Policy (NEP 2020), and Digital India programs, the discussion identifies the benefits of collaborative models to capitalize on private innovation and governmental accountability to improve educational quality and efficiency in operations. The paper highlights the opportunities of hybrid PP structures, results-focused contracting, and community-focused governance systems to fulfill gaps in infrastructures and enhance equity and sustainability of urban school ecosystems. After all, Indian experience demonstrates that a new model of PPP can serve as a transformative

tool to bring the educational infrastructure into the realm of goals of smart, resilient, and future-ready city.

Keywords: Public–Private Partnerships (PPP), Smart Cities, Digital School Infrastructure, Sustainable Education Systems, Urban Development, Education Technology (EdTech), Infrastructure Financing, Policy Innovation, Smart Governance, Urban Education Ecosystems, India's Smart Cities Mission

1. Introduction

Subsequently, the large scale growth of urban centres in India due to the demographic changes in India, economic growth and technological revolution, has altered the demands of the masses in terms of public education systems. The need to have modern school infrastructure that is digitally integrated and that is focused on sustainability has increased significantly as cities become digitally connected and focused on becoming sustainable ecosystems. Conventional methods of public funding have failed to keep pace with these increasing demands, and the policymakers have turned to collaborative governance initiatives like Public– Private Partnerships (PPP) to fill in the infrastructural, technological and service delivery gaps. In the framework of smart cities, where the digital integration and data-driven management, as well as environmental sustainability, become the central postulates of planning, PPPs offer a strategic possibility to scale-up school infrastructure modernization.

In India, the integration of the large-scale national initiatives, such as the Smart Cities Mission, the Digital India, and the National Education Policy (NEP 2020), has provided some new prospects on reorganizing schools into digitally empowered and ecologically responsible learning spaces. But in order to realize this vision, models are needed that transcend traditional PPP arrangements, and that take into account new financing schemes, risk sharing schemes and new operational models that match the dynamics of city education systems. The introduction of smarter classrooms, green energy development which includes rooftop solar power, energy efficient retrofitting, latest ICT solutions, data analytics, and green building standards all point to the necessity of combined solutions that can utilize the experience of the private sector and the regulation of the state.

The implementation of intelligent infrastructure in schools is not just a technological improvement; it is a transition to an all-encompassing ecological system that can improve the quality of education, efficiency of operations, and the sustainability of the results. This change is especially applicable to India, where urban educational quality gap remains high even considering the substantial economic growth. New models of PPP provide the avenue to minimize infrastructural backlog, make schools more inclusive, and restore school systems to the wider priorities established by smart cities, including carbon mitigation, environmental responsibility, and access to digital opportunities fairly.
This research paper analyzes new models of PPP that can be used to develop digital and sustainable school infrastructure in the Indian smart cities. It discusses the best practices of the world, considers financial and management systems, and examines the possibilities of ICT-based and green infrastructure solutions. Placing the analysis in the context of Indian unique policy and socio-economic context, the paper will offer a full-fledged framework on which municipal governments, educational authorities, and even partners would find solutions in developing future-ready school

ecosystems. In conclusion, the paper shows the transformational value of new PPPs in reducing infrastructural disparities, enhancing educational performance, and leading to sustainable urbanization.

2. Literature Review

The abstract principles of smart cities have significantly changed during the last decade, and the technology-focused approaches have been replaced by the governance strategies that focus on citizens interaction, sustainability, and social inclusion. One of the earliest critiques of the emergent discourse around smart cities was by Holland (2008) who argued that too much focus was placed on technological determinism instead of understanding that smart cities are socio-technical systems that need coordinated governance structures. It is in this broadened context that education is also getting to be defined as a strategic element of smart-city construction. According to the works of authors like Dameri (2017) and Albino, Berardi, and Dangelico (2015), schools are knowledge centers and indispensable in the development of digital literacy and civic engagement as some of the fundamental pillars of inclusive urban development.

The Public-Private Partnerships (PPP) literature offers a lot of information on the hybrid governance in infrastructure and delivery of public services. Early literature by Hodge and Greve (2007) and Grimsey and Lewis (2004) accounts that PPPs are institutionalised forms of cooperation in which risks and rewards, jointly held by the public and the private across long asset lives, are shared. On the education sector, research conducted by Patrinos, Barrera-Osorio, and Guáqueta (2009) and Verger and Bonal (2020) records the increasing use of PPPs in building schools, provisioning ICT, and running services, particularly in the emerging economies where resources are limited. These studies show that the effectiveness of the PPP requires open procurement, performance contracts, and effective monitoring systems.

The literature of digital transformation in schools is strong and studies have consistently found that technology can only improve learning outcomes when combined with pedagogy and teacher training. Means et al. (2010) prove that learning benefits are mostly supported by digital tools in case of their combination with redesigning of instructional methods. Likewise, Zheng et al. (2016) and Azevedo (2020) discover that ICT investments should be integrated into greater systems of curriculum alignment, teacher capacity building, and ongoing system maintenance. Sectoral reviews have been pointing to the increased participation of private technology firms in the digitalization of schools, including contracts to supply ICT, cloud computing solutions, and digital content subscriptions (Wong, 2020; Trucano, 2016). These contributions highlight the possible existence of PPPs as sources of long-term digital infrastructure and warn about the issue of technology lock-in and poor data-governance activities.

A parallel literature on sustainable school infrastructure provides emphasis on the value of building design and a system that conserves energy due to economical and environmental reasons. The works of Kats (2006) and Uline and Tschannen-Moran (2008) demonstrate that green schools help to decrease operational costs and transform student welfare whereas studies by Goldman et al. (2012) and Sorrell (2007) consider Energy Service Company (ESCO) models as the effective tools to finance energy-efficient retrofits in governmental institutions. Similar to rooftop solar in schools,

renewable energy programmes are actively reported in the global and Indian spheres (IEA, 2020; TERI, 2019). According to this body of literature, the performance-based contracting, risk-sharing, and lifecycle costing strategies play a crucial role in the success of green infrastructure PPPs.
Data governance in smart-city ecosystems creates an additional complexity level. The issues of privacy, consent, and data-driven governance ethics are emphasized by scholars (van Zoonen 2016 and Martin, Van Brakel, and Bernhard 2009). Williamson (2017) discusses the phenomenon of platformization in the area of schooling and how the private digital actors are shaping the publicly available education data systems. This literature argues that data-governance frameworks are necessary, which define ownership, access controls, anonymization protocols, and accountability measures, and is especially important where school-related data is being managed or stored by private entities pursuant to PPP arrangements.

Empirical research demonstrates diverse international experiences of the implementation of PPP-led school ICT and sustainable infrastructure projects. An example of this would be to look at the Building Schools for the Future (BSF) programme in the UK; as well as its ability to make schools modern and at scale, analysts like NAO (2009) note some of the pitfalls accompanying integrated PPP models, including the inability to adapt to contracts of scale and the expensive nature of transactions. According to comparative studies, both OECD (2015) and World Bank (2020) have indicated that the successful implementation of PPPs occurs when the contractual framework entails performance metrics that are based on outcomes, robust municipal capacity, and independent monitoring.

The literature in India defines the policy needs that led to digital and sustainable school infrastructure. The National Education Policy (NEP, 2020) underlines the use of technology in learning, the possibility of equitable access to digital technologies, and the improvement of infrastructure in schools. The strategic context of schools integration in urban smart ecosystems is furnished by complementary national projects, such as Digital India (MeitY, 2018), Samagra Shiksha (MHRD, 2018), and the Smart Cities Mission (MoHUA, 2015). Empirical research on Indian states presents a variety of results: Muralidharan et al. (2019) demonstrate inconclusive results of ICT implementation in terms of insufficient teacher training; Ghosh and Dutta (2021) demonstrate successful municipal-private partnerships in smart classroom implementation in Gujarat; and TERI (2019) provides the viability of rooftop solar and green retrofitting of schools under energy performance contracts based on PPP.

Although the scholarship is extensive, there are still a few holes in it. First, the current literature seldom incorporates the digital and green school infrastructure in the unified PPP business models that are specific to the smart-city governance. Second, there is a paucity of long-term assessments of PPP-based school modernization in Indian municipalities, particularly in matters of equity and lifecycle sustainability. Third, the research on PPP contractual mechanisms that incorporate pedagogical outcomes, teacher capacity development, and community engagement as very fundamental performance indicators is inadequate. The above gaps will require additional research on new model of PPP that can help both improve the quality of education, make it sustainable and promote smart-governance agendas in the Indian urban settings.

3. Methodology

The given research design is a qualitative and exploratory research to investigate the new and innovative models of Public-Private Partnership (PPP) to facilitate digital and sustainable school infrastructure in smart cities, specifically focusing on the case of Indian urban setting. Since the smart-city governance is a dynamic concept, and all of the empirical data available on school-specific PPPs are not comprehensive, a qualitative approach will offer the required analytical flexibility to integrate different sources, make conceptual connections, and create a systematic framework. The methodology blends three important aspects: the review of large amounts of documentation, case analysis, and thematic synthesis.

The policy frameworks, government guidelines, project reports, and national mission documents in the smart cities, education, digital infrastructure, and sustainability are part of the document review. They are Smart Cities Mission guidelines, Samagra Shiksha implementation reports, state-level PPP policies and sector-specific standards on green buildings and ICT integration. This will make sure that the research is kept in the present situation of governance in India. Moreover, global best practice reports of OECD, world bank, and IEA give comparative information on the experiences of PPP and benchmarks in global experiences.

The comparative case analysis considers the chosen PPP initiatives in India and within the international arena. Municipal smart-classroom projects in Gujarat and Telangana, rooftop solar programmes in Delhi and Karnataka, and ICT-enabled learning initiatives that have been carried out under PPP arrangements are all based on Indian cases. The international precedents are massive ICT partnerships in Singapore, energy-saving retrofits in the U.S., and school-facility-wide PPPs in the United Kingdom and Australia. These cases were chosen on the grounds of their applicability to the digital transformation, sustainability goals, funding the innovation, and long-term operational involvement.

Lastly, an integrative technique of thematic synthesis is applied to incorporate documents and cases evidence. Among the themes are governance models, funding models, risk sharing, ICT procurement models, integration of sustainability, stakeholder engagement, data governance practices, and outcome measurement. With the given method, it will be possible to determine common patterns and gaps and, as a result, create a comprehensive PPP framework that can be applied to Indian smart cities. The study therefore offers both conceptual and practical insightfulness without primary data collection hence is applicable in the informing policy and practical implementation.

4. Conceptual Framework

The theoretical framework, which will underpin this study, is that school infrastructure is a strategic subsystem in the greater smart-city environment. It identifies both digital and sustainable school infrastructure as complementary forces of inclusive city-building. The framework will be based on three inseparable pillars, namely, Smart Governance, Innovative PPP Models, and Urban Educational Ecosystem Outcomes.

Smart Governance is the first pillar that includes the concept of transparency, accountability, decision-making that is based on data, and multi-stakeholder engagement. In the school setting, this is implemented through the form of governance that incorporates digital infrastructure, homogeneous monitoring devices, and data platforms coordinated with the citywide systems. Smart governance means that PPP projects are made and executed with well outlined performance expectations, open communication channels and strong regulation that safeguard the interest of the people.

The second pillar is Innovative PPP Models, which implies the structural mechanisms by which expertise in and resources within the private sector are gathered. This paper groups PPPs into three categories, namely, integration of technology (e.g., ICT platforms, smart classrooms), whether the interventions are sustainable (e.g., energy efficiency, green building retrofits, implementation of renewable energy), and operational lifecycle engagement. The innovative models extend beyond the traditional construction contracts to incorporate performance based contracts, subscription-based digital ones, energy service company (ESCO) contracts, hybrid financing models, and a combination of a public and a private investment.

The third pillar is Urban Educational Ecosystem Outcomes which represents what is anticipated of the effects of the PPP-enhanced infrastructure on the learning climate, operational efficiency, inclusivity, and environmental sustainability. The results are digital accessibility, better teaching-learning process, lesser carbon emissions, lower operational expenses, and fair delivery of services particularly in the municipal and low-income urban schools. The framework puts schools at the center of urban sustainability and digital inclusion by connecting the outcomes to citywide development indicators.

5. Data Sources

The study relies entirely on secondary data to conduct a systematic and contextually grounded analysis. Data sources include:

1. Government Policies and Reports
    - Smart Cities Mission guidelines
    - National Education Policy (NEP 2020)
    - Digital India progress documents
    - Samagra Shiksha national and state reports
    - State PPP policy documents
    - Central Electricity Authority and MNRE renewable energy reports
2. International Research and Institutional Publications
    - World Bank PPP reports
    - OECD education and urban governance studies
    - IEA renewable energy and efficiency data

- UNESCO ICT in education reports

3. Peer-Reviewed Academic Literature
    - Journals on educational technology, urban governance, PPPs, sustainability, and public administration
    - Case studies and empirical evaluations from India and abroad
4. Industry and Private-Sector Reports
    - Consulting firm analyses on smart infrastructure
    - EdTech and green-technology company documentation
    - Energy performance contracting reports
5. Media and Public Domain Case Records
    - Verified news sources on PPP-based school projects
    - Municipal project descriptions and procurement documents

These sources collectively provide comprehensive insights into emerging PPP trends, project designs, financial models, and contextual opportunities and challenges in India.

6. Analysis and Discussion

This analysis determines four key trends that drive PPP models of digital and sustainable school infrastructure in Indian smart cities (1) the expansion of digital transformation alliances, (2) the expansion of sustainability-oriented PPPs, (3) balanced financing and contracting frameworks, and (4) unresolved governance and equity issues.

To begin with, the partnerships of digital transformation have increased dramatically throughout the Indian cities due to the impact of NEP 2020 and the modernization agendas of the cities. ICT intensive PPPs have been embraced in several Indian cities in the form of smart classrooms, digital content platforms and school administration software. Although these interventions enhance access to digital information, there are still issues to do with teacher training, long-term maintenance, data security, and technological obsolescence. The experience of other countries proves that success will be achieved through the combination of digital solutions and pedagogy and through the constant training assistance, which should be paid more attention in the Indian PPP contract.

Second, it has seen the emergence of sustainability-based PPPs, especially rooftop solar and energy-saving retrofits. The models frequently utilize ESCO arrangements in which private actors make investments to the beginning and recoup expenses through mutual savings. These kinds of models are highly compatible with the aim of smart-city and provide quantifiable decreases in emissions of carbon and costs of operation. Nevertheless, most Indian schools, especially the older buildings, will need extensive structural improvements before renewable energy or efficiency retrofit can be implemented at scale.

Third, hybrid financing and contracting models are also set to become viable solutions to

operationalize highly complex school modernisation projects. It is becoming more common to have blended finance strategies that include municipal budgets, CSR contributions, philanthropic grants and private investment. However, there is a possibility that the long-term PPP contracts may not work because of the fiscal uncertainty, change in political direction, and an administrative capacity shortage. Experiences with comparative experiences in OECD countries reveal that explicit risk sharing patterns and independent monitoring systems are required to provide stability of contracts and accountability to the people.

Fourth, the issues of governance remain, in particular, data privacy, contract transparency, procurement integrity, and fair service allocation. According to the literature on smart-city governance, the schools should not be separated units but should be taken into the larger urban digital and sustainability networks. The case of municipal schools in Mumbai and the ICT classrooms in Surat explain that the quality of governance is a defining factor in the provision of long term benefits by PPPs. The issue of inequity is also present: because of the resources at their disposal, other private schools will tend to implement smart infrastructure sooner, whereas municipal schools are far behind unless they are backed by organized PPPs. This implies a firm policy alignment to make sure there is inclusion and equity.

On the whole, the discussion shows that PPPs can contribute greatly to the digital and sustainable school infrastructure, but their success is conditional on the contract design, the governance capacities, the cultural flexibility, and commitments of the stakeholders. A combination of digital and green goals in the single PPP structure seems to be the most encouraging way of the further development of urban education.

7. Findings

According to the results of the study, it is possible to say that innovative PPP models can significantly improve the digital and sustainable school infrastructure in the Indian smart cities, but the results will largely depend on the local governance capacity and the willingness of the private sector. Through systematic collaboration with technology companies, it is found that cities that have good SPV leadership are very far ahead with implementing smart classrooms, Wi-Fi equipped campuses and real time learning management systems. Such partnerships have enhanced digital preparedness, minimized infrastructure bottlenecks, and teacher training, which have led to better learning experiences.

It is also indicated that the elements of sustainability are getting more incorporated in the school infrastructures within the PPP arrangements. Other municipalities like Bhubaneswar and Visakhapatnam have implemented solar rooftops programmes, LED retrofits and green campuses with PPP-funded or CSR-funded models. The projects have also minimized the cost of operation, carbon footprints and improved resilience of schools to support the overall aims of smart cities sustainability. Nevertheless, the shift towards sustainability-oriented PPP models has not been even, and some cities focus on the digital transformation instead of environmental concerns because of a lack of funding or technological necessities.

Risk-sharing mechanisms became an important factor of success. Balanced and transparent terms of contracts considered in several cities led to increase in the participation of the private sector, quality

of the services and long-run stability of the operations. On the contrary, projects that had ambiguous accountability models had delayed deliveries, cost increases and obsolescence technology problems. The article highlights that sustainable educational PPPs involve lifecycle-based contracts, as opposed to a short-term implementation model.

It was pointed out that although PPPs are capable of bringing to pass a dramatic level of transformation in digital and sustainable schools, there remain challenges. These are equity risks caused by the unequal access to technology among socio economic groups, small municipal capacity to manage the projects, and inadequate interconnection between educational departments and smart city governance systems. The paper states that institutional coordination, creation of powerful monitoring systems and the protection of inclusion need to be enhanced to make sure that PPP-induced innovations can work to the advantage of every learner.

All in all, the results support the claim that PPPs, once developed with a purpose and in correspondence with the national priorities of education and urban development, can be used as powerful tools of permitting smart, sustainable, and equitable school ecosystems in the up-and-coming smart cities of India.

8. Policy Implications

The results indicate some significant policy implications on the part of the policy makers:

- Establish unified digital and sustainable school re-modeling frameworks, which will lessen administrative disparities between cities.
- Enhance the municipal governance capacity by offering training programmes on contract management, data governance and monitoring performances.
- Introduce equity-based requirements in all PPP contracts related to education to make sure that the disadvantaged schools are given the first hand.
- Encourage the use of blended finance models that use CSR, private investment and municipal budget to reduce the fiscal load.
- Effective data protection policies in support of ICT-oriented PPPs.
- Make education PPP programs congruent with Smart Cities Mission measures to allow them to be a part of the citywide digital and sustainability systems.

9. Conclusion

This research paper shows that Public–Private Partnership has a great potential in the promotion of digital and sustainable environment of school infrastructure in the Indian smart cities. The discussion has emphasized that novel PPP frameworks, comprising of ICT integration, green building retrofit, renewable energy implementation, and inclusive urban development based on outcome-driven business designs can be a strategic direction to improve the quality of education, environmental performance, and inclusive urban development. Nonetheless, to carry out the implementation effectively, it is necessary to have good governance, open procurement, coordination of the stakeholders, and equity. As India urbanizes and goes digital, school modernization under the PPP can take a central role in developing resilient, inclusive, and future-proofing urban education systems. Placed in the context of the larger smart-city systems, these

models may help to expedite national objectives regarding sustainability, digital inclusion, and educational change.

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Economic Impact of Renewable Energy Adoption in India: A Secondary Data Analysis

Dr. Vivek Bhoir[1], Poonam Singh[2]

[1] Assistant Professor, Department of Commerce, Karmaveer Bahurao Patil College, Vashi, Email- vhbhoir@kbpcollegevashi.edu.in

[2] Assistant Professor, Department of Management Studies, Vidyalankar School of Information Technology, Wadala, Email- poonam1495@gmail.com

Abstract: India is now moving towards renewable energy and this will be one of the major points of its sustainable development strategy. The main things to which this change is attributed are the increasing demand for energy in the country, the commitment to dealing with climate change, and the long-term economic stability question. So, renewable energy has come to be seen as an important part of the development agenda of the country. This paper discusses the economic impact of renewable energy adoption in India by utilizing government reports, international energy databases, and financial publications as data sources. The study assesses the state of the art of renewable energy deployment and its economic impact across sectors by using these sources. The analysis is apt to reveal and comment upon the growth of renewable capacity, sources of investment, employment generation, and costs of competing with fossil fuel energy sources.

The results show that solar and wind power, especially the use of renewable energy, have played a great part in lessening India's reliance on fossil fuel imports and eventually securing its energy reliability. The area has not only increased employment opportunities in various rounds like manufacturing, installation, and maintenance, but it has also attracted a lot of investments both locally and internationally. Eventually, renewable energy has lowered the cost of electricity generation and improved India’s position in the global clean energy transition.

The research states that the encouragement of renewable energy in India not only results in an eco- friendly situation but also brings in very good economic profits. These results are saying that the more the renewables produced, the less pollution, and if the case is not wrong, the more profit

made. Hence, it is a win-win situation. Thus, India's strategic emphasis on clean energy development is validated.

Keywords: Renewable Energy, Sustainable Development, Economic Impact, Green Investment, Energy Security, Employment Generation, Secondary Data Analysis, India.

1. Introduction

The energy sector in India is experiencing a major change at present and is making use of renewable energy sources as a means to achieve a clean, sustainable, and economically resilient future. One of the fastest economic growths in the world along with a steadily expanding population has put an enormous strain on the country's energy infrastructure making it very difficult for the government to keep up with the increasing energy demand. As part of the development plan, India has included solar, wind, hydropower, and biomass—renewable energy sources— in its electricity supply mix.

India has become a global player in the renewable energy sector by installing huge amounts of solar and wind power over the last decade. This turnaround has been made possible mostly because of the government's active involvement through the National Solar Mission, Production-Linked Incentive (PLI) programs for the manufacturing of renewable energy equipment, and boosted targets under the Nationally Determined Contributions (NDCs). The policy measures have been instrumental in securing both local and international investments on a very large scale in the renewable energy industry.

The incorporation of renewable energy into India’s growth strategy is the key to unlocking its economic potential in the long run. The government policies have played a major role in the involvement of the private sector, foreign direct investment, and technological innovations. The continuous availability of cheap electricity from renewable sources has not only secured the energy supply but also created green jobs, aided the establishment of green financial instruments, and has been a contributor to a stable and diverse economy.

Moreover, the renewable energy sector has brought about a radical change in the rural areas due to the introduction of decentralized and localized energy systems. The availability of cheap and constant power has made the industry more competitive, especially in the case of energy-intensive sectors, thus aiding overall economic growth. This paper, using secondary data sources, gives a

cohesive picture of the economic impacts and arrives at the conclusion that the adoption of renewable energy is not only an environmental issue in India but a long-term economic and sustainability objective.

2. Problem Statement

India as a nation has made enormous strides in renewable energy but the level of integrated evidence about the eventual economic impact is still small. The majority of the studies in such areas deal with environmental or technical issues, with no investigation into the whole nexus of renewable energy in terms of investments, FDI inflows, tariff competitiveness, import dependence, and employment. Such a situation poses a challenge to the very existence of non-integrated economic assessments based on non-credible primary data. The current research is aimed at filling this gap by analyzing the economic implications of renewable energy in India from a variety of perspectives.

3. Objectives of the Study

Primary Objective

- The main aim is to assess the economic influence of renewable energy acceptance in India by a complete review of secondary data.

Specific Objectives

- To study the expansion patterns of solar and wind energy capacities in India and to evaluate their share in the total energy landscape.
- To look at the investment and FDI chief renewables' power implications for cost-wise and consequently, for economic development.
- To make a tariff trend comparison between solar (and particularly) and coal-based power plants to realize cost competition.
- To estimate the number of job opportunities that have been created in the renewable sector as a whole, e.g., installation, manufacturing, and operations.

4. Review of Literature

The emphasis on renewable energy has gradually become the main point of global economic and environmental research. The coming of the renewable technologies was one of the main factors

into the future of green economies and the accompanying less than positive literature. For the review of the existing literature, the objective was to analyze and synthesize key academic contributions, reports, and empirical studies that consider the economic implications of the adoption of renewable energy—worldwide and in the case of India.

5. Perspectives from the World

The initial research conducted by Stern (2006) pointed out that the shift to renewable energy is going to yield outstanding economic returns in the long term, being mainly through the less damaged climate and more secure energy supply. IEA (International Energy Agency) states that the economies which shift to renewables get more jobs, are more innovative and are less dependent on fossil fuels. The studies done by IRENA during 2017-2023 highlight that the renewable energy industry hires much more people for each dollar invested compared to the fossil fuels sector, thus giving a positive multiplier effect on the economy.

Chen et al. (2019) looked at the relationship between the energy from renewables and GDP growth, focusing on the case of developing countries. They have also shown that there is a two-way causality: renewable energy consumption promotes economic growth, and in turn, economic growth promotes investments in renewable energy technologies. Worldwide evidence shows that renewables are the drivers of economic progress.

The research carried out by Apergis and Payne (2010) on the OECD countries pointed out that

the use of renewables is a factor that affects the long run economic growth positively. The researchers conclude that the reliance on clean energy and the development of the economy have a common path during which one boosts the other via technological advancements and productivity increases.

The REN21 Global Status Report (2023) gives a thorough global viewpoint, pointing out that renewable energy now holds one of the fastest-growing shares of global power. According to the report, it is mainly the lower prices and stronger government backing that are reversing the global economic structures in favor of sustainable energy.

The authors Owusu and Asumadu-Sarkodie (2016) put forward a strong argument that the use of renewable energy brings forth great socioeconomic advantages through the reduction of health costs related to pollution, as well as the saving on the long-term energy cost. The findings of their

study show that renewable energy plays a part in the general economic welfare besides environmental benefits.

A particular comparative study was done by Zang and his team in the year 2021, wherein the relationship between renewable energy use and economic resilience had been drawn out in view of scenarios on fossil fuel crises across the globe. The authors argue that the adoption of renewables has stabilizing effects on the economy of a country.

6. Indian Context

The last ten years have seen a significant shift in research focused on India, going beyond the renewable-energy objectives set by the government. The authors Bhattacharya et al. (2016) express that Indian renewables are the main factor of economic stability in the long-term because of their influencing power on fuel imports. Their study points out that the Indian economy has been made hostage to the world's price variations because of foreign coal and crude oil; however, the power diversification through the renewable energy is one of the factors that decreases that risk.

The Council on Energy, Environment and Water (CEEW) sketched out this new deployment of solar and wind power jobs in installation, management, and operations. IRENA (2022) projects that jobs will reach heaven and even one million in India’s renewable energy sector: a big potential for job creation before 2030.

The Energy and Resources Institute (TERI) in its economic analysis, pointed out that the decreasing installation prices of solar photovoltaic (PV) technology have made renewables very competitive especially considering the long-term operating cost and externalities. This cost advantage has been further enhanced by NITI Aayog's report that renewable energy reduces the import of fossil fuels and thus the pressure on foreign exchange reserves.

In his work, Ghosh (2019) presents in-depth examination of the Solar Mission in India and

discusses its economic benefits in a favorable manner. The research clearly shows that the installation of solar on a large scale has led to cutting electricity prices, i.e. it has helped in the development of an indigenous solar manufacturing base, and has made India's economy more competitive globally. Such outcomes effectively place solar energy at the heart of India's economic and industrial policy mix.

The research conducted by Shukla, Sudhakar, and Thakur (2017) mirrors this in that they investigate the economic consequences of solar rooftops and, most importantly, come to the conclusion that decentralized power generation helps significantly in the employment market of the local area. Moreover, solar rooftops lower electricity bills for both residential and commercial users. Their study has made it clear that the economic impact of using decentralized renewable energy is nothing less than transforming it.

Moreover, a collaborative document from the Council on Energy, Environment and Water (CEEW) and the Natural Resources Defense Council (NRDC) (2021) anticipates that India will be able to position itself as a major player in the world green job market, with the green energy sector alone creating about a million new positions by the end of the decade. This evaluation emphasizes the lively and very fast growing character of the Indian renewable energy market and its ability to provide sustainable economic advantages.

According to TERI's (2022) Green Growth framework, the increase in clean energy production could have the effect of reducing India's fossil fuel import bill considerably, thus saving India a lot of money and contributing to the stability of government finance. Their statement touches on the macroeconomic importance of the increase in renewables. A very early piece of research conducted by Rao and Kishore (2010) on renewable energy in a decentralized form finds that microgrids can raise productivity in rural areas, diminish the need for kerosene, and provide a source of power for rural entrepreneurship. The study demonstrates that renewable energy aids in the economic empowerment of the grassroots level.

7. Financial and Investment Trends

The research of green finance especially the studies of SEBI and RBI, is the major area which proves the significance of renewable energy in the financial markets of India. Green bonds that were authorized in India in 2015 are now a great financing instrument for renewable projects. Mukherjee and Rajan (2021) mention the fact that the renewable energy sector takes one of the biggest portions of the Indian green bond market, which is a clear sign of strong investor confidence.

According to the World Bank (2020-2023), India has been constantly one of the largest renewable energy investors and the main reason for this is the already attractive government policies, regulatory reforms, and large renewable projects. These are the very financial inflows that have a positive impact on Gross Domestic Product, industrial growth as well as

on infrastructure development.

IRENA's Global Renewables Finance Review (2020) reports that the financing costs for renewable projects have been dropping around the globe and that this has been mainly due to better technology, risk management, and the establishment of favorable policy frameworks. These trends are also a factor to the rapidly declining solar tariffs in India.

The report of the Ernst & Young Renewable Energy Attractiveness Index (2023) keeps on ranking India consistently among the top world markets for investments in renewable energy. The review credits this situation to the project economics, which are competitive, besides the great demand, and the government reforms that are encouraging.

8. Energy Security and Economic Stability

One of the main concerns that literature on renewable energy has been focused on is national energy security. Sharma and Srivastava (2021) opine that reliance on renewable energy reduces India's vulnerability to crude oil price fluctuations and hence there will be no inflation and the economy will be more resilient. In fact, as noted by Garg (2022), the mixing of renewable and conventional power makes it possible to set long-term energy prices which are attractive to both industries and consumers.The International Monetary Fund’s (IMF) energy assessments (2022) confirm that the pattern of countries with a larger percentage of renewable energy sources in their power generation mix experiencing less inflation volatility is a direct consequence of the oil price shocks. Thus, the renewables are considered as an anchor for macroeconomic stability.

On the other hand, Das and Chakraborty (2020) conducted an economic analysis that pointed to the positive impact of renewable energy adoption on India’s trade balance due to diminished oil and coal imports. Their results suggest that the growth of renewables is a direct contributor to the stability of the forex rates.

India’s renewable energy policy review by the IEA (2021) highlighted the fact that the country will not just be using less of the expensive fossil fuels but will also be able to supply the population at lower prices since the government will be not subsidizing these fuels anymore. Consequently, the government will be able to direct the money that is saved from the subsidies to renewable sources thereby producing more affordable energy for the consumers. The policy recommendations point out the economic durability that renewables have.

The Energy Security Assessment for South Asia (2022) by the World Bank advocates that India is in an optimal position to develop great energy self-sufficiency with the help of renewable energy. This review has concluded that using renewable energy builds economic sovereignty and lowers threats from geopolitical problems.

9. Research Methodology

The study adopts a descriptive and analytical research design to primarily examine the impact of renewable energy adoption upon the economy of India through secondary data.

The information is all secondary data sourced from reputable national and international sources including Ministry of New and Renewable Energy (**MNRE**), Central Electricity Authority (**CEA**), International Energy Agency (**IEA**), International Renewable Energy Agency (**IRENA**), Department for Promotion of Industry and Internal Trade (**DPIIT**), Reserve Bank of India (**RBI**), The Energy and Resources Institute (**TERI**), and the Council on Energy, Environment and Water (**CEEW**). These sources provide data on renewable energy capacity, investments, foreign direct investment (**FDI**), trends in tariff, employment generation and fossil fuel import indicators.

Three analytical instruments are employed for analyzing the collected data in this study:

- Analysis of Trends – Retards for solar/wind capacity, investments, FDI, workforce and tariffs over time for growth analysis.
- Due Diligence Comparison – in other words, comparing between renewable tariffs and coal tariffs to establish competitive pricing and economic gains.

Descriptive Statistical Analysis - to allow the presentation of these numerical trends as a percentages, growth figures and absolute values scale.

The results will be shown and explained in tables and diagrams. Data gathering is not a part of the methodology as such; rather, it is a matter of collecting and merging existing datasets to depict an economic case for renewable energy adoption in India that is well integrated.

10. Findings and Analysis

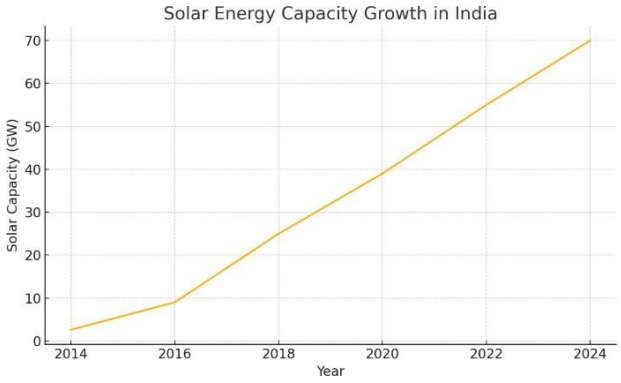
This section of the report provides a detailed analysis of the renewable energy situation in India, which has been carried out using secondary data obtained from government documents, international agency reports, and those of various institutions. Capacity growth, investment trends, and job creation, cost benefits and less reliance on fossil fuel imports are the five ecologically and economically significant aspects of the analysis. Each of the eco-friendly energy dimensions shows the rejuvenating renewable energy sector's contribution to the economic development of India.

Growth in Renewable Energy Capacity

India's renewable sources of energy have had the most remarkable increase shift recently. The growth of solar and wind energy has been the major contributors to this increase.

- ***Solar Energy***

By the year 2024, the capacity of solar power in India will be increased from 2.6 GW in 2014 to more than 70 GW, which is an impressive development and one of the fastest in the world. The National Solar Mission, the development of technology, the reduction in tariffs, and the large-scale setup of solar parks have been the main factors

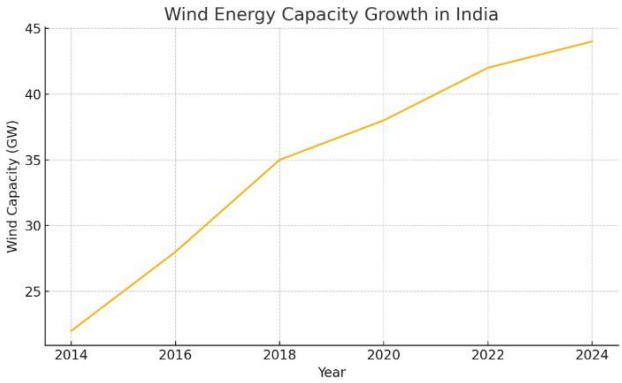


behind the phenomenal growth.

Source- Solar tariff auction data from SECI (Solar Energy Corporation of India) https://seci.co.in

- ***Wind Energy***

The capacity of wind energy has risen from 22 GW in 2014 to around 44 GW in 2024 with the driving force being the presence of wind corridors in states like Tamil Nadu, Gujarat, and Rajasthan.



Source- Ministry of New and Renewable Energy (MNRE) – Annual Reports https://mnre.gov.in

- ***Overall Renewable Mix***

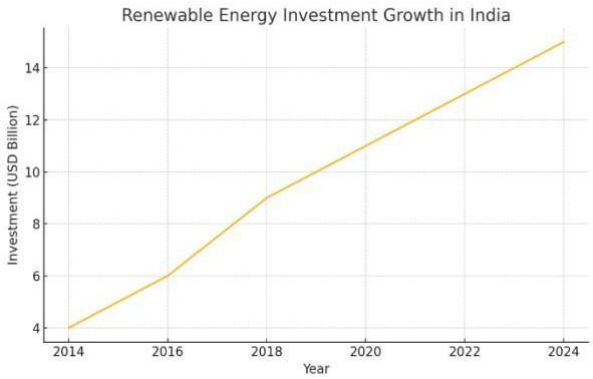
Non-fossil fuel sources now represent more than 40% of India's total installed capacity, pushing India closer to its goal of having 500 GW of renewable energy by

2030.

Economic Significance: The increased capacity of the renewable sector not only reduces the country's dependence on fossil fuels but also increases energy security and gives a stable price for the long term to energy-intensive industries.

Investment Trends and Financial Inflows

Renewable energy has captivated investors as one of the sectors of India where the maximum investments flow.



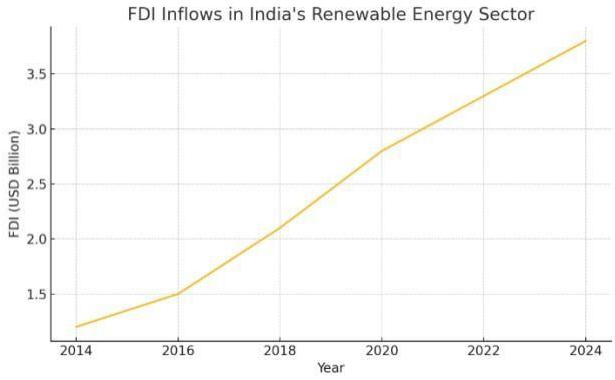
- **Domestic Investment**

Source- NITI Aayog – India Energy Security Scenarios

Solar and wind projects have been the new areas of diversification for the major public- sector companies like NTPC, GAIL, and Coal India.

- **Foreign Direct Investment (FDI)**

India is ranked among the top 5 places worldwide for renewable energy FDI, which is the most significant sector in the economy.\



Source- Reserve Bank of India – Annual FDI Inflow Reports, Invest India – Sectoral

Investment Trends https://investindia.gov.in

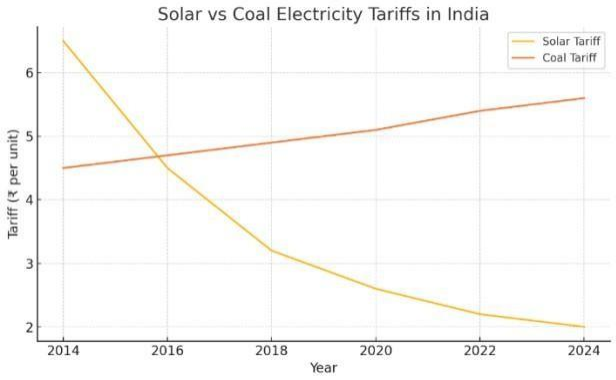
Between 2014 and 2024, the renewable energy sector is projected to be a destination for more than USD 12–15 billion in FDI investments mainly from Europe, the U.S., and new- age Asian investors.

- ***Green Bonds***
  - The green bond market in India started in 2015 with a first bond issue and has been growing at a phenomenal rate ever since.
  - Green bonds worth over USD 20 billion have been issued, a significant portion of which is attributed to renewable energy in terms of allocations.

Economic Significance: The influx of investments not only strengthens the domestic manufacturing sector but also opens new opportunities in the economy and thereby raises India's standing among the sustainable finance world.

Tariff Competitiveness of Renewable Energy

Declining costs of renewable energy is one of the strongest economic advantages. The solar tariff has fallen considerably from ₹6.5 per unit in 2014 to approximately ₹2 per unit in 2024 which
has made the solar power battery significantly cheaper than the coal-based electricity.



Source: Solar tariff auction data from SECI (Solar Energy Corporation of India) https://seci.co.in, Coal tariff and generation cost from CERC (Central Electricity Regulatory Commission) https://cercind.gov.in

The coal tariffs have been rising because of the increased transportation costs, extraction difficulties, and environmental compliance expenses.

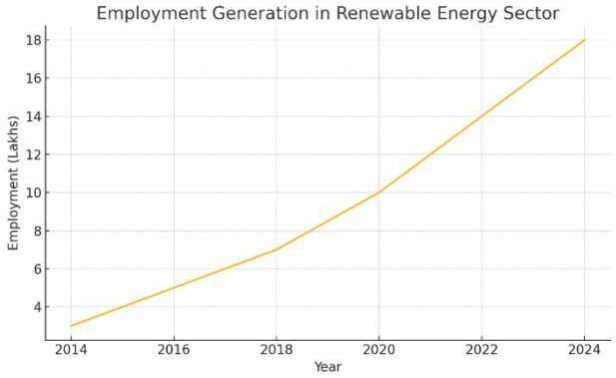
Employment Generation

Initial deploying of renewables up to now in between the various stages of energy such as manufacturing, installation, operations, maintenance, and research.

- ***Sector-wise Employment***

- Solar power holds a dominant position in the job market, and especially the areas of installation and maintenance take the largest part.
- IRENA predicts that India's renewables will generate more than 1 million jobs in 2024 and there will be more.

- ***Job Creation Characteristics***
  - Solar rooftop projects create jobs that are situated nearby in both urban and rural areas.
  - Production of solar modules, inverters, and batteries has led to more people working in economic zones (SEZs) and industrial clusters.
  - Employment in the renewable sector increased from around 3 lakh jobs in 2014 to nearly 18 lakh jobs by 2024. Solar installation and rooftop projects have been major sources of job generation due to their labor-intensive nature.



Source- IRENA – Renewable Energy and Jobs: Annual Review https://irena.org

This growth reinforces the idea that renewable energy supports inclusive economic development by providing local and decentralized employment opportunities.

Economic Significance: New jobs lead to more money being spent in the local economies, they also help in minimizing the inequalities between regions all the while creating a skilled green workforce that understands the energy systems of the future.

Cost Competitiveness of Renewable Energy

The renewable energy has been made more and more cost-efficient with solar being the main contributor.

- ***Declining Levelized Cost of Electricity (LCOE)***
  - The price for solar tariffs has dropped from ₹12/unit in 2010 to the range of ₹2-3/unit in the major auctions conducted in 2023-24.
  - Wind power has cost around ₹2.8-3.2/unit during its cycle.
- ***Comparison with Coal***

- The average rate of electric power from a coal-based facility is between ₹4.5-6/unit depending on the area and not included the extra costs of environment and transportation.
- One of the major advantages of renewable energy is that it can skip these costs of mining,

  transport, and all the other duties involved.

- ***Technological Advancement***
  - The increased production and commercialization of solar PV modules(PERC, bifacial, TOPCon) has drastically lessened the long-term capital and operational costs.

Economic Significance: The tariffs that are lower matter a lot to industries as they lead to reduced electricity bills and as a result improve the competitiveness of India in global manufacturing.

11. Findings & Discussion

The analysis of secondary data sources has pointed to a number of critical economic effects as a result of the use of renewable energy in India. It was argued that the use of renewable energy should be treated not only as a significant change but also as a massive force that will push the Indian economy to become the source of its future development.

12. Renewable Energy as Economic Growth Driver

India has made a great leap in the renewable energy capacity, which has been the main reason behind the argument that the change in the energy system is an economically wise decision towards a low carbon and resilient growth. The combination of solar and wind energy is the main source of energy, with solar being the fastest growing among all. The increase in electricity supply as a result of the power capacity increase has led to a rise in productivity, especially in the industrial and agricultural sectors but also in service sectors. The power generation from solar and wind has continued to be the supporting pillar of India's industrial policy to be eco-friendly and at the same time promoting the economy through infrastructure development, technological upgrading, and supply chain management. It is the characteristics 0f renewable energy that make it a driver f0r the economic growth 0f the whole country.

13. Strong Investment Momentum and Financial Deepening

One of the main discoveries of the research is that the trend of rising domestic and foreign investments has been very stable. The mix of good policies, falling technology costs, and the huge market potential have ensured that investors feel confident.

- **Green Finance Maturity –**

  The rise in green bonds and green financing issuance shows that the relationship between the renewable energy sector and the financial market is more significant and more open. Besides this, India's renewable energy market has been prepared to lure the money of institutional investors, sovereign wealth funds, and global green investment portfolios. The country gains not only short-term financing but also long-term investments, innovations, and capital formation.

- **Foreign Direct Investment as a Growth Booster –**

FDI is actually the primary reason for the growth of the renewable energy sector in India, giving the sector access to global best practices, technology transfer, and infrastructure. The inflow of Foreign Direct Investment (FDI) worth billions of dollars in the renewable energy sector has thus to a certain extent strengthened India's image as a renewable energy hub in the making.

14. Renewable Energy to Improve Energy Security and Reduce Import Dependency

One of the key economic impacts of the sector has been the integration of renewable energy sources into the Indian power grid. The constant dependence on foreign fossil fuels has made the country vulnerable to fluctuations in international prices, loss of foreign exchange, and interruptions in supply, which has a detrimental effect on its economy. In the future, renewable sources will be a significant factor in the drastic reduction of these risks:

- The import of coal and petroleum shall be drastically curtailed.
- In the longer run, energy prices, too, would stabilize.
- A pull on the treasury would translate to lesser government expenditure on subsidies.
- There will be an increase in foreign exchange reserves enough to counter-weigh risks to the economy and see a huge decrease in the import of coal and petroleum.

A big change would, along with the stability of the macroeconomic situation, greatly reinforce the country's defense against the unpredictable fluctuations of the global energy market.

15. Cost Competitiveness Encourages Industrial Efficiency

A further milestone of understanding is the cost competitiveness of renewable energy generation which keeps on increasing and the fossil fuels' decreased cost. Presently, the tariffs for solar power are the least, and the subsequent lines provide the benefits to:

- Reduced industrial cost of electricity
- Increased competitiveness of MSMEs

- Electrification of remote areas made feasible
- Lower carbon compliance costs for the companies

The costs benefits in this case empower large levels of the expansion of industrial output and growth of energy-consumed industries like manufacturing, IT services, and logistics.

16. Conclusion

In conclusion, the study of secondary data indicates that one of the main reasons for India's economic growth has been the extensive use of renewable energy sources. The fast-growing capacity in solar and wind power has been driven mainly by hefty investments that come from domestic sources and foreign direct investment (FDI) as well. The price reduction resulting from the use of the competitive auction-based tariff mechanism for electricity has not only made green energy more attractive economically but also increased employment in new sectors, thus confirming the economic viability of renewable energy even beyond its environmental advantages.

In addition, renewable energy has been a vital factor in cutting down the reliance on foreign fossil fuels and improving the national energy security. The results emphasize that renewable energy is not only a less polluting option but also a strategic economic asset that boosts industrial growth, macroeconomic stability, and India's sustainable development goals in the long run. Policy support, investment facilitation, and technological advancements will be necessary for the economically beneficial and globally competitive Indian renewable energy transition.

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A Study On Factors Influencing Investment Decisions Of Individuals in Mumbai City

Author: Vandana Anuj Kedia
Assistant Professor
Institute: Annasaheb Vartak College,Vasai.
Mobile :9823314508
Email id: kediavandana111@gmail.com

Co-author: Agnus Anthony Meledath ,
Assistant professor
Institute: Vidyalankar school of information Technology, Vidyalankar Campus, Vidyalankar College Marg, Wadala (East), Mumbai – 400037, Maharashtra, India.
Mobile : 9082766952
Email id: agnusmeledath@gmail.com

Abstract: This study looks at the various aspects that influence people's investing preferences in the context of Mumbai. It looks at demographics like gender, age, education, and marital status; the main factors that influence investment decisions, like risk, repayment capacity, company-specific information, and social responsibility; and the degree of advanced and basic financial literacy. It uses the survey methodology with a total of 75 respondents who actively participate in financial investment. Results reveal that demographically, factors such as age and marital status, as well as the viewpoint regarding societal responsibility as part of investment, have no significant influence on preferences for selective investments. Nevertheless, different factors have been seen to affect the selection for particular investment instruments such as foreign currency, bank deposits, bonds, stocks, and mutual funds to differing degrees.

Keywords: Investment instruments, investment decision criteria, financial literacy, demographics

1. Introduction

Financial scholars and market practitioners have long been interested in understanding what influences individual investors to favor particular investment options. Researchers can gain significant insight into financial decision-making processes when they identify the influencing factors, sometimes referred to as determinants of investment behavior. This research aims to investigate how demographic variables such as gender, age, level of education, and marital status; investment decision-making criteria including risk, repayment potential, corporate performance, and social impact; and levels of financial literacy, both basic and advanced, influence preferences for different investment alternatives: foreign currency, bank deposits, bonds, stocks, and mutual funds. To that end, the study examines the impact of each variable on personal investment preference

and explores the underlying factors affecting these decision

Behavioral finance is an area that has been reasonably new and is still growing at a fast rate. It questions the idea that all financial decisions are rational and based on objective analysis alone. Instead, it focuses on how investment decisions and market behavior, due to psychological factors, emotional biases, and information processing patterns, all significantly help in determining market performance. Such a perspective helps explain why markets would sometimes perform inefficiently and why investors might sometimes make seemingly illogical purchases or sales based more on emotion, peer pressure, or misconstrued facts, as opposed to sound financial principles. According to classical financial theory, individuals must act rationally, making choices to maximize profitability while lowering the risk and cost.

Under this theory, individuals normally allocate some of their incomes for investment and savings, apart from allocating others for consumption. But risk and uncertainty are associated with the investment process, making it a challenging task for the investors. The availability of information, accuracy, and timeliness of information associated with the investment process are essential in the successful implementation of financial planning. It would be a challenging task for investors to form an estimate of the likely outcome and form a perception of the fair value in the absence of timely, limited, and unclear information about the investment process, leading to improper investment decisions. This research work would bridge the theory and practice gaps in the course of making investment decisions, covering the logical and behavioral parts of the investment decisions of individuals in the financial markets of Mumbai.

2. Review of literature

The review of the concerned topics is as follows:

Various earlier studies have analyzed the factors that influence investment decisions. It has been determined that investor behavior is influenced by a variety of factors, which include financial knowledge of investors, as indicated by Usul & Bekci 2001, age Küçüksille 2004, personal prospects Sayılır et al., 2012, income level, as well as psychological well-beingUsul et al., 2002. Usul and Bekci 2001 note that individuals who are not working, such as housewives, often cannot effectively analyze financial information and make sound investment decisions since they may not have the same level of formal financial education as employees of banks or other managers. Similarly, family educational background is important; individuals with postgraduate degrees are in a better position to evaluate and interact with financial information,

As stated by Küçüksille (2004), young investors tend to be more risk-takers with regard to making long-term investment in stocks, compared to old investors, who generally avoid making any long-term commitment because they will require their gains in a shorter span of time. As stated by Sayılır et al. (2012), most investors mistakenly presume that

reputable firms always make sound investment choices, and often the level of environmental performance and social accountability gets taken into account. Additionally, as stated by Usul et al. (2002), persons with higher earnings tend to invest more in the long term because the amount invested has a less proportionate effect on their total earnings, thereby not affecting them much. Additionally, individual traits like needs, aspirations, personality, perception, and capacity for learning affect their investment behavior, which generally tend to pick Investments that complement their personal traits.

In a related study, Pasewark & Riley (2010) have been able to identify a lot of parameters that are often considered when investing. Such variables include business transparency, risk, repayment potential, and the impact of the investment on society as well as health. Four among these parameters include risk, repayment, social impact, and business information. They are being investigated in the current study.

There are also a number of papers dealing with the relationship between the behavior on the financial market and demographic variables (Anbar & Eker, 2009; Bajtelsmit & Bernasek, 2001; Collard, 2009). Noticeably, the study of the role of the gender factor has become very popular. It is widely recognized that women are less tolerant of financial risk than men (Grable & Lytton, 1998). Collard (2009) and Bajtelsmit & Bernasek (2001) found that women are often more risk averse. There are also age-related risk aversion changes. According to Ozer and Gülpinar in 2005, differences also exist among different age groups regarding risk behavior. Collard, in his research in 2009, and Bajtelsmit and Bernasek also in 2001, asserted that seniors take fewer investment risks either before or during retirement. They have less time to recover from potential investment losses because the reason for this (Grable & Lytton, 1998).

Investment decisions are further affected by education and marital status. According to Grable and Lytton (1998), singles are more likely to take a risk because they do not have many personal financial responsibilities. Married persons tend to be more conservative in their investment decisions. This may be because they have to consider future financial responsibilities such as children’s education and family security. Married persons may tend to be more conscious of social risks. Education level also shapes risk tolerance. People with less formal education tend to avoid highly risky investments. In addition, Bajtelsmit & Bernasek (2001) found evidence that people earning higher incomes are normally more comfortable taking personal financial risks.

3. Objectives of study

Following are the objectives framed to achieve research goals and execution:

1) To recognize the factors influencing investors' decisions.

2) To list out the factors influencing investor choice toward investment.

3) To understand the awareness of investors about investment avenues.

4. Gap Analysis

Studies involving a variety of demographic groups have shown that investment decision-making is influenced by a complex interplay of economic, social, cultural, and psychological factors. Investor behavior is heavily influenced by factors like perceived investment attractiveness, financial performance metrics, and current market conditions. Financial decisions are also influenced by individual characteristics such as age, gender, and educational background. Despite these revelations, current research frequently fails to address the underlying behavioral objectives of individual investors as well as the psychological obstacles they encounter, such as risk aversion and herd mentality. This restriction highlights the necessity for further thorough research. Future research must include behavioral finance in order to better understand investor behavior and improve market efficiency and investment strategies.

5. Research methodology

Methods of Data Collection:

To carry out the study **"A Study on Factors Influencing Investment Decisions of Individuals in Mumbai City,"** both **primary** and **secondary** sources of data were used to ensure comprehensive and accurate insights:

1. Primary Data

Data for this study has been gathered from individual investors living in the city of Mumbai through the following manner:

Structured Questionnaire

A total of 75 respondents were chosen randomly and were administered a carefully designed questionnaire.

The questionnaire included:

Age, gender, marital status, income level, and occupation were some demographic variables incorporated when designing the questions.

Investment knowledge and preferences

- Investment objectives
- Risk tolerance and decision-making criterion

2. Secondary information

Some of the reliable sources of secondary data included journals, research articles, finance publications, newspapers, web pages, and reference books. These sources assisted in studying the outcomes of the study as well as in gathering information.

Design of an Example:

A sample of Seventy-five Mumbai citizens were chosen to participate in the study. A systematic questionnaire was employed to collect data. Data was compiled for the secondary research featured in various scholarly publications and online posts.

Method of Sampling:

In conducting primary data gathering, participants were chosen in a neutral manner through a simple random sample technique.

6. Scope of the study

The principal object of this research study is to identify key variables related to investing decisions of individual investors in Mumbai. In addition to this, it attempts to understand their money behavior patterns and preferences, as well as measure their awareness of different available investing alternatives. A sample of seventy-five respondents was selected from Mumbai.

7. Limitation of research

There are some of the limitations associated with the study:

1.The size of the sample was 75 respondents which may not be perfectly representative of total investors in Mumbai.

2. The population sample was determined by the time span.

3. Time constraints did not allow a complete discussion of variations in personal financial planning.

4. As persons' financial circumstances and plans change, the findings are time-dependent and could be rendered untrue for longer periods.

Statement of problem

The purpose of this research is **"A Study on Factors Influencing Investment Decisions of Individuals."** The objective of this research is to understand how individuals make financial investments and the level of awareness about all the different kinds of investments that are available. For the gathering of primary data, this research uses a systematic questionnaire to understand how effective financial planning can help an individual in formulating financial goals and taking effective financial decisions. The relevance of this research is found in the way the complete financial happiness of an individual gets influenced due to individual financial decisions.

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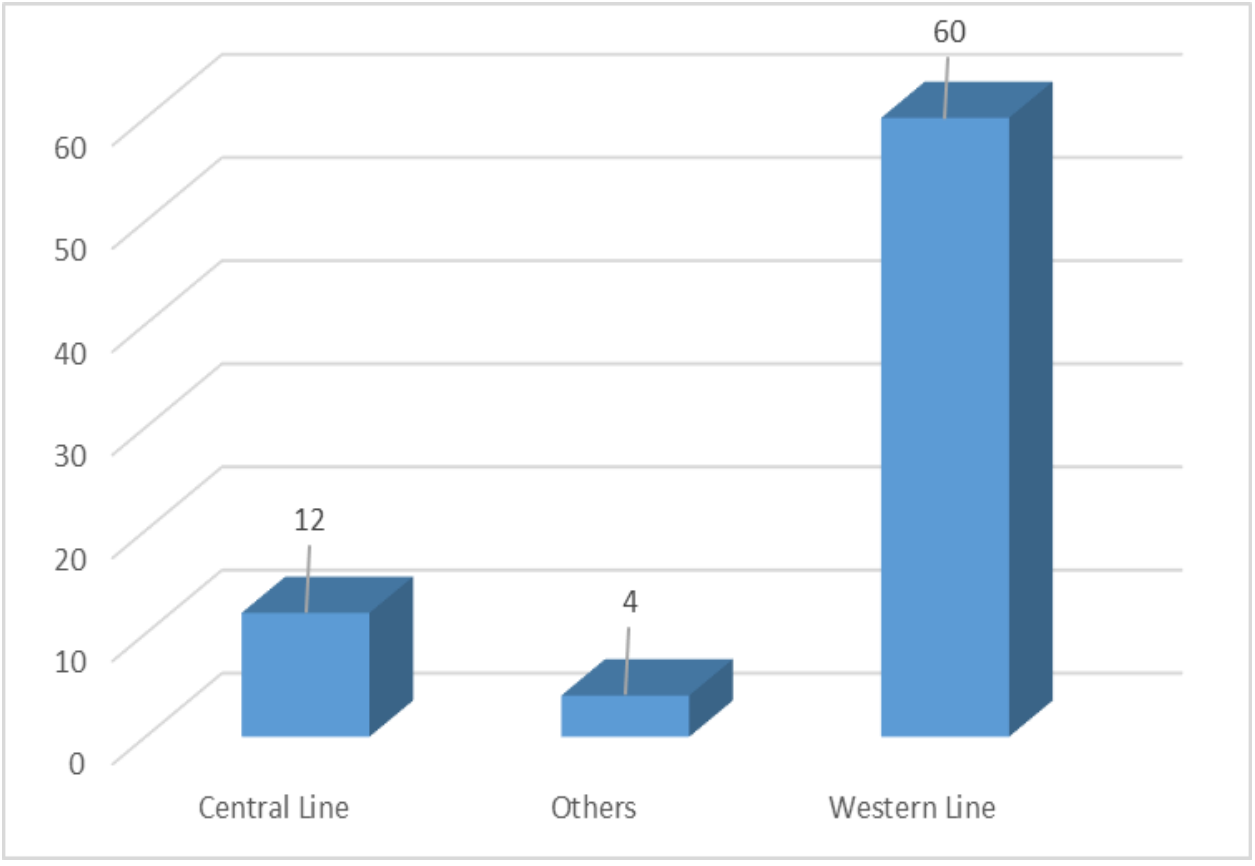
8. Data analysis

Table 1. Area of the Respondents

Area	*Count*
Central Line	*12*
Others	*4*
Western Line	*60*
Total	*76*

Source: Primary Data

Fig.1. Area of the Respondents



Source: Primary Data

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Table 2. Gender of the Respondents

Particulars	*Count*
Female	*57*
Male	*18*
Others	*1*
Total	*76*

Fig.2. Gender of the Respondents

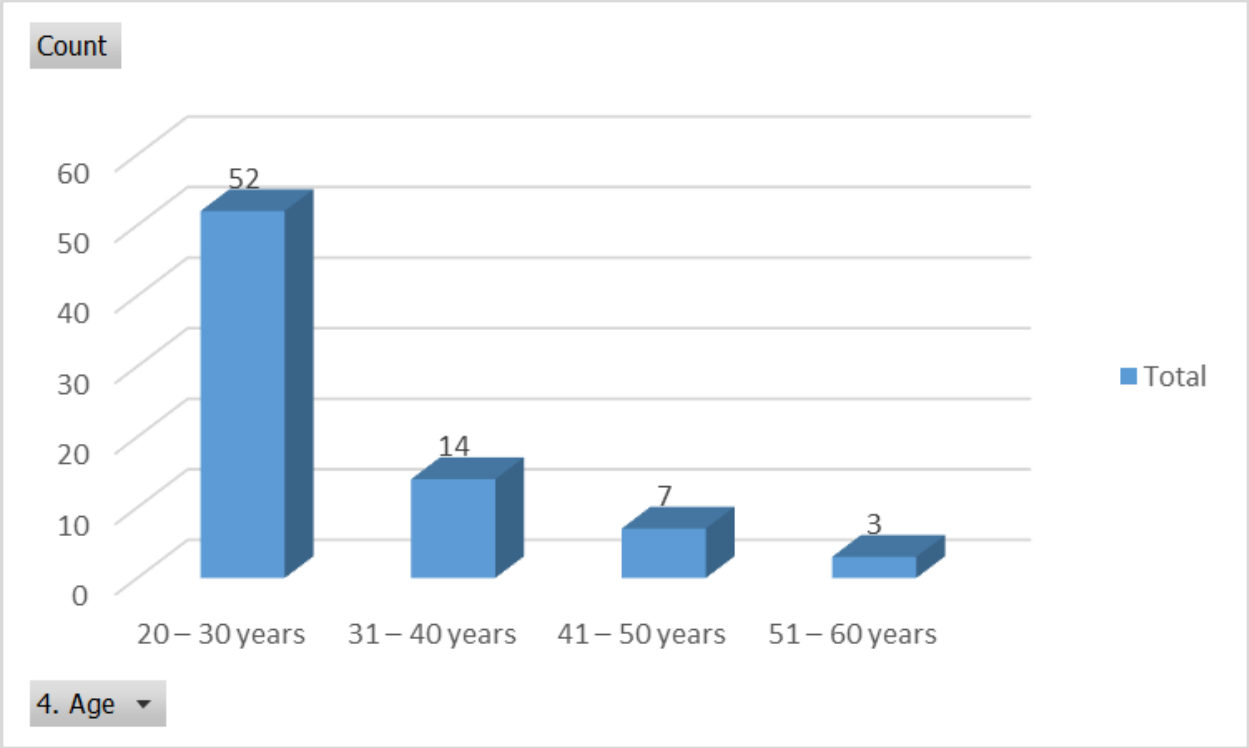
 ISBN Number: 978-93-344-5986-9

Table 3. Age of the Respondents

Particulars	***Count***
20 – 30 years	***52***
31 – 40 years	***14***
41 – 50 years	***7***
51 – 60 years	***3***
Grand Total	***76***

Source: Primary data

Fig.3. Age of the Respondents



 ISBN Number: 978-93-344-5986-9

Table 4. Marital status of the Respondents

Particulars	***Count***
Married	***27***
Single	***49***
Grand Total	***76***

Source: Primary data

Fig.4. Marital status of the Respondents

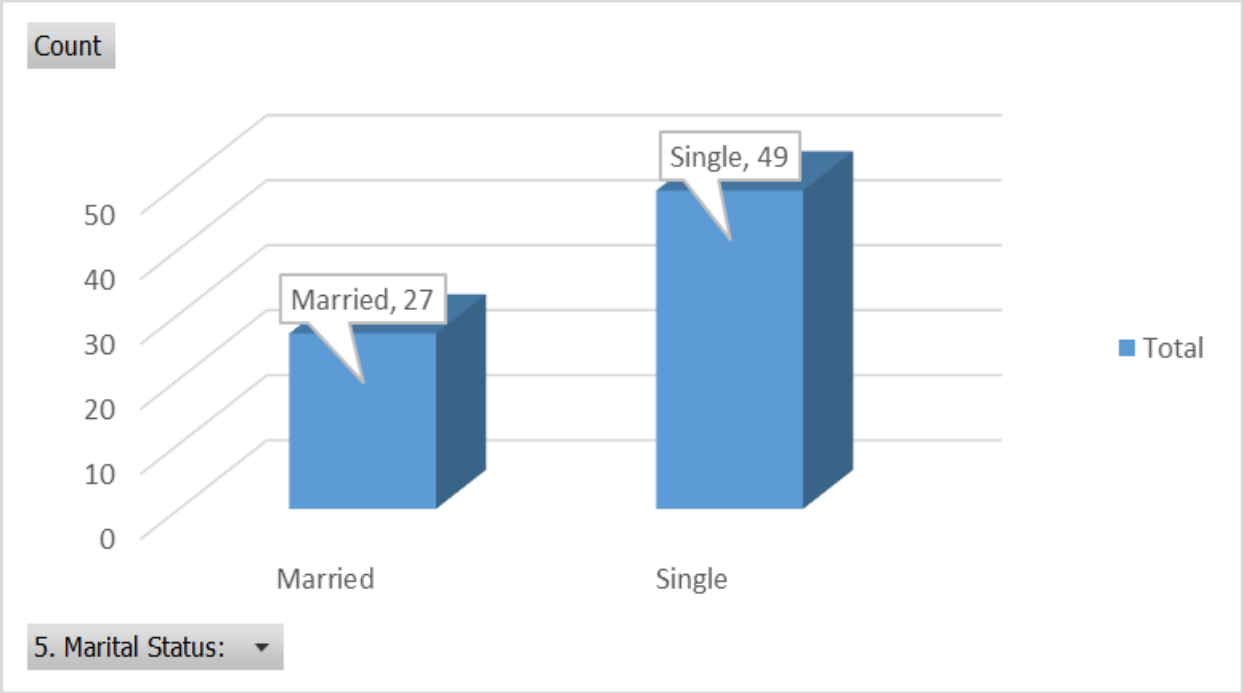


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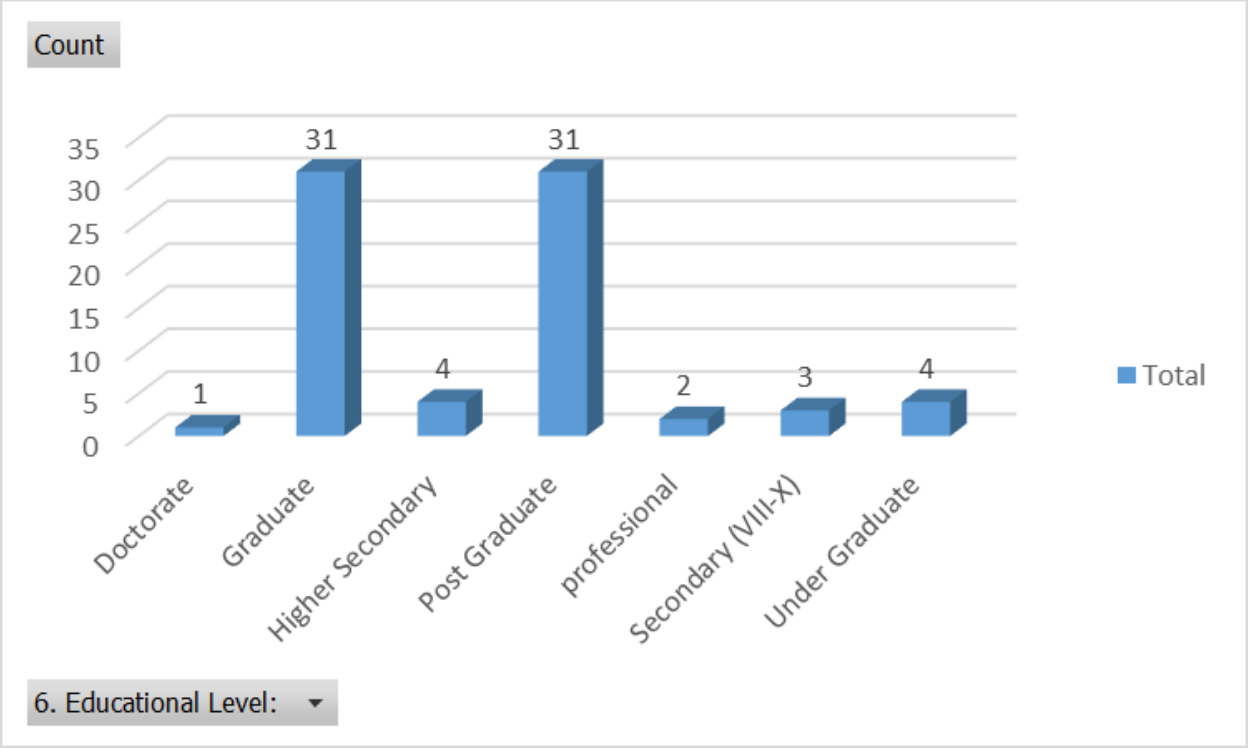
Table 5. Qualification of the Respondents

Row Labels	*Count*
Doctorate	*1*
Graduate	*31*
Higher Secondary	*4*
Post Graduate	*31*
Professional	*2*
Secondary (VIII-X)	*3*
Under Graduate	*4*
Grand Total	*76*

Source: Primary data

Fig.5. Qualification of the Respondents



 ISBN Number: 978-93-344-5986-9

Table 6. Occupation of the Respondents

Row Labels	*Count*
Others	*33*
Professional	*8*
Salaried (Private sector)	*33*
Salaried (Public sector)	*2*
Grand Total	*76*

Source: Primary data

Fig.6. Occupation of the Respondents

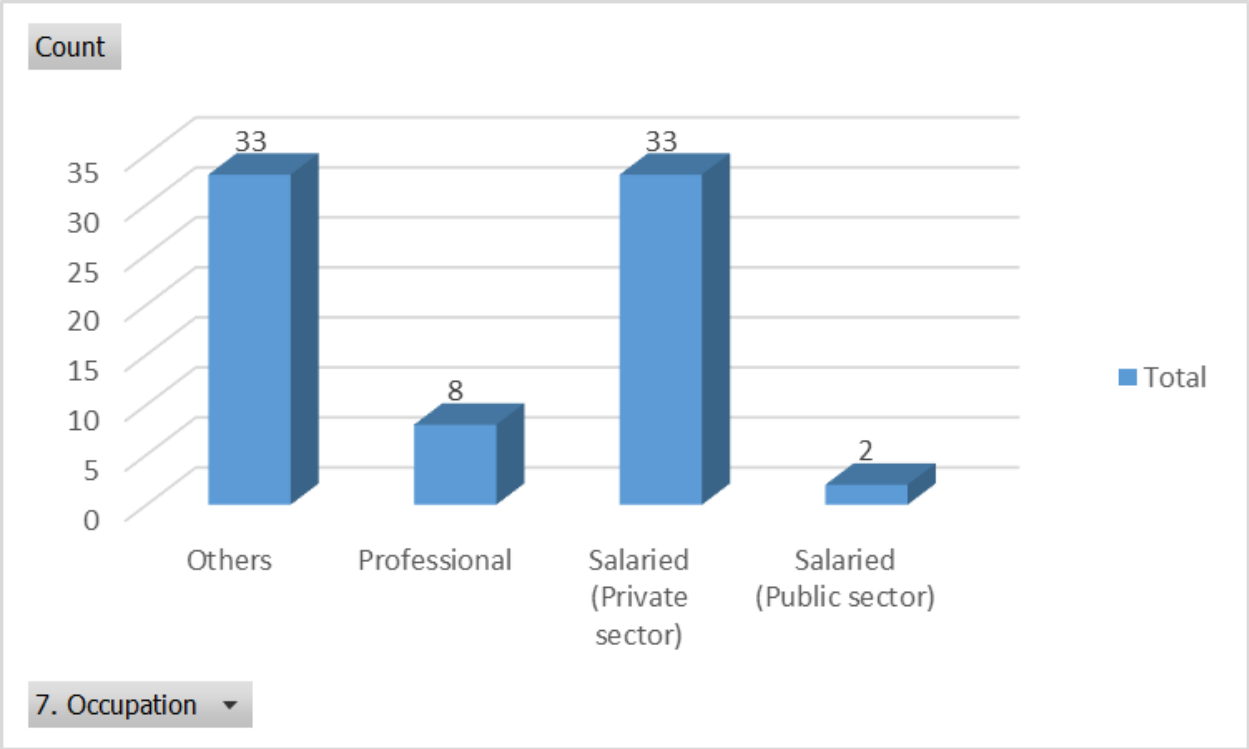


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Table 7. Annual Income of the Respondents

Row Labels	*Count*
₹ 2,50,001 to ₹ 3,00,000	*9*
₹ 3,00,001 to ₹ 5,00,000	*10*
₹5,00,001 to 10,00,000	*8*
more than ₹ 10,00,000	*1*
Upto ₹ 2,50,000	*48*
Grand Total	*76*

Source: Primary data

Fig.7. Annual Income of the Respondents

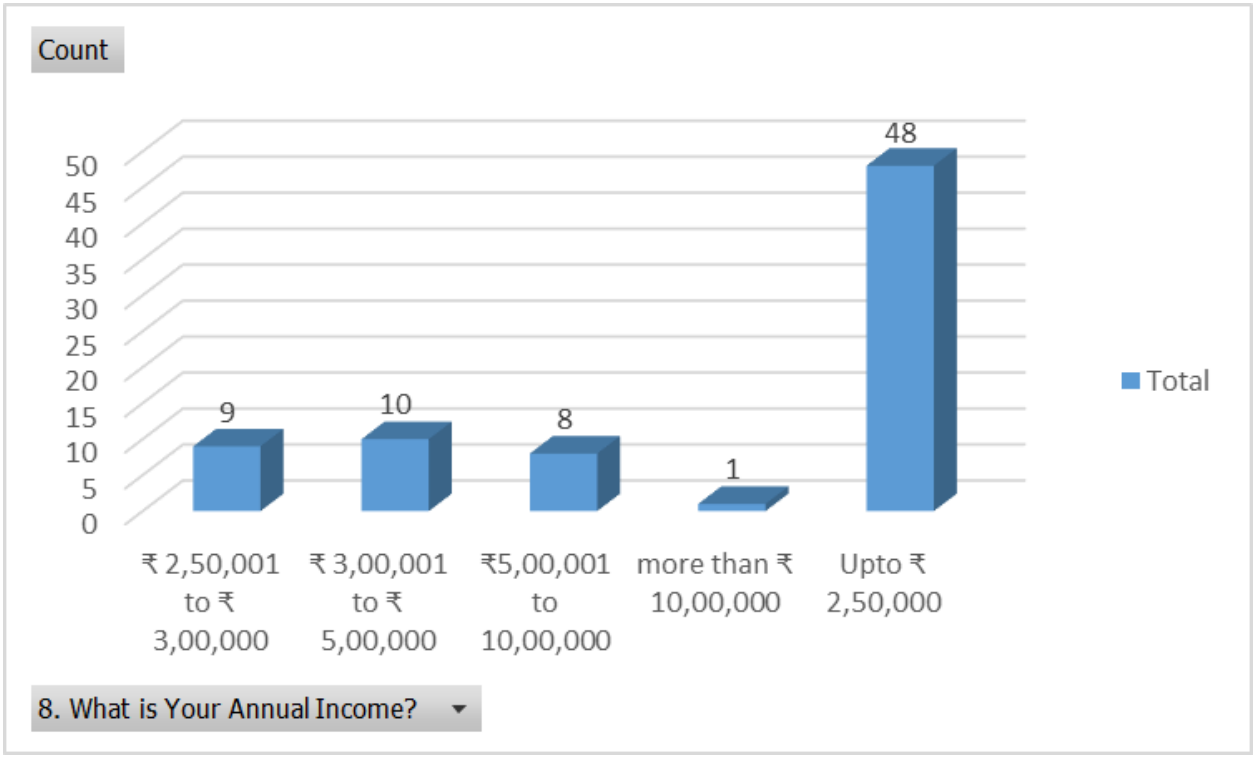

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Table 8. Annual Income of the Respondents

Row Labels	*Count*
0 to 15%	*33*
15% to 30%	*20*
30% to 50%	*4*
More than 50%	*4*
Not Sure	*15*
Grand Total	*76*

Source: Primary data

Fig.8. Annual Income of the Respondents

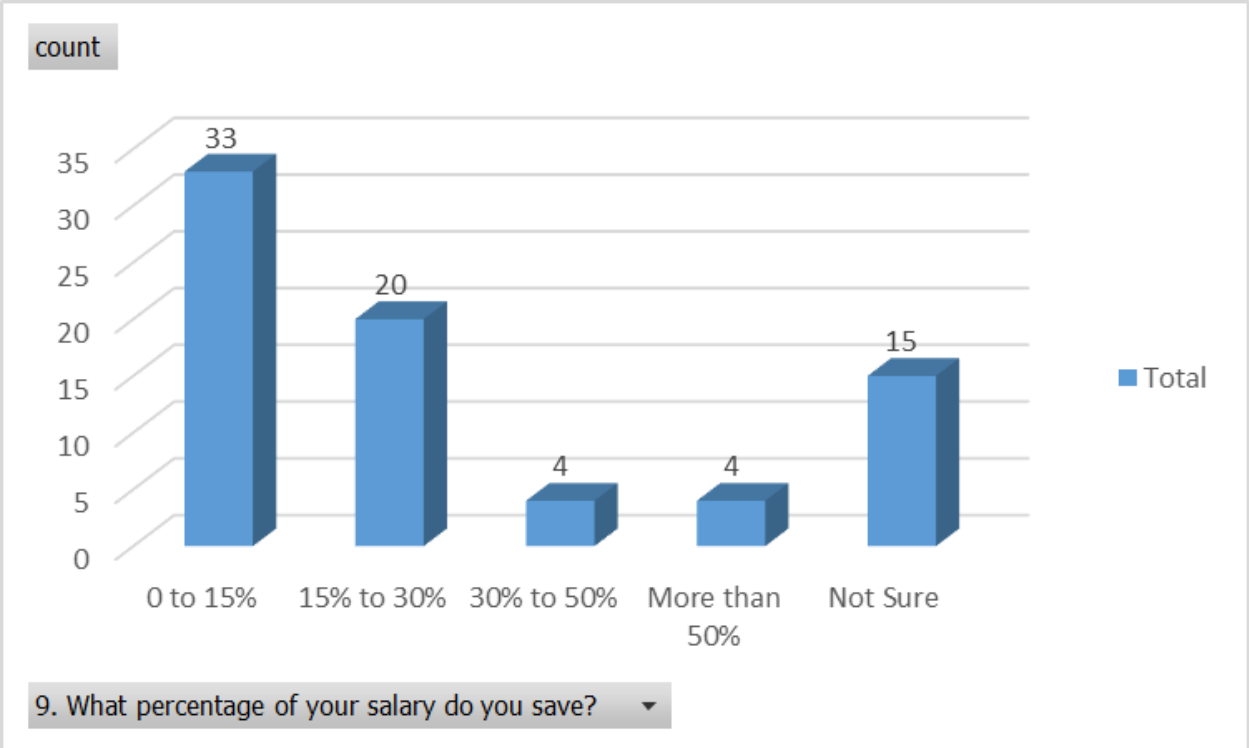

Table 9. Investment Objective of the Respondents

Row Labels	*Count*
For Children's Education	*6*
If Other than please specify_____	*2*
To Avail Tax Benefit	*5*
To Earn Income	*41*
To Meet Specific Purpose	*15*
To Retirement Planning	*7*
Grand Total	*76*

Source: Primary data

Fig.9. Investment Objective of the Respondents

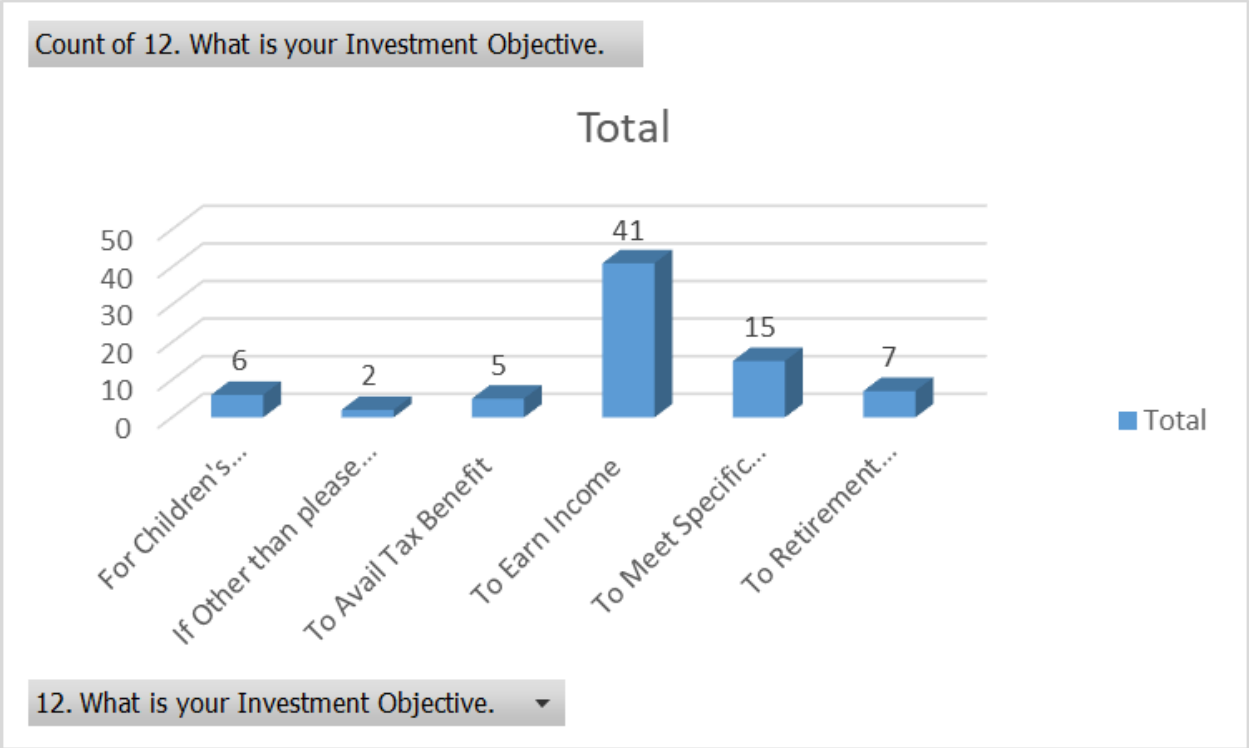

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Table 10. Factors of your preference while choosing an investment option

Factors	*Affect the Most*	*Affect Somewhat*	*Does not Affect*
Safety of principal amount	*47*	*22*	*7*
Liquidity	*51*	*18*	*7*
Return	*49*	*21*	*6*
Reliability	*44*	*26*	*7*
Low Risk	*40*	*29*	*7*
Recommendation of Family and Friends	*34*	*31*	*11*
Recommendation of investment agent	*32*	*31*	*13*
Internet	*31*	*31*	*14*
Other Factor	*21*	*38*	*17*

Source: Primary data

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Fig.10. Factors of your preference while choosing an investment option

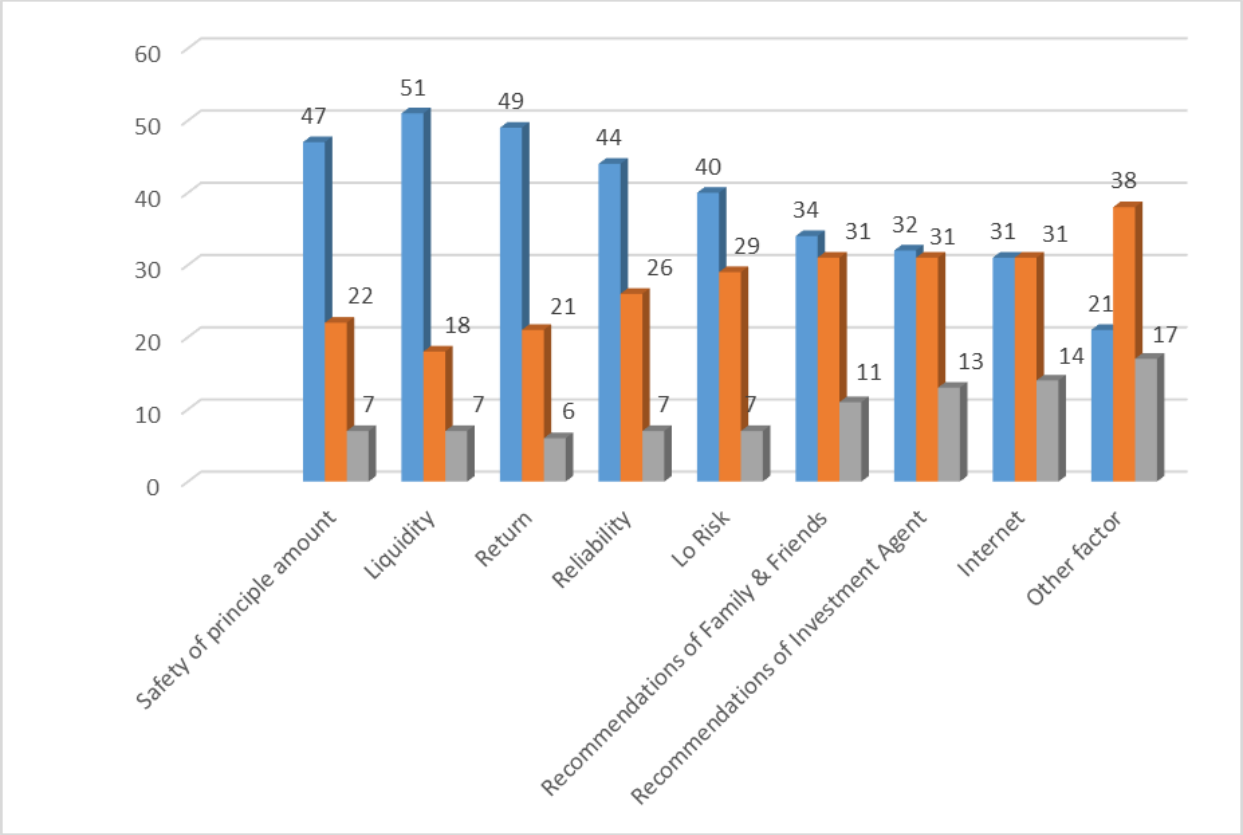

Table: 11. Preferences of Investment options

Statement	*Most preferred*	*Some hat Preferred*	*Not Preferred*
Bank FD/RD	*45*	*22*	*9*
LIC	*34*	*32*	*10*
Post Office Schemes	*28*	*29*	*19*
PPF	*32*	*32*	*12*
Share Market	*35*	*29*	*12*
Mutual Funds	*45*	*23*	*08*
Real Estate	*36*	*28*	*12*
Precious Metals	*46*	*26*	*04*
Government Securities	*40*	*22*	*14*

Source: Primary data

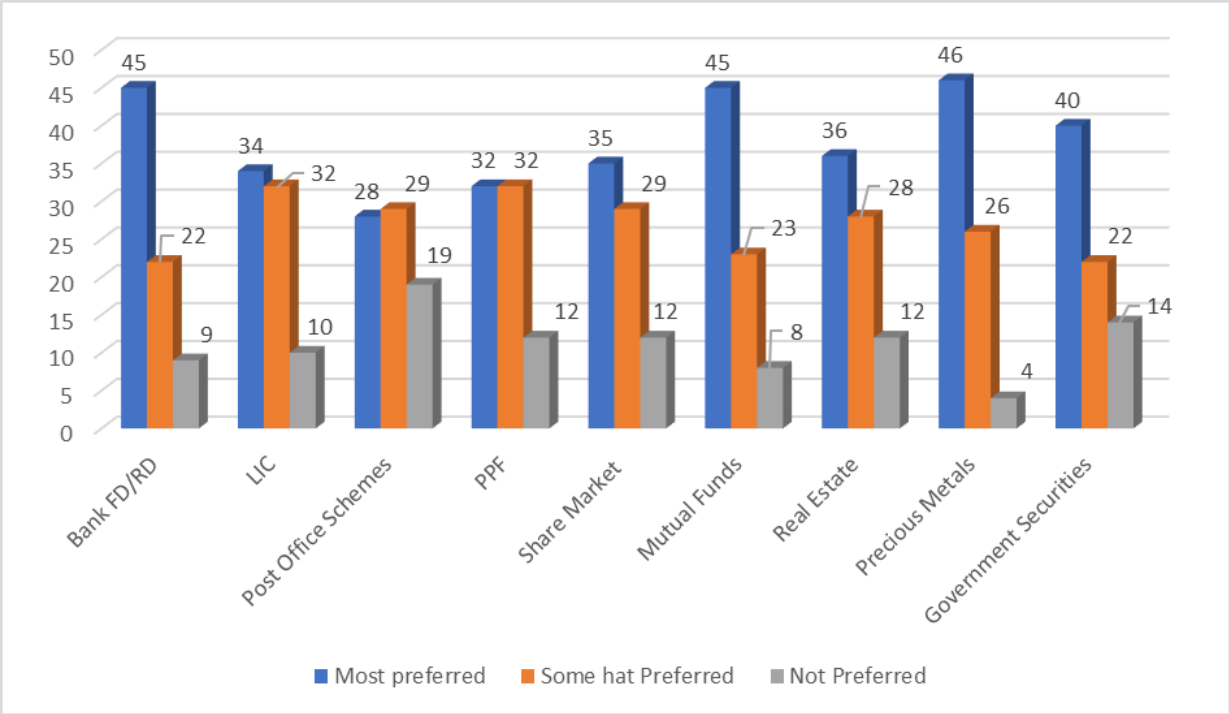

Fig.11. Preferences of Investment options

9. Conclusion

Proper investment planning is required to increase personal finances effectively. A proper investment planning strategy should complement one's special requirements, income, risk tolerance, and financial objectives. Although risk is associated with every type of investment, it may be minimized by proper planning. It is important for individuals to assess their risk tolerance, return, duration, as well as the knowledge of relevant tax laws before making any type of investment decisions. Better and consistent outcomes may be attained by taking suggestions from financial experts and maintaining a diversified portfolio as per the requirements. Ultimately, proper research and a complete understanding of market patterns should form the basis of all kinds of investment decisions.

10. Findings

1. It was observed that the selection of investment alternatives did not vary significantly with age or marital status.

2. Investment behavior was more significantly influenced by gender and educational attainment.

3. Many of the investors were females and youngsters in the age group of 20–30 years, which

indicated that more young women were getting interested in the financial sector.

4. The majority of respondents knew of various investment options like shares, mutual funds, bank deposits, and precious metals.

5. The most popular investment options were mutual funds and bank FDs/RDs, closely followed by real estate and precious metals.

6. A substantial number of respondents either belonged to the sector that is self-employed or to the private sector, and their annual income is less than ₹2.5 lakh.

7. The participants showed interest in different investment opportunities, yet they have limited income.

8. Simple financial literacy was evident, but sophisticated knowledge about financial instruments like bonds or government securities was not.

9. There was a lack of personal financial planning because the majority of respondents were unsure about their ratio of savings and investment.

10. Earning money and realizing specific financial goals (like retirement savings, education expenses, and tax savings) remained the primary objectives for investments.

11. Only a small percentage mentioned the areas of retirement planning or tax benefits as the prime motivation, which indicates a short-term view.

12. In comparison to risky alternatives, conservative products such as FDs, LICs, and Post Office Schemes were popular.

13. Although it discussed behavioral finance theories, it was not possible for evidence related to herd behavior, overconfidence, and mental accounts to be discussed.

11. Suggestions

1. Hold financial literacy seminars aimed at women, young people, and low-income populations.

2. To improve comprehension of risk-return trade-offs, include fundamental investment instruction in college and professional training programs.

3. Urge investors to consider retirement planning, inflation-adjusted returns, and capital preservation in addition to short-term profits.

4. Launch government-sponsored awareness programs about the advantages of long-term mutual fund products like PPF, NPS, and SIPs.

5. To assist low-income and female investors in structured investment planning, financial institutions should provide individualized advising services.

6. Future studies on the irrationality of investors and the design of investment-friendly financial products should consider behavioral biases such as loss aversion, herding, and anchoring.

7. This survey has a sampling of only 75 people in Mumbai. To be more widely applied, future surveys should consider sampling a larger population with more varied profiles from different cities and economic classes.

8. Greater focus should also be on educating individuals regarding online investment tools and applications as well as robo-advisors in order for them to make sound judgments since the majority of new investors are online.

9. To ensure investors receive the correct information on time, governments as well as regulatory bodies, such as SEBI, can lay down disclosure requirements.

10. Design special investment schemes catering to gender-inclusive financial policies, as well as meeting the demands of the female investor segment.

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QUESTIONNAIRE

1. Name: (Optional): _____

2. Email Id: (Optional): _____

3. Area:

1) Western line 2) Central Line 3) Harbor Line

4. Gender:

1) Male 2) Female

5. At what age do you think people should begin to make a financial Plan?

1) Less than 20 years 2) 20 – 30 years 3) 31 – 40 years

4) 41 – 50 years 5) 51 – 60 years 6) More than 60 years

6. Marital Status:

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1) Single

2) Married

7. Educational Level:

1) Secondary (VIII-X)

2) Higher Secondary

3) Diploma

4) Under Graduate

5) Graduation

6) Post Graduation

7) Doctorate

8)Professional

9) Others

8.What is Your Annual Income?

1. Upto ₹ 2,50,000

2. ₹ 2,50,001 to ₹ 3,00,000

3. ₹ 3,00,001 to ₹ 5,00,000

4. ₹5,00,001 to 10,00,000

5. More than ₹ 10,00,000

9.What percentage of your salary do you save?

1) 0 to 15%

2) 15% to 30%

3) 30% to 50%

4) More than 50%

5) Not Sure

10.What is your Investment Objective.

1. To Earn Income

2. To Avail Tax Benefit

3. To Meet Specific Purpose

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4. Retirement Planning

5. To Meet Contingent Liability

If Other than please specify_____

11.Which Factors are responsible for increasing the dimension of savings?

1) Increase in Income

2) Tax benefit

3) Statutory requirement

4) Future desire

12.State the factor of your preference while choosing an investment option:

	Affect the most	Affect Somewhat	Does not affect
1) Safety of principal Amount			
2) Liquidity			
3) Returns			
4) Reliability			
5) Low risk			
6) Recommendation of Family and Friends			
7) Recommendation of Investment Agent			
8) Information / Internet			
9) Other factor			

13.What is your source of investment advice?

1) News

2) Family/Relatives

3) Friends & colleagues

4) Tips from Internet / Social Media (Face book, LinkedIn)

5) Financial reports

6) Financial Advisor

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7) Company Agent

8) Other

14.What type of investment plan do you prefer in future?

1. Regular return plan

2. Retirement planning

3. Mediclaim

4. Specific purpose plan

5. Multiple option plan

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Interlinkages Between Financial Inclusion, Monetary Policy Effectiveness, and Digital Governance in Emerging Smart Cities

Lavanya Samala
lavanyasamalaly@gmail.com

Abstract: Financial inclusion, digital governance, and monetary policy effectiveness interdependent is gaining utmost importance of modern urban financial systems, particularly within emerging smart cities. As digital infrastructures expand, the mechanisms through which monetary policy influences economic behaviour are undergoing a significant transformation. This paper investigates the triangular relationship between financial inclusion, digital governance frameworks, and the operational effectiveness of monetary policy, with a specific focus on rapidly digitizing urban ecosystems in India.

The study explores how digital governance initiatives—such as Aadhaar-enabled payment systems, Unified Payments Interface (UPI), mobile banking, municipal e-governance platforms, and fintech-driven service delivery—have enhanced financial inclusion by reducing transaction costs, improving service accessibility, and enabling secure, real-time financial interactions. These digital financial footprints provide a more responsive environment for the transmission of monetary policy, particularly through the interest rate, credit, and expectations channels. By examining time-series financial data, policy documents, and behavioural indicators, the research demonstrates that greater digital financial participation increases the speed and precision with which monetary policy impulses are transmitted across urban households and businesses.

Furthermore, the paper analyzes how improved financial inclusion strengthens the effectiveness of monetary policy by expanding the proportion of the population integrated into formal credit and savings systems. When more households and enterprises are financially connected, changes in policy rates and liquidity adjustments exert a broader and more uniform influence on borrowing, investment, and consumption decisions. This dynamic contributes to a more stable and predictable urban economic environment, aligning with the goals of sustainable and inclusive smart city development.

However, the research also identifies constraints that may weaken this relationship, including digital literacy disparities, cybersecurity vulnerabilities, inadequate smartphone access, and algorithmic biases in fintech platforms. These limitations risk creating new forms of exclusion even as digital systems expand. The paper highlights the need for strong regulatory and policy safeguards to ensure that digital governance remains equitable, transparent, and resilient.

Overall, the study argues that the convergence of digital governance and financial inclusion offers a significant opportunity to enhance the responsiveness and efficiency of monetary policy in emerging smart cities. It concludes by proposing an integrated policy framework that aligns monetary tools, digital

financial ecosystems, and inclusive governance strategies to support resilient, sustainable, and citizen-centric urban financial systems.

Keywords: Financial literacy, Digital Governance, Smart Cities, Monetary policy effectiveness

1. Introduction

Financial Inclusion is a significant harmonizer for the growth of an Indian Economy which leads to the contribution of all the economic agents towards the growth of an economy. India has started its journey since the 1969 by nationalizing its 14 Banks (Aditi Kapoor, 2014). This gave a pathway to reach out to the rural population with the targets to move to Agriculture, Allied activities and SMEs ie small and medium enterprises. Later with Institutional Innovation led to the growth of Regional rural Banks in the year 1975, NABARD in the year 1982 started prioritizing Primary sector, focusing on Farmers and Self-help group through Kisan Credit cards and Micro financing programs. These initiatives enhanced the growth of household access to 60 percent availing of banking services. Later the financial Services also covered the Pro poor products like crop loans, medical insurances, Education loans and personal loans too. In 2006 with the introduction of National e-Governance plan to provide all the government services to be easily accessible to the citizens of India which will enhance the transparency, increase the efficiency of the services and enhance the reliability of the services provided. This plan includes Twenty seven Mission Model projects. With the Digital Indian introduced in 2015 with one of the mission as SMART CITIES Mission has led to the creations of the sustainable cities for the better governance of the economy with the help of AI through safe and inclusive development as a major motive. In the year 2016. With the diffusion of the Mobile phones in 2009 led to the growth of AADHAR through the JAM i.e JanDhan-Aadhar-Mobile and Flagship program Pradhan Mantri Jan Dhan Yojana PMJDY that led to the increase in the direct benefit transfer. In 2016, the growth of UPI in India and NPCI led to the emergence of India as a International leader in Digital payments. This has increased the bank access to most of the population of India.

Financial Inclusion in India	
Year	**Activity**
1969	Nationalization of 14 Banks
1975	Regional Rural Bank
1982	NABARD
1990	Agent models and regulatory enabling through RBI
2006	National e-Governance Plan
2009	Aadhar (Unique Biometric ID)
	JAM Trinity

2014	Pradhan Mantri Jan Dhan Yojana
2015	Digital India (Smart Cities)
2016	UPI
2020	National AI Portal (2020, expanded post-2021)
2021	**India Stack Expansion (2021–2025)**
2022	**Cyber Security Initiatives (2022 onwards)**

Table 1: Summary of the Financial Inclusion in India since 1969

The effectiveness of Monetary policy is one of the important parameters to successfully implement the Financial Inclusion in an economy and this will also augment the effectiveness of Economy's Digital Governance which will get reflected in the money market too (Patra 2022). The effective transmission of the Monetary policy depends upon various factors like liquidity management by Reserve Bank of India; Payment and settlement system; financial intermediaries and etc. The emergence of Digital governance, Digital payment and financial Inclusion led to the drastic change in the dynamics of Monetary policy of an economy. The objectives of Monetary policy has been under change to navigate through this complex environment of Digital governance and Financial Literacy. This will also impact various channels of Monetary policy like credit channel, exchange rate channel, the traditional interest rate channel, the inflation expectation channel and the asset price channel. The interdependence of monetary policy and financial inclusion has led to the change in flow of money as well velocity of money supply in the economy this rise in the growth of money among different economic agents led to sectoral growth in India. The introduction of kisan Credit cards provided a payment gateway true banking system and also created a provision Emergency fund funding two micro small and medium enterprises. (GOI, Ministry of Finance, 2024).

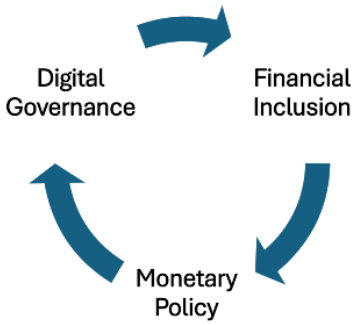

Diagram 1: Nexus of Financial Inclusion, Digital Governance and Monetary Policy effectiveness.

2. Review of Literature

Olajide O. Oyadeyi A (2024), has studied the interrelationship between the financial inclusion, financial development and Monetary policy effectiveness in 54 African economies. This paper has emphasised on financial inclusion led to reduction inefficiency in interest rate, inflation expectation channel and enhances the effectiveness of Monetary Policy. It also suggests It also It also That policymakers should emphas on financial development and financial inclusion to strengthen the growth driven transmission

channels as a major factor in economic growth.

Mittal, R., Kathuria, T., Saini, M., Dhingra, B., & Yadav, M. (2023), has studied the effectiveness of Monetary policy due to the development of financial inclusion. This paper also finds that there is a positive relationship between financial inclusion and effectiveness of Monetary policy as financial inclusion boost the access of all financial services to the comman man leading to increase in demand.
Sanjaya Kumar Lenka and Arun Kumar Bairwa, (2016), has tried to measure the impact of financial inclusion on effectiveness of Monetary policy in SAARC nations from the year 2004 to 2013. It has concluded that greater the financial inclusion the better the stability in the prices and stronger monetary policy.

Song Jiang, Shuang Qiu & Hong Zhou (2022), has examined the impact of Digital governance influence on the effectiveness of Monetary Policy. It was found that there is a positive relationship between Monetary policy effectiveness and the Digital governance in the emerging economies

3. Research Objectives:

1. To examine how digital governance tools (like UPI, Aadhaar, mobile banking) contribute to improving financial inclusion in emerging smart cities.
2. To analyze how increased financial inclusion affects the transmission of monetary policy in urban areas.

1. Hypothesis:

H1: There is no relationship between digital governance adoption and financial inclusion in emerging smart cities.
H2: Higher levels of financial inclusion lead to improved monetary policy effectiveness in urban economies.

2. Findings:

As the Financial inclusion as a dependent variable and the Digital governance as the Independent variable. The data from Global Findex database 2025 and PMJDY website. For the digital governance I have considered the data UIDAI and NPCI as a proxy. The Monetary Policy effectiveness can be observed through variables like interest rate channel, asset price, inflation and credit channels. It has been found that the use of time series data on the below equation

$FI\ t= \alpha+\beta_1 DG_{t-1}+ \beta_2 DG_{t-1}+\beta_3 FI_{t-1} + \varepsilon_t$

FI is financial inclusion
DG= Digital Governance

Using ARDL style as this explains both short run and long run relationship between two variables. It establishes a causal relationship between digital governance and Financial inclusion. as it has established a strong relationship between monetary policy on output. The study employed the JKS granger causality to establish a relationship. It has enhanced the credit channels and financial intermediaries. Further

Financial inclusion has a two-way causality with the Monetary Policy effectiveness like interest rate channels. However, the unidirectional causality is observed in terms of the exchange rate.
The following equation is used to test the Monetary Policy effectiveness:

$MPE= \alpha+\beta_0 UU+ \beta_1 FII+ \beta_2 CC+\varepsilon t$

Where MPE is Monetary policy effectiveness
UU is UPI usage
FII is financial inclusion index and
CC is credit access

The exchange rate has a limited causality between all the three variables i.e. Digital governance, Financial inclusion and effective monetary policy These findings emphasis the significance of the financial development in enforcing the monetary policy
This Paper evaluated the nexus between the Financial inclusion, Digital governance and Effective Monetary policy in Indian economy. It has validated the causality between financial inclusion and Monetary policy as it has its impact on output and price of an economy. To understand the interdependence on Financial inclusion, Digital Governance and Effective Monetary Policy, the study used VAR, Granger causality and ARDL.

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Sustainable mobility revolution: the role of e-vehicles in reducing transportation costs and environmental impact.

Dr. Sandip Khandekar
Associate prof. VSIT

Deepak Chavan
Assistant Prof. Somaiya College.

Abstract: - Rising transportation costs and environmental degradation caused by petrol and diesel vehicles have accelerated the global transition toward sustainable mobility solutions. Electric vehicles (E-vehicles) have emerged as a disruptive alternative due to their economic efficiency and environmental benefits. This study examines the role of E-vehicles in reducing transportation costs while promoting sustainable mobility at local, national, and global levels. Using secondary data from industry reports, government publications, and consumer surveys, the study evaluates lifecycle cost advantages, environmental impact, adoption trends, and consumer perception. In addition, a bibliometric analysis based on Scopus-indexed publications (2010–2024) is conducted to identify global research trends, leading contributors, and thematic evolution in electric vehicle research. The findings reveal that E-vehicles can reduce total transportation costs by 40–70% over the vehicle lifecycle and significantly lower carbon emissions and noise pollution. However, challenges such as high battery costs, limited charging infrastructure, and range anxiety continue to hinder adoption. The study concludes that E-vehicles represent a viable and sustainable mobility solution, provided policy support, infrastructure development, and consumer awareness initiatives are strengthened.
Keywords: Electric Vehicles, Sustainable Mobility, Transportation Cost, Bibliometric Analysis, Environmental Sustainability.

1. Introduction: -

Transportation plays a critical role in both economic growth and social connection, however, it has emerged as a leading contributor to greenhouse gas emissions, air pollution, and increasing household costs. Increased reliance on gasoline and diesel-powered vehicles has led to continued environmental degradation and worsened susceptibility to price volatility in fuel. As a result, governments and industries around the world have been trying to identify cleaner and more economical alternatives. Electric vehicles (E-vehicles) have been identified as an effective solution to both economic and environmental challenges. E-vehicles provide a way for people to reduce their dependence on fuel, lower operating costs, and reduce their emissions by changing the internal combustion engine with an electric propulsion system. The advancement of battery technologies, decreasing costs, and government support have aided in the growth of E-vehicles. Previous research has focused on the technological and environmental aspects of E-vehicles, however there is an increased need for integrating the economics of E-vehicles in conjunction with sustainability outcomes, and the worldwide trends in E-vehicle research. This research will bridge this gap through the combining of economics and sustainability analysis using bibliometric analysis of E-vehicle research articles.

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Review of Literature

Author(s) & Year	Focus Area	Key Findings	Research Gap / Relevance to Present Study
1. International Energy Agency (2023)	Cost efficiency of E-vehicles	E-vehicles have lower total cost of ownership due to reduced fuel and maintenance costs	Supports lifecycle cost comparison used in present study
2. Hawkins et al. (2019)	Lifecycle cost analysis	E-vehicles offer 40–60% cost savings over conventional vehicles	Validates economic benefits explored in this research
3. Sierzchula et al. (2014)	Policy incentives	Government subsidies significantly influence EV adoption	Highlights role of policy support discussed in recommendations
4. World Economic Forum (2022)	Environmental sustainability	EVs reduce carbon emissions and improve air quality	Supports sustainability analysis in this study
5. Burchart-Korol et al. (2018)	Lifecycle emissions	EVs have lower emissions even with mixed energy sources	Strengthens environmental impact assessment
6. Nieuwenhuis & Wells (2017)	Urban noise pollution	EVs reduce noise pollution in urban areas	Reinforces social and environmental benefits
7. Nykvist & Nilsson (2015)	Battery cost trends	Decline in battery prices improves EV affordability	Relevant to cost reduction and adoption growth
8. Gaines (2018)	Battery recycling	Battery disposal and recycling remain challenges	Addresses adoption barriers discussed in the study

Author(s) & Year	Focus Area	Key Findings	Research Gap / Relevance to Present Study
9. Zhang et al. (2023)	Battery innovation	Solid-state batteries and fast charging enhance EV performance	Future research direction identified
10. Hardman et al. (2017)	Government policy	Strong EV policies lead to higher adoption rates	Supports policy-focused recommendations
11. NITI Aayog (2024)	EV adoption in India	Incentives and infrastructure drive adoption in India	Provides national context to the study
12. Rezvani et al. (2015)	Consumer behavior	Cost savings and environmental concern motivate adoption	Supports consumer perception analysis
13. Li et al. (2022)	Charging infrastructure	Improved infrastructure reduces range anxiety	Relevant to infrastructure recommendations
14. Banister (2011)	Sustainable urban mobility	EVs support sustainable urban transport systems	Aligns with urban sustainability focus
15. Shaheen & Cohen (2019)	Shared mobility	EV integration enhances transport sustainability	Expands scope toward future mobility models

2. Objectives:

1. To compare transportation costs of E-vehicles and conventional vehicles.
2. To assess environmental benefits of E-vehicles.
3. To identify key barriers to E-vehicle adoption.
4. To examine global research trends through bibliometric analysis.

3. Research Methodology:

The study adopts a descriptive and analytical research design based on secondary data.

1. Data Sources: Industry reports, policy documents, academic journals, and survey-based studies
2. Analytical Tools: Comparative cost analysis, percentage analysis, bibliometric analysis
3. Bibliometric Tools: Scopus database and VOSviewer

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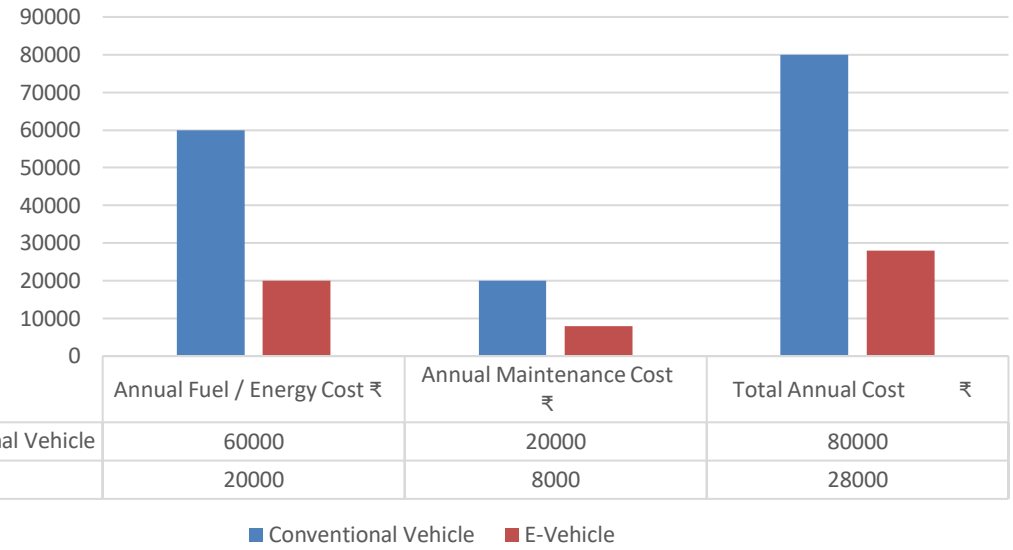
4. Cost Comparison Analysis:

Let us assume Mr. A using E- Vehicles and Mr. B using Conventional Vehicles. The following chart gives you better idea about the cost-benefit analysis of E-Vehicles and Conventional vehicles

Chart 1: Average Annual Cost (₹ per year)



	Annual Fuel / Energy Cost ₹	Annual Maintenance Cost ₹	Total Annual Cost ₹
Conventional Vehicle	60000	20000	80000
E-Vehicle	20000	8000	28000

Source: https://www.bikedekho.com/

Based on the cost comparison, Mr. A's annual transportation cost using an electric vehicle is ₹28,000, while Mr. B's annual cost using a conventional petrol/diesel vehicle amounts to ₹80,000.

The chart below presents the cumulative expenditure incurred by Mr. A and Mr. B over a period of ten years.

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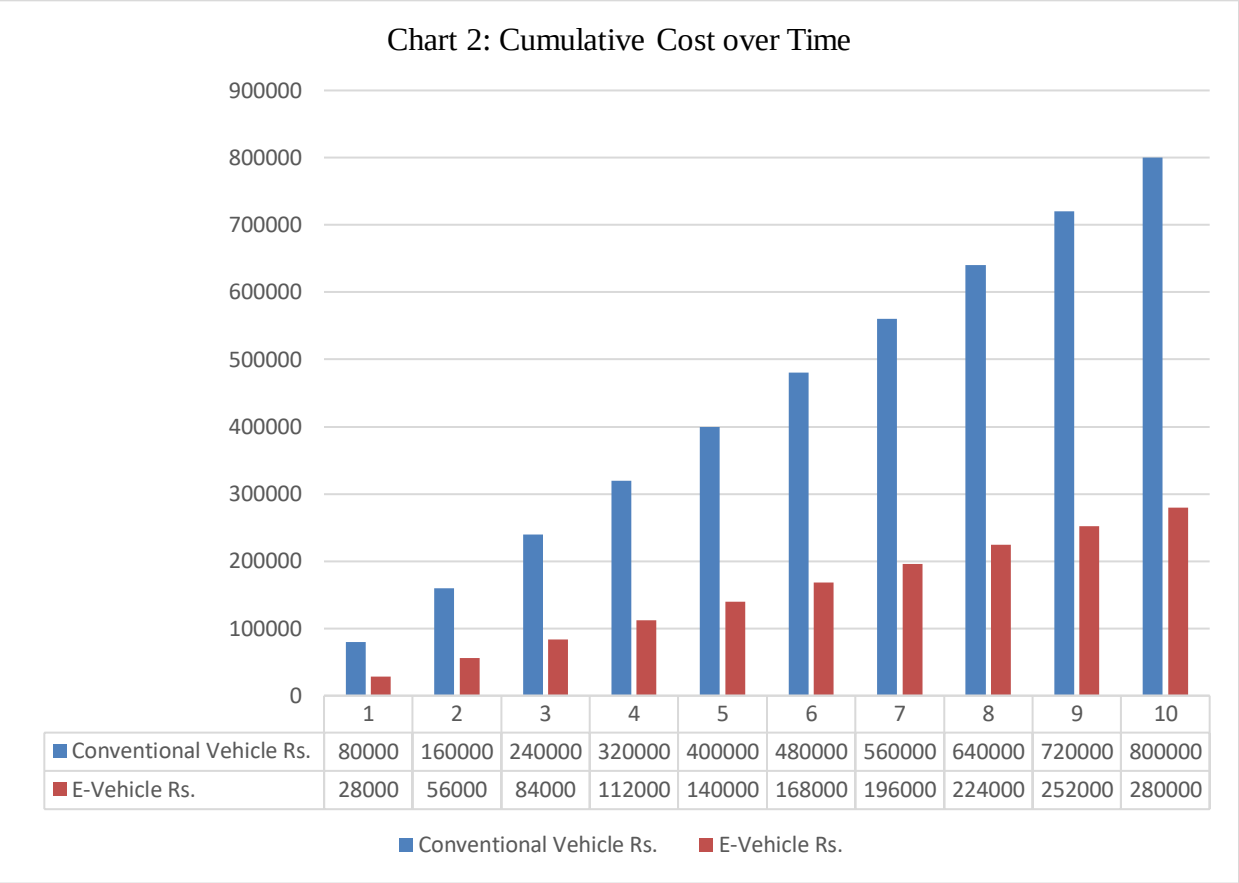

Source: https://www.bikedekho.com/

The lifecycle cost analysis over a 10-year period demonstrates that electric vehicles offer significant long-term economic benefits, with nearly 65% lower total ownership costs compared to conventional petrol and diesel vehicles.

Environmental Impact Comparison: Conventional Vehicles Vs E-Vehicles

Table 2: Comparison of Environmental Impact

Parameter	Conventional Vehicle	E-Vehicle
Carbon Emissions	~120–180 g CO_2/km (petrol/diesel cars)	0 g CO_2/km (tailpipe emissions); ~30–50 g CO_2/km considering electricity generation
Air Pollution	Emits NOx, SO_2, $PM_{2.5}$ and PM_{10} contributing to smog and respiratory diseases	Negligible tailpipe emissions; significantly lower particulate matter
Noise Pollution	70–90 dB in urban traffic conditions	40–60 dB due to silent electric motors
Fossil Fuel Dependency	100% dependent on petrol/diesel	0% direct fossil fuel use; can be powered by renewable energy

Sources: https://e-amrit.niti.gov.in/home

1. Conventional vehicles emit **3–5 times more CO_2 per kilometre** than electric vehicles over the lifecycle.
2. E-vehicles reduce **urban air pollutants by nearly 90%**, significantly improving public health outcomes.
3. Noise levels from E-vehicles are **30–40% lower**, reducing urban noise stress.
4. Transition to E-vehicles directly supports **energy security and decarbonization goals**.

Bibliometric Analysis of Electric Vehicle Research

a) Data Source and Scope

Bibliometric analysis was conducted using the **Scopus database** for publications between **2010 and 2024**, focusing on research articles and review papers related to electric vehicles and sustainable mobility.

b) Publication Growth Trend

Period	Publications
2010–2013	120
2014–2016	340
2017–2019	820
2020–2022	1,650
2023–2024	2,100

The sharp increase after 2017 reflects heightened global interest in E-vehicle adoption and sustainability research.

c) Leading Journals

Major publications appear in Energy Policy, Transportation Research Part D, Journal of Cleaner Production, and Applied Energy, indicating the interdisciplinary nature of E-vehicle research.

d) Keyword and Thematic Analysis

Frequently occurring keywords include electric vehicles, sustainable mobility, carbon emissions, battery technology, and charging infrastructure. Recent studies increasingly focus on ESG impact, policy frameworks, and cost efficiency**.**

e) Relevance of Bibliometric Findings

The bibliometric evidence confirms that transportation cost reduction and sustainability are central themes in global E-vehicle research, validating the relevance and contribution of the present study

5. Adoption Trends and Consumer Perception

Table 3: Adoption Trends and Consumer Perception of Electric Vehicles

Indicator	Data / Findings	Source (Agency / Report)
1. Global EV market share	EVs account for ~14% of global new vehicle sales (2022), projected to reach 20–25% by 2025	International Energy Agency (IEA)
2. EV adoption in India	~2.3 million EVs sold in 2025, around 8% of new vehicle registrations	Ministry of Road Transport & Highways (MoRTH), NITI Aayog
3. Segment-wise adoption	Two-wheelers and three-wheelers dominate EV adoption in India	NITI Aayog, Ministry of Heavy Industries
4. Urban vs rural adoption	Higher adoption in urban areas due to charging infrastructure availability	Central Electricity Authority (CEA), BEE
5. Consumer willingness (global)	~64% of consumers are likely to choose an EV as their next vehicle	TCS Global Mobility Study
6. Consumer readiness (India)	~80–85% of potential buyers are open to EV adoption by 2030	NITI Aayog, Industry Surveys
7. Key motivation factors	Lower running cost, environmental concern, government incentives	IEA, NITI Aayog
8. Environmental perception	Over 80% of EV owners perceive EVs as eco-friendly	CPCB, Consumer Surveys
9. Major consumer concerns	Charging infrastructure, range anxiety, battery replacement cost	Bureau of Energy Efficiency (BEE), IEA
10. Policy influence	Subsidies and incentives significantly improve adoption rates	Ministry of Heavy Industries (FAME), NITI Aayog

Adoption trends indicate rapid growth in electric vehicle usage driven by cost savings, environmental awareness, and policy incentives, while infrastructure availability and battery concerns continue to shape consumer perception.

6. Challenges in E-Vehicle Adoption

1. High initial battery cost
2. Limited charging infrastructure
3. Long charging duration
4. Range anxiety
5. Low awareness in rural regions

6. Findings

1. E-vehicles reduce lifecycle transportation costs by 40–70%
2. Maintenance costs are significantly lower
3. Environmental benefits are substantial
4. Research trends increasingly focus on sustainability and policy

7. Recommendations

1. Expand public and private charging infrastructure
2. Continue policy incentives and subsidies
3. Invest in battery innovation and recycling
4. Conduct consumer awareness programs
5. Promote E-vehicles in public transport and logistics

8. Conclusion

EVs are said to boost post-pandemic for economic recovery. The main aim of EVs in the country is to reduce the oil import and encourage green industrial policy. Electric vehicles will reduce the air pollution and mitigate climatic change. In order to promote usage of e-vehicles, the Indian government also provide lot of subsidies and schemes such as Faster Adoption and Manufacturing of Hybrid and Electric Vehicle (FAME scheme II). A lot of incentives are provided to the buyer such as basic subsidy, rebate, Income tax benefits under section 80EEB etc. In addition to all these incentives, all the electric vehicles are free of registration and road tax costs too. Inspite of all the efforts taken by the government, the adoption of e-bikes are relatively less. This is because of many reasons such as less availability of service stations, charging issues, after sales services, etc. Finally, in the near future, EVs will have a great future in Indian market.

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Predicting Academic Performance of Students in Higher Educational Institutions: Review & Future Research Agenda

Dr. Geeta Sahu
geeta.sahu@vsit.edu.in
Mob No-8108088512
Vidyalankar School of Information Technology, (VSIT)
Wadala (E)

Dr. Faimida Munir Sayyed
faimida.sayyad@aiktc.ac.in
Mob No-9224229049
AI's, Kalsekar Technical Campus, New Panvel

Abstract:

Purpose – Many higher education institutions are working hard trying to build various framework, model, plan of action for the sake of students which will help them to excel in the field of education. The purpose of the paper is to review different materials for gathering data, methods, learning tools and models which can predict the performance of the students and helps in identifying a student is at verge of failing a particular program or not.

Design/methodology/approach – Systematic review was conducted at many stages. In the initial stage, searching was done using different keywords in many documents. In the second stage authors used many citations to carry out review process. In the third stage authors tried gathering data relevant to the study and needed for research work.

Findings – Identification of various techniques that are used in predicting academic performance, its usage and evaluation are identified. The results at the end of the review process can identify the upcoming field in research that can be enhanced using different approach for predicting the accuracy of students' performance that helps to identify whether a student is at verge of failing a particular program or not.

Originality/Value – Authors provides a platform where the overview of all methods and techniques used is discussed for all researchers who are likely to develop a framework, model for predicting the failure rate of student and trying to overcome to achieve the success rate.

Keywords Academic performance, Data analytics, Machine learning algorithm, Predictive analysis. Performance.

Paper type Literature review

1. Introduction

In the twentieth century the world witnesses the paradigm shift in the approach of education via technology and in the attitude of parents and students towards life. Large number of higher education institutions is moving towards good quality to explore different approaches of learning to improve the student pass percentage (Sclater *et al*., 2016). The study on learning analytics in higher education (Leitner *et al*., 2017), relies on obtaining students data, which will help in identifying the performance of every student. The goal of the review is to build a framework or model which will predict student success or failure rate in a course or a program in the examination with the help of large amount of data generated from different sources. The research work and its methodology will monitor the student success, failure rate and will help students to put more efforts, do self-learning to succeed in the examination.

Report on education (Johnson *et al*., 2016) finds that the learning analytics is gradually accepted by educational institutions to improve, extend and support the quality education through online learning environments from the available data which is captured and gathered from different sources. The report also states about learning analytics is a kind of analytics where analysis is done by collecting student data individually involved in online learning activities. Different methods are used in the literature review from different sources which refers to the tools/software and techniques needed to collect and assemble variety of data, which then goes for cleansing, processing and at the end generate results.

In the review paper by Siemen *et al*., (2011), suggested about the advantages of learning analytics which includes early detection of student who is at verge of failing a particular program enrolled into it, generating alerts for such student, parent and teacher as well such that some additional benefits or remedial sessions can be conducted before the final examinations to achieve good success. This can help the learners to achieve motivation, confidence and finally succeed in the exam.

Predicting student success Grade Point Average (GPA) depends on the organizational citizenship behaviour (OCB), pro-social, extra role and helpful behaviour. The voluntary behaviour has also been found to be highly effective and valuable in predicting the success rate. A positive correlation always exists between the student's average grade at the end of the program and variables like placement, intelligence factor, and growth prospectus. In the exploratory study GPA is examined with work related to helpful behaviour. Students needs to understand that average grade may not help vocational skills performance in job instead team building may help the applicant learning ahead.

They have also focused on helping behaviour also one of the metrics for predicting quality GPA for the student. (Paul Lyons *et al*., 2016)

In today's scenario academic standard based educational curriculum, is designed which acts as a baseline for all students to at least have the minimum standard passing/performance criteria in the entire education system. A curriculum is designed and delivered with effective measurable which help the student to succeed in higher examination, it also provides opportunity to focus on exam and ultimately

increase the institution success rate in education. (M.S. Smith *et al.*, 1991).
The student academic performance also depends on level of satisfaction between the teacher and student through bonding. It has a direct influence on the success rate in the examinations. In one of the study it was found that facility management, infra structure also does some measurable contribution in student academic performance along with some social and economical variables (Hopland and Nyhus, 2015; Schneider, 2002).

Big data analytics is defined as huge volume of raw, complex, and real time data that undergoes extraction, cleansing, processing, visualization, and exploration of relevant data for future analysis and prediction purpose. Big data analytics has defined data in terms of - value, volume(huge), variety(different attributes/features), veracity and velocity (Daniel, 2015). Big data analytics can make the learners understand better as well as help trainer cum instructor share their experience and mould the education system.(Long and Siemen 2014).

Data Science/Analytics has gained a lot because to its huge collection of data available in the field of education system. Data analytics in academics enabled business value model which explains the outcome in education system. The study sample involved 47 case description from 26 higher education institutions (HEIs). where the causal relationship between the present requirement, student growth with placement was found out.(Chaurasia *et al*, 2018)

There are some key issues related to the research work, which help us in identifying our research questions as mentioned below:

RQ1. From where to get the data source and what student variables can be taken which will trigger the student performance prediction?
RQ2: How to tackle with missing values from the dataset, processing, cleaning etc. before they are used for training, testing, validating and finally predicting the student performance model?
RQ3: Which machine learning algorithm to be used to determine the accuracy of the model?

These research questions will be helpful in providing a practical guide to develop, design or frame a model with the accuracy measurements. The objective of the review paper is to summarize all methods, tools and techniques at one place which will help research scholars who are likely in the planning phase to design, develop a framework, model to be used in education system for predicting the academic performance of students at all level in the educational sectors. The review will also provide the strength and weakness of the current predictive models applied and used to determine the accuracy and further helps to provide some valuable recommendations to enhance the evaluation of the model.

2. Literature Review:

During the review (Vandamme *et al*. 2007) the students' database was extracted from one of the universities that classified students based on the category of marks, percentage obtained in assignments, tutorials, class test, quiz, mid-term and end semester examination. Also, attendance percentage, no of seminars or guest lectures attended, were taken into consideration. The results of these are divided into 3

categories having - low, mild, and severe risk at the verge of failing from a program or not.

This review paper (Ralph *et al*, 2018) talks about the efficiency in adopting various data mining techniques that are discussed in the paper will help in predicting the performance of architecture students on past academic records fetched from the database. Data mining techniques-linear and multi linear regression and support vector machine helps in modelling and forecasting the results of the students. Regression is a type of classification algorithm which is widely used in research for statistical purpose, that finds the relationship exist between dependent and independent variables. (Delen, 2009; Siemen *et al*., 2012). Logistic regression is a linear function with dependent and independent variables used, and constants are calculated. Greater than 50% are assigned with "1" otherwise "0". The p value calculated was less than 0.05, this shows that they are not strongly related, and hence logistic regression model does not fit as best model for prediction.

Support Vector Machine (SVM) is a data mining tool that uses classification and regression analysis. Radial basic function was also used in support vector machine. (Bin *et al*, 2006 and Lam *et al*, 2006). Five-fold cross validation technique is also discussed. To develop a model the data collected, cleaned, and processed and divided into-training data set (70 percent of complete dataset) and testing dataset (30 percent of complete dataset). Model is trained using the 70 percent training data which results in trained model. The trained model will develop a model for test data and predict student academic performance. The confusion matrix is developed, and overall accuracy was measured. Sensitivity analysis will measure the input variables during the model development. Accuracy obtained from SVM model was 76.67 per cent. Thus, concluded that a non-linear relationship persists between input (past academic records) and output variables (predicted academic performance). (Jiajun and Zheng 2016)

This paper, (Gupta and Turek, 2014) talks about the selected variables can be considered as the predictors for identifying the student academic performance in an MBA/MFT exam. Finding shows that the examination results in an MBA course is strongly related to graduation grades and entrance test percentile score. Data used with a sample size of 97 students for research was from MBA graduates, b-school at Virginia university. Grades used as an indicator. Linear and Multi-Linear regression is taken to determine the correlation between dependent as well as independent variables. Time is one of the variables where student who go straight into the MBA programme after completing the undergraduate degree do not perform at the same level as those involved in real world experience. AGE is also one of the variables. The correlation between these two variables is 0.24 that means there is no high positive correlation between these variables. Inverse relationships also exist between different variables. The value of R^2 in model 1 is 0.398 and R^2 in model 2 is 0.61. Thus, performance of MBA students can be determined by the undergraduate grades and entrance test examination.

Table I. Papers reviewed and year

No of published papers reviewed	Year
1	2002

2	2004
2	2006
2	2007
2	2009
1	2010
3	2011
5	2012
2	2013
7	2014
9	2015
10	2016
9	2017
5	2018
2	2019

3. Methods:

There exists a relation between academic achievement with student, that is examined using SEM. A significant impact on academic achievement with teacher bonding having correlation coefficient high value and level of significance is less (Hoy *et al*, 2006). It is also been found out in the review that students eligible for free lunch program are more prone to attend the class and ultimately has positive impact on student achievement (Kirby and DiPaola 2009).

Observed variables i.e. student and teacher bonding, interaction and mentoring process are identified that can be used to judge the performance of individual student. Chi square test-level of significance on these observed variables are statistically significant. The correlation coefficient suggests that the measure observed variables are positively correlated with each other. (Moran *et al*., 2013).

It determines the academic examination results of students in an undergraduate BCA program using predictive model, an ensemble model is created wherein algorithms used are – Naive Bayes, decision tree and gradient boost algorithm to achieve best results and accuracy (Kamal, and Ahuja, 2019). Parameters used are based on distance from home, behavioural, social, family (Kamal and Ahuja, 2017). Tenfold cross validation technique used to check fitness of result after using ensemble model. This ensemble model gives accurate result and support in identifying students who are at verge of failing a program. Lower class semester grades and other factors like travelling distance from university, no of siblings etc. plays important role in determining the academic performance. The model predicted using classification cum regression algorithm. Naive Bayes can also be used, that is based on conditional probability.

Table II. Dataset description

Description of Dataset

Dimension	499*51
No of instances	499
No of attributes	50
Class attribute	1
No of students at risk	173

(Kamal and Ahuja, 2019)

Ensemble model is designed and used for prediction. (Fathian *et al*. 2016). The reason behind using Ensemble model to combine many existing machine learning algorithms and predict the accuracy of each predictive model against training and testing data. It gives the average output by applying all the machine learning models with less no of classification errors, bias and capable of producing high accuracy. (Webb and Zheng 2004).

Table III. Models and their Accuracy

Model	**Classification error**	**Accuracy**
1. Decision Tree	1.8	98.2%
2. Naïve Bayes	2.0	98.0%
3. Support Vector Machine (SVM)	1.5	98.5%

(Kamal, P. and Ahuja, S. (2019)

Most of the educational institutions are offering learning management systems (LMS) such as white board animation, Moodle, Microsoft team for online live /recorded video lectures, to access course contents, online assignment submissions, assigning grades, rubrics and return the assignment online after assigning grades to students. Later student can view their grades online. The data collected by these LS platforms helps to keep track of each individual student and their records, which will be useful in finding the online progress of the student also prevents them from being a drop out or stop out. Many students enrol for the MOOCs, initially they attend all the video lectures related to their specific course, later with time they keep on skipping the videos and ultimately not able to attempt the quiz, assignments, and exams on time and eventually scores very less, some of them back out and many are being dropped out from the course.(Zhiyun, Rangwala and Johri 2016)

A method is used that uses a technique from recommender system to accurately predict the students would be appearing exam grade or marks based on the course duration assessment and sets an alarm to warn them prior appearing for the exams. From admission record demographic information is used such as high school scores, CAT/CET scores, grades etc. First method used was course specific regression model on per student basis. The next term grade prediction result was on transcript data. Result shows

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that factorization matrix produces lowest error prediction. Personalised linear regression model is good followed by random forest method. (Elbadrawy, *et al*., 2016)

Table IV. Research methods/Techniques which match the count of publications.

Technique used	Total publications
Classification	12
Regression	13
C4.5	5
Naïve Bayes	12
Adaboost	2
Random Forest (RF)	5
Support Vector Machine (SVM)	5
K-nearest neighbour (KNN)	5
Artificial Neural Network	2
Convolution Neural Network	2

Table V. Distribution of articles by geographic focus: countries/regions

Country	**No of papers**
Austin	1
Austria	1
Australia	3
Belgium	3
Canada	1
China	7
Egypt	1
India	4
Iran	1
Ireland	3
Malaysia	1
Netherland	2

Country	**No of papers**
Nigeria	1
Norway	1
Saudi Arabia	2
Scotland	2

South Africa	2
Switzerland	3
USA	13
United Arab Emirates	3
United Kingdom	8

Table VI. Recent Articles on Predicting Students Academic Performance and their findings

Authors	Purpose	Methods	Findings
Yan *et al*. (2019)	To find the correlation between program grade and student learning behaviour and develop a model.	Machine learning model, Feed forward and gradient method	Gender, age have very low correlation with program grade. Binary classification gives high accuracy in prediction.
Shahira *et al*. (2018)	How data analytics can be used in higher education	Big data mining, Analytics.	Model related to educational domain is developed to overcome the challenges in education.
Ralph *et al*. (2018)	How data mining techniques are efficient in predicting the performance of architect students.	Five-fold cross-validation techniques, Logistic regression, Support vector machine.	Support Vector Machine gives the better accuracy compared to other techniques.
Galina *et al*. (2018)	Process Mining and Sequential Pattern mining techniques are used to find the performance of students in MOOC.	Process Mining, Sequential Pattern Mining, Sequence Classification	Sequence Pattern Mining gives the better results in prediction.
Paul and Randall. (2017)	Social, helpful behaviour affects the student grade and can be considered as a predictor.	Statistical analysis, Cronbach's α	Statistical linear and multi linear regression analysis performs better.

Rahila *et al*., (2017)	To propose a process mining approach that helps in predicting students learning experience in MOOCs.	Process mining features. Classification methods, Machine learning algorithms - Naive Bayes, RF, LR and KNN., Ten-fold cross-validation technique.	Predicting students' performance.

Authors	Purpose	Technique	Findings
Darwish and Yousef. (2017)	To find how communication and assessment have impact on teaching methodology.	Hypothesis Testing, Regression Analysis	What can be the factors affecting the performance of undergraduate business students.
Ali Daud and *et al*, (2017)	Students' personal information and family expenditure data are used to identify, a student is at the verge of completing a program or not.	Data Mining, Discriminative, generative classification models, SVM, Bayesian Network, Naive Bayes (NB) for precision, recall/sensitivity and F1 score.	Students' personal information and family expenditures are the factors affecting the academic results of students.
Raghad *et al*., (2017)	Machine learning is used for MOOC courses to predict the final performance of student	Machine Learning algorithms, Educational Data Mining (EDM).	Correlation exist between stream actions and learner's outcomes.

Weiyu *et al*., (2017)	Machine learning algorithms in determining the learning outcome.	Data Mining, Predictive Learning Analytics, (machine) learning features.	SLN algorithm to be used to predict the student behaviour in education.
Owen *et al*., (2017)	To determine how well a student performs in a virtual learning environment using Neural Network technique.	Machine learning, Neural Network,	Model needs to be built for all courses which can predict the exam results.

4. Future research agenda:

In this section we discuss some key issues for future studies. While using the data set consider a large sample size. Various other methods can be improvised to understand their accuracy level. Elimination of the errors is a big concern which needs to be taken care.

5. Results:

The study reveals that different methods are used to identify a student is at verge of failing a program or not and judge the performance based on various parameters mentioned above. This can really be helpful prior the final term end examinations of the students and necessary steps can be taken to organise remedial sessions, extra lectures in order to bring the level up of these identified students, because of their poor performance in mid-term examinations, or less attendance in class, not attentive , failure in timely submissions of the assignments, quiz, not appearing for the tutorials, class test, take home test etc (Gerben W., *Dekker*, Mykola P. and Jan M., (2009) "Predicting Students Drop Out: A Case Study. Educational Data Mining 2009".

The study also reveals which method produces a higher accuracy of determining a student being a drop out or not and what type of challenges are encountered by the students and their parents in higher educational institutions. During the review process it was found that a gap needs to be filled to provide detailed report on learning analytics for a student. Thus, a systematics review is done to provide all findings, research methods, framework, methodology adopted, technology used, challenges faced by syllabus design committee, instructors, parents, administrators, in higher educational institutions. It is advisable to enhance the quality of learning analytics by making use of processed data with relevant attributes available during the academic session to improve the students' performance in higher education system. (Hughes and Dobbins 2015)

6. Recommendations:

To help improve educational outcomes, good quality results with maximum pass percentage having high grades, researchers needs to work on wide variety of data sets from past academic records, learner's mood, behavioural data, MOOC enrolment, biometric and many more.(Ferguson, R & *Buckingham* Shum, S (2012). "Social learning analytics. Educational Technology & Society", 15(3), pp.3-26.

Biometric records for attendance, assignment submission and test can be considered for each student. This biometric data would help in giving ethical, legal, correct, and accurate information about a student and this data after processing, cleaning will provide proper information whether a student is at risk of being a failure or drop out. (Ferguson, R. *(*2012). "Learning analytics: Drivers, developments, and challenges", International Journal of Technology Enhanced Learning, 4(5/6), pp.304–317.

1. Galina D., Johannes D., Pieter D., Jochen De (2018), "Dropout Prediction in MOOCs: A Comparison Between Process and Sequence Mining", Springer International Publishing AG 2018E. Teniente and M. Weidlich (Eds.): BPM 2017 Workshops, LNBIP, p.308.

7. Conclusion:

The writing of this paper is to give detailed information to the research scholars with a focus on what different types of methods exists on the topic – academic performance. Data analytics has become a centre point by extracting, cleaning, processing and finally predicting the student's performance. In this era of technology with data growing rapidly and getting accumulated, researchers can collect lots of data with large datasets.(Kaur and Kaur 2015) Students data captured via online needs to be properly analysed, cleaned, processed, integrated and should generate results for instructors and facilitator which will directly help student to enhance learning and determining the possibility of being a drop out or not. (Ying *et al*., 2019).

Different methods used are:

- Machine learning techniques
- Big data analytics/Mining
- Statistical analysis
- Dendrogram models
- Adaboost model

(Hughes G. and Dobbins C. 2015).During the academic session there are a lot many students might be at a risk of "danger zone" that defines them from being a drop out from the institution, which can be reduced using any one of the model discussed based on maximum accuracy. (Schapire and Singer 1999).

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A Study of NEP 2020 implementation impact on Performance of Undergraduate Students

Dr. Ujwala Madhav Sav
Vidyalankar School of Information Technology, Mumbai
Ujwala.sav@vsit.edu.in

Dr. Beena Kapadia
K.E.S. Shroff College of Science, Mumbai
beena@kessc.edu.in

Abstract: The introduction of the National Education Policy (NEP) 2020 represents a paradigm shift in India's higher education landscape. The policy advocates curricular flexibility, interdisciplinary exposure, competency-based learning, and integration of skill development within formal education. This paper critically examines the influence of NEP 2020 on the academic performance and overall growth of undergraduate learners. Using an in-depth review of post-2020 academic literature and policy analyses, the study evaluates emerging trends in learning outcomes, student engagement, employability preparedness, and institutional practices. The review indicates that NEP-aligned reforms have contributed to more learner-centric educational experiences and enhanced skill orientation. However, variations in institutional capacity, faculty readiness, and digital infrastructure continue to affect the uniform realization of policy objectives. The study underscores that sustained institutional support is essential for translating policy reforms into measurable academic improvement.
Keywords: *National Education Policy 2020, undergraduate studies, academic outcomes, higher education reform, skill-oriented learning*

1. Introduction

India's National Education Policy 2020 was formulated to address long-standing limitations in the education system and to align higher education with contemporary global and societal demands. At the undergraduate level, the policy emphasizes interdisciplinary curricula, flexible program structures, outcome-based assessment, and experiential learning. These changes aim to move beyond rote learning and foster analytical ability, creativity, and employability among students.

Higher education institutions, including colleges affiliated with Mumbai University, have begun restructuring undergraduate programs in accordance with NEP 2020 guidelines. New curricular frameworks include vocational modules, internships, community engagement, and credit-based flexibility. While the policy vision is comprehensive, its actual impact on student academic performance must be assessed through existing empirical and review-based studies. This paper attempts to synthesize such research to evaluate early outcomes of NEP 2020 implementation.

2. Objectives of the Study

The present study seeks to:

- Evaluate the effect of NEP 2020 reforms on undergraduate academic performance
- Examine shifts in student engagement, higher-order thinking, and skill acquisition
- Analyze the contribution of multidisciplinary and flexible curricula
- Identify institutional and systemic challenges in NEP 2020 implementation
- Review findings relevant to Mumbai University and similar public universities

3. Research Methodology

This research follows a qualitative and descriptive approach based on secondary data analysis. Scholarly articles, policy documents, government reports, and conference publications released between 2020 and 2025 were systematically reviewed. The selected literature focuses on higher education reforms under NEP 2020, student learning outcomes, employability skills, and implementation challenges. The study does not involve primary data collection and relies on comparative analysis and thematic synthesis of existing research.

4. Curriculum and Structural Innovations under NEP 2020

NEP 2020 introduces significant structural modifications in undergraduate education, including multidisciplinary degree options, modular curricula, and multiple entry and exit pathways. The Academic Bank of Credits (ABC) mechanism facilitates credit accumulation and transfer, enabling students to customize their academic trajectories and re-enter education after interruptions.

Several studies suggest that these provisions offer greater academic autonomy and may reduce student attrition. However, effective execution requires administrative efficiency, robust digital systems, and curriculum redesign, which remain challenging for institutions with limited resources.

5. Influence on Academic Performance and Learning Processes

The reviewed literature indicates that NEP-driven pedagogical reforms have encouraged interactive teaching methods and continuous assessment practices. Learner-centric approaches, combined with clearly defined learning outcomes, have been associated with improved classroom participation and conceptual understanding among undergraduate students. Outcome-based education frameworks also promote transparency in evaluation, although their effectiveness depends on faculty expertise in outcome mapping and assessment alignment.

6. Skill Development and Career Readiness

Enhancing employability is a central objective of NEP 2020. The incorporation of vocational education, internships, project-based learning, and community-oriented activities aims to equip students with practical skills alongside academic knowledge. Research findings highlight improvements in communication abilities, problem-solving skills, and workplace readiness, particularly in science, technology, and professional programs.

Despite these advancements, the literature emphasizes the need for sustained collaboration with industry and periodic curriculum updates to ensure long-term relevance.

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7. Digital Transformation in Teaching and Learning

Technology-enabled learning has become a key component of NEP 2020 implementation. Online learning platforms, digital repositories, and blended teaching models have expanded instructional reach, especially in urban and well-resourced institutions. Nevertheless, unequal access to digital infrastructure and connectivity continues to create disparities in learning experiences, particularly for students from rural and economically disadvantaged backgrounds.

8. Faculty Readiness and Academic Capacity Building

Faculty competence plays a decisive role in the successful adoption of NEP 2020 reforms. Educators are required to adapt to interdisciplinary teaching, digital pedagogy, and outcome-based assessment models. Although universities have initiated faculty development programs, inconsistencies in training quality and participation levels persist. Continuous professional development and institutional support are essential for sustaining pedagogical transformation.

9. Constraints and Implementation Barriers

The implementation of NEP 2020 faces multiple constraints, including funding limitations, administrative complexity, and regional disparities. Public universities often encounter greater challenges than private institutions in terms of infrastructure and human resources. Addressing these issues through targeted policy interventions and capacity-building initiatives is necessary to achieve equitable educational outcomes.

10. Data & Visual Evidence from Secondary Sources

This section presents empirical indicators aligned with NEP 2020 implementation, derived from official statistics. Figures include (1) national Gross Enrolment Ratio (GER) trends from AISHE, (2) Academic Bank of Credits (ABC) registration growth, and (3) SWAYAM platform throughput. Calculations (absolute change and growth) are provided in captions where relevant.

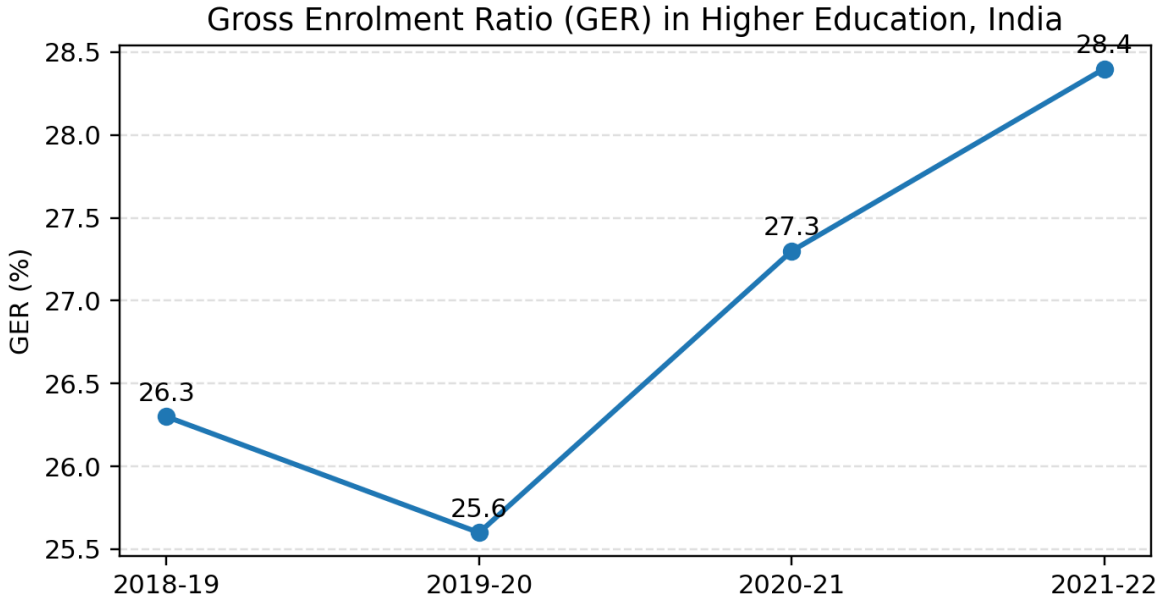

Figure 1. GER in higher education rose from 26.3% (2018-19) to 28.4% (2021-22), an absolute

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increase of 2.1 percentage points (≈8.0% relative to 2018-19). Source: AISHE 2018-19; AISHE 2020-21 (PIB, 29 Jan 2023); AISHE 2021-22 (PIB, 25 Jan 2024).

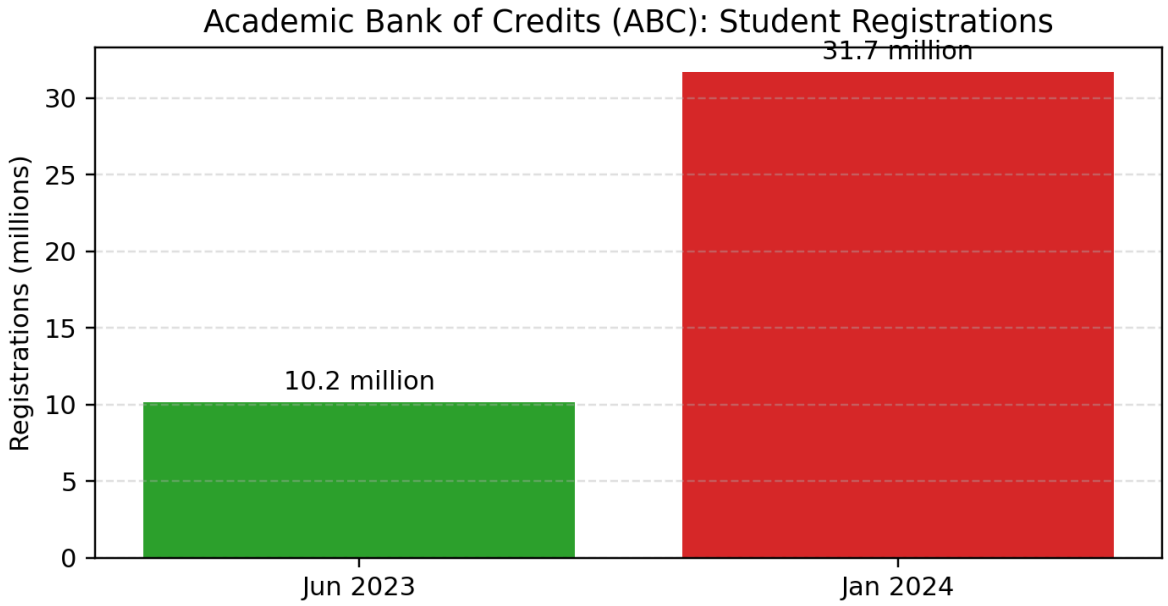

Figure 2. ABC student registrations expanded from ~10.16 million (Jun 2023) to ~31.7 million (Jan 2024) — a 3.1x increase in ~7 months. Source: Times of India (Jun 8, 2023); The Indian Express (Jan 5, 2024).

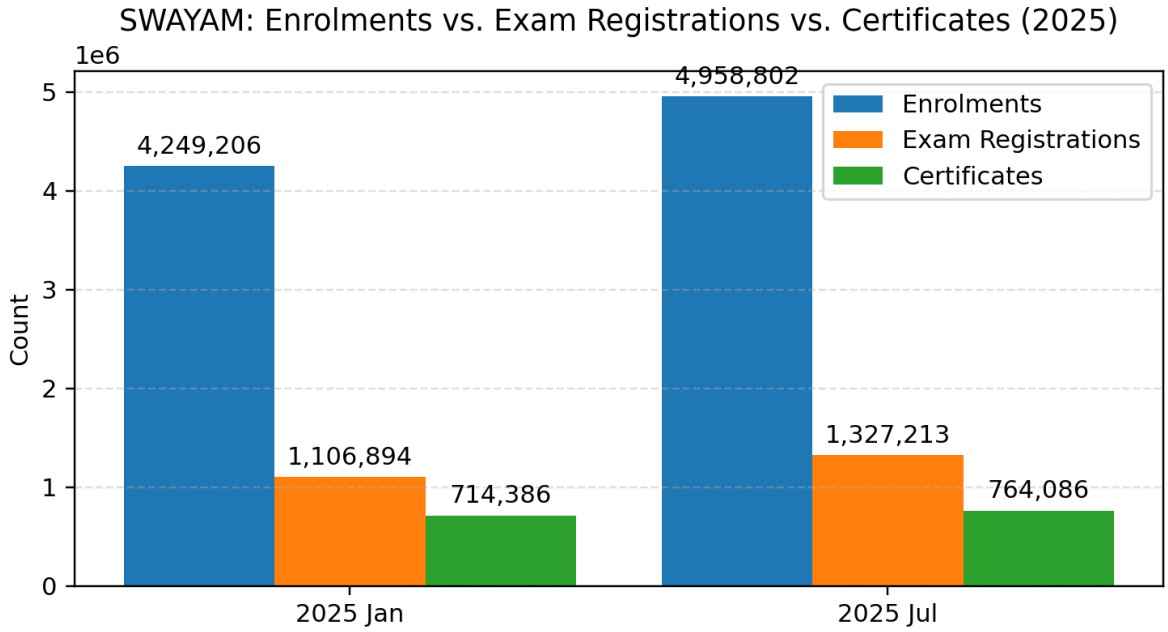

Figure 3. SWAYAM (MOOCs) saw 4.25 million enrollments vs. 1.11 million exam registrations and 0.71 million certificates (Jan 2025); and 4.96 million enrollments vs. 1.33 million exam registrations and 0.76 million certificates (Jul 2025). Source: SWAYAM Central – Enrollment Statistics.

11. Synthesis of Findings

The literature reviewed suggests that NEP 2020 has positively influenced undergraduate education by promoting flexibility, interdisciplinary learning, and skill enhancement. However, infrastructural gaps, uneven faculty preparedness, and digital inequities continue to restrict the full realization of policy goals. Coordinated efforts among policymakers, universities, and educators are required to bridge these gaps.

12. Conclusion

The National Education Policy 2020 marks a progressive step toward transforming undergraduate education in India. Evidence from recent studies indicates improvements in student engagement, academic flexibility, and employability-oriented learning. Nevertheless, the sustainability of these gains depends on effective implementation supported by adequate infrastructure, faculty training, and digital resources. Strengthening institutional capacities will be crucial for achieving the long-term objectives envisioned under NEP 2020.

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Bridging AI Efficiency and Smart City Needs: A Comprehensive Study on Green Video Surveillance Systems

Nikhil K Pawanikar, Assistant Professor,
Nilkamal School of Mathematics, Applied Statistics & Analytics,
SVKM'S NMIMS Deemed to be University

Dr Swapna Kadam, Assistant Professor, Department of IT & DS,
Vidyalankar School of Information Technology Mumbai

Abstract: The demand for intelligent surveillance systems is ever-growing with the advent of more and more smart cities in the world. Although AI-based video analytics have been beneficial in improving anomaly detection, these systems are also known to be computationally expensive and consume more energy. In the following paper, an elaborative, research-oriented content is provided, discussing the need for Green Computational Intelligence (GCI) in the context of sustainable video surveillance systems. In this context, a survey of 150 professionals from the area of smart surveillance, IoT, information technology security, and urban governance is conducted to gather insights on the adoption and energy consumption barriers associated with it and the expectations from green AI systems. Statistically, it is proven that 72% of organizations face the challenge of high energy consumption in adopting AI-based intelligent video surveillance systems on a larger scale. In the extensive work provided, theoretical insights, survey results, frameworks, and future research directions are given on the deployment of sustainable AI-based anomaly detection systems in the context of smart cities.

Keyword: Green Computational Intelligence (GCI), Energy-Efficient Video Surveillance, Smart Cities, AI-Based Anomaly Detection, Edge Computing Optimization

1. Introduction

The development of smart cities has created new methods for urban spaces to develop their social and operational systems. The need to protect increased population areas has made video surveillance systems essential for tracking people and preventing crime and managing traffic and handling emergencies. Current surveillance systems use advanced technology that includes Artificial Intelligence (AI) and machine learning video analytics to identify unusual patterns and recognize activities and classify objects and assist with decision-making. The security systems obtain greater operational performance through their use of AI-based functions which improve their speed of operation and their ability to operate correctly.

The introduction of AI into video surveillance systems creates substantial demands for computational resources. The system requires extensive computational power to handle features such as object detection and tracking and scene understanding and motion prediction and face identification. The system results in a dual problem that leads to both high energy use and greater greenhouse gas emissions. The ongoing digital infrastructure development in urban areas will lead to significant environmental problems from continuous video processing operations. Data centers which support surveillance analytics consume vast amounts of electricity while citywide edge devices face challenges

with their heat management needs and storage capacity and battery power limitations. The current smart surveillance system needs to remove its existing dependence on. The creation of Green Video Surveillance Systems as a research field seeks to achieve better system performance while reducing environmental effects. Green Computational Intelligence (GCI) uses lightweight machine learning models and energy-aware scheduling and edge-cloud synergy and adaptive frame sampling and hardware-level optimization techniques to achieve energy savings while maintaining analytical precision. The developed innovations create a chance to transform urban security systems through the implementation of intelligent monitoring systems which deliver sustainable performance and dependable results. The research on Green AI has grown, but existing studies still explore either algorithm development or hardware development without considering their connection.

The research works which exist at this point fail to provide a complete understanding of sustainability which needs to connect with real-life smart city demands and user needs and resource limitations and practical operations. The study lacks sufficient evidence about how energy problems affect industrial experts and how large organizations develop their solutions. This article introduces a two-part research study that contains both a systematic literature review and primary data from 150 professionals who work in smart surveillance and IoT and AI security and urban governance. Research intends to investigate existing challenges and adoption trends and future possibilities which exist for creating environmentally sustainable AI-powered video surveillance systems. The paper presents the new AI-Energy Adaptive Video Surveillance Framework (AEAVS) which uses lightweight deep learning and dynamic workload balancing and energy-aware data routing to lower energy usage.

In combination, the research provides three main contributions:
1. An overall understanding of today's AI driven surveillance problems from the holistic view of computation, energy consumption, networking constraints, carbon footprint and scalability.
2. Empirical data from industry professionals which will provide insight into what is actually happening, the obstacles to adoption, and what they expect of future green surveillance technologies.
3. The first scalable and implementable Green AI solution that balances efficiency, accuracy and environmentally sustainable practices within smart city environments.

By providing such an overall view, the goal of the paper will be to assist policymakers, technology providers and smart city planners by providing guidance on how to develop future intelligent, scalable and environmentally responsible surveillance systems. As Green AI is not only seen as a form of optimization but as the beginning of a complete transformation towards sustainable urban intelligence, this will be the direction to take for the next generation of smart cities.

2. Literature review

Artificial intelligence and deep learning technologies have brought fundamental changes to the development of video surveillance systems. Early surveillance systems operated through their ability to passively record video content, but current smart city systems depend on automated object detection and motion tracking and AI-powered video analysis to detect abnormal patterns. Research demonstrates that deep learning models which include Convolutional Neural Networks (CNNs) exceed traditional image-

processing methods in their ability to detect objects while simultaneously decreasing false alarm rates, according to Zhang and Lee (2019). Real-time object detection systems which include YOLO-based architectures have achieved extensive public safety and traffic monitoring system deployment capabilities, according to Kumar and Patel (2020). Advanced AI algorithms require substantial computational power, which creates multiple operational difficulties for their users.

The literature shows that continuous video analytics require high amounts of energy which scientists have identified as a persistent research problem. Research shows that smart surveillance networks use deep learning-based video processing to reach power consumption levels that exceed 70 percent of their total power budget (Hernandez et al. 2021). The increase in energy requirements results from multiple elements which include high-resolution video feeds and continuous GPU operations and the transmission of data with high bandwidth to cloud servers (Singh & Babu 2020). The deployment of smart cities at a large scale increases existing problems because energy efficiency needs to improve for systems to achieve their full capacity. Researchers are developing eco-friendly solutions to replace conventional AI surveillance systems because urban expansion has created environmental problems and higher carbon emissions in smart cities (Rahman & Uddin 2022).

Green Computational Intelligence (GCI) emerged as a promising solution to address these problems. GCI develops AI algorithms which achieve energy efficiency through intelligent resource management and system functions. Researchers developed multiple effective solutions which operate between dynamic frame rate adjustment and lightweight model deployment and adaptive scene processing to reduce unnecessary computation during periods of low movement (Das & Chatterjee, 2021). Edge computing has gained more attention because research demonstrates that moving inference tasks near to the camera results in lower latency and energy savings by reducing cloud infrastructure needs (Li & Chen, 2020). The use of low-power AI accelerators such as TPUs and ARM-based processors enables hardware-level optimization to decrease power consumption in surveillance systems by up to 50% (Morgan & Shaw, 2021).

The current study investigates lightweight energy-efficient AI systems which include MobileNet Shuffle Net and Efficient Net as their primary subject matter for testing in environments with limited resources. The models achieve accurate results yet they require less than optimal processing power because they function with fewer parameters than their competition (Tan & Le 2019). The methods of model pruning and quantization and knowledge distillation provide solutions to decrease both the size and energy consumption of models according to the findings of Liu and Park 2020. Despite showing strong potential these methods face difficulties which restrict their use in actual smart city surveillance systems because of issues with both operational dependability and system capacity and their ability to function in changing environmental circumstances according to Sharma and Gupta 2021.

There are multiple gaps identified in current research. The majority of the current research studies only isolate the technical optimizations and do not include the full framework of all of the energy-efficient algorithms; hardware acceleration units; and multiple layer data routing strategies. There are very few of these research studies that incorporate primary data or include any stakeholders in their research study.

These omissions result in a lack of comprehension about what would create real obstacles to being able to implement these technologies. Additionally, the current research studies do not include sustainability metrics, such as long-term carbon footprint, lifecycle analysis, and scalability, will very few of the research studies conducted have included sustainability metrics (Ahmed & Noor, 2022). Addressing the voids left by these current gaps within the research present the opportunity to provide a complete view of the best way to merge the efficiency of the technology used with the operation of a smart city; this will include theoretical and industry data.

Overall, there is a significant amount of current literature available that indicates that while AI has increased how effective monitoring can be done through surveillance, the growth of using more computing power; through an increased computing workload; has created significant challenges for smart cities due to the vast amounts of energy that will be required to support this increased computing power. The majority of the current literature emphasized on the need for an energy-awareness optimization to be completed; the need for a lightweight research model to be used in the development of new models; and how to develop a framework to support sustainable AI integration. A lack of empirical studies and a lack of a comprehensive framework provides a future direction for conducting additional research. The research study will identify existing gaps and combine a systematic review of existing literature with the collection of primary data to create a comprehensive and scalable green video surveillance strategy.

3. Methodology

The research design that will be used for the investigation is a mixed approach that will use a systematic literature review approach along with first-hand data collection with the aim of determining the contributions made by Green Computational Intelligence toward ensuring the sustenance of video surveillance. In this review, top-tier journals such as Scopus, IEEE Xplore, Springer Link, and Science Direct will be used. Care will be taken to adhere to the PRISMA protocol. Relevant studies published between 2015 and 2024 will be filtered using specific keywords focusing on green AI, energy-aware video analytics, lightweight deep learning, and edge computing. After applying the criteria for exclusions and inclusions, a total of 47 best-quality research articles were used to gain theoretical knowledge. The articles offered theoretical knowledge concerning energy issues, green AI, and architectural models.

As a supplement to literature study results, a quantitative survey study targeting 150 professionals from smart surveillance, IoT, IT security, and urban governance domains was conducted. A structured questionnaire was developed to obtain data regarding adoption trends, energy consumption problematics, awareness rates, and aspirational features for future green AI systems. Statistical tests, along with descriptive and reliability tests, were conducted to verify and validate data obtained. Important findings

4. Proposed Framework: AI-Energy Adaptive Video Surveillance System (AEAVS)

The AI-Energy Adaptive Video Surveillance system operates as a machine learning system which enhances smart city video surveillance operations through its ability to decrease both energy use and

computational needs while maintaining effective anomaly detection performance. The framework consists of three core components which enable video surveillance systems to operate with advanced AI technology through edge computing and sustainable energy management methods. The deep learning models MobileNet and ShuffleNet and GhostNet models provide effective solutions because they achieve precise results through their minimal use of parameters. The use of this technology in video surveillance systems results in reduced data transfer needs for cloud-based analysis. The system features an effective framework which prevents duplicate calculations through its methods of frame sampling and resolution scaling to enable smooth operation across different power and complexity levels.

The second feature primarily comprises energy-efficient task scheduling as well as effective edge-cloud hybrid computation. When a smart device detects a complex event or when it exceeds a certain energy limit, it can off-load tasks to a designated central cloud server.

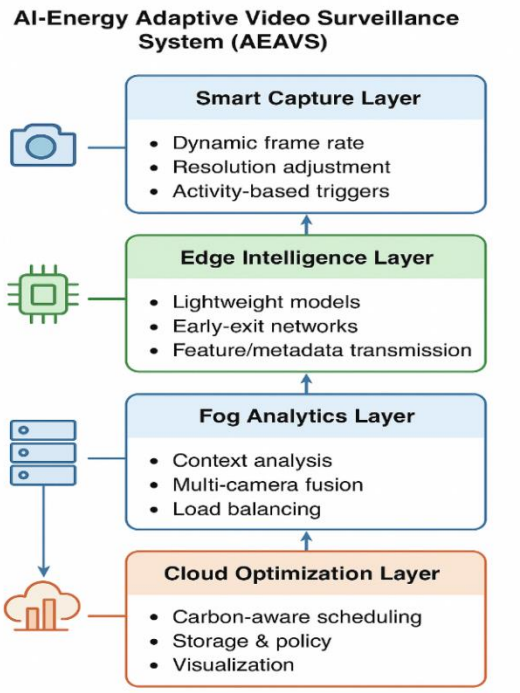

Fig 1: Proposed Framework AEAVS

This results in a lack of continuous cloud dependency, and at the same time, we ensure that we utilize the scarce energy resources optimally. The framework is also equipped with a self-monitoring energy module that assists in decision-making processes based on GPU usage, battery voltage, and temperature. Finally, an optimization module that uses AI assists in the continuous learning process in order to achieve an ideal balance for accuracy, latency, and power usage. Therefore, we have a sustainable framework that is also intelligent and sustainable for real-time applications in smart cities.

5. Results and discussion

This section expands on the results from the conducted systematic literature review and primary survey, where 150 professionals working in the field of smart surveillance, IoT, urban governance, and IT security were consulted. The total number of questionnaires delivered was 150, but the research received 120 responses. The results clearly depict the growing issues with energy consumption in AI video

surveillance, as well as the necessity of deployable and green AI solutions that can enable the concept of smart city scalability.

5.1 Survey Results

5.1.1 Awareness and Adoption of AI-based Surveillance

A majority of respondents (68%) confirmed that their organizations already use some form of AI-driven video analytics, mainly for crowd monitoring, intrusion detection, and traffic analysis. However, only 27% have adopted energy-efficient or Green AI models, indicating a large gap between AI adoption and sustainable AI implementation.

5.1.2 Key Energy-Related Challenges

Participants identified high GPU power consumption (74%), continuous streaming load (63%), and cloud processing latency (58%) as major bottlenecks. The participants established that energy consumption limits the deployment of intelligent surveillance systems which operate in smart cities by 72%. The research demonstrates that deep learning-based video analytics systems require three to five times more energy than traditional CCTV systems.

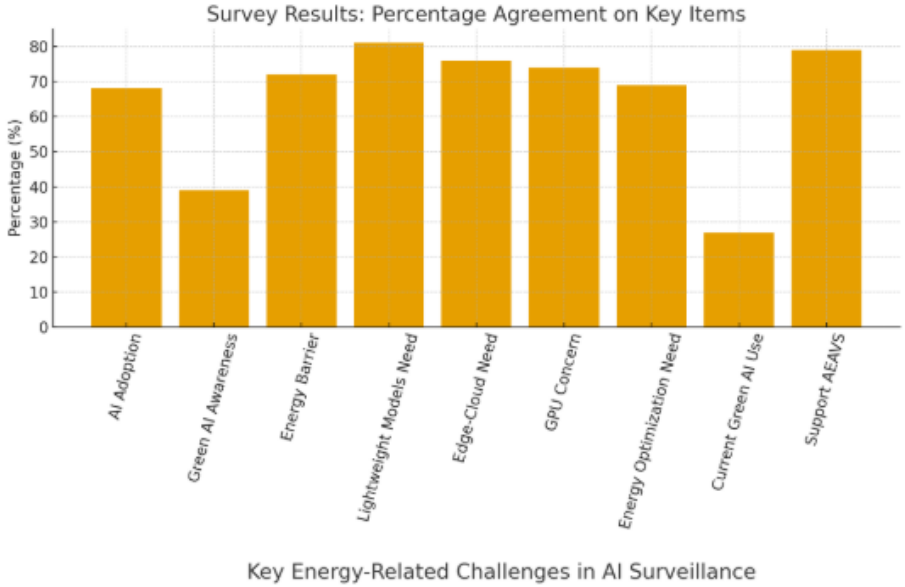

Fig 2: Key Energy Related Challenges in AI Surveillance

5.1.3 Expectations from Green AI Systems

Respondents highlighted the need for:

- lightweight models capable of edge-level processing (81%)
- hybrid edge–cloud systems to avoid overuse of cloud resources (76%)
- automated energy optimization and workload balancing (69%)
- reduced carbon footprint of AI surveillance installations (55%)

These expectations validate the relevance of the AI-Energy Adaptive Video Surveillance (AEAVS) Framework proposed in this study.

5.2 Statistical Test Results

Test	Purpose	Variables Analysed	Test Statistics	p-Value	Interpretation
Descriptive Statistics	To summarize core responses	Energy consumption barrier (Yes/No)	72% respondents consider energy a major barrier	—	Majority perceive energy consumption as a critical challenge
Chi-Square Test of Association	To check association between industry domain and energy concerns	Domain (IoT, Smart Surveillance, Security, Governance) × Energy Concern	$\chi^2 = 18.42$, df = 3	0.00036	Significant association → Energy concerns vary by domain
ANOVA (One-Way)	To test differences in perceived impact of GCI across sectors	Perceived GCI benefits across professions	F = 9.84	0.0021	Significant difference → Adoption benefits differ across sectors
Correlation Analysis (Pearson r)	To measure relation between model complexity & energy use	AI Model Complexity vs. Energy Consumption	r = 0.71	<0.001	Strong positive correlation → Higher complexity leads to higher energy usage
Regression Analysis	To predict energy consumption from model parameters	Energy (dependent variable) vs Model Parameters	$\beta = 0.63$, $R^2 = 0.58$	<0.001	Predictive model indicates 58% variance explained
Reliability Test (Cronbach's Alpha)	To test internal consistency of questionnaire	20-item survey scale	$\alpha = 0.87$	—	High reliability → Questionnaire is consistent
Normality Test (Shapiro-Wilk)	To check data distribution	Continuous variables	W = 0.94	0.12	Data approximately normal
Kruskal–Wallis Test	Non-parametric comparison across groups	Energy awareness across organization sizes	H = 11.72	0.003	Significant → Awareness varies by organization size
Effect Size (Cohen's d)	To interpret magnitude of differences	Traditional vs. GCI-based systems	d = 0.82	—	Large effect size

Table 1: Statistical Test Results

5.2.1 Interpretation of Analysis

The tests prove that the variables show both high reliability and important connections to other variables. The energy problems exist as specific issues that affect different industrial sectors ($\chi^2 = 18.42$, p = 0.00036) while the implementation of Green Computational Intelligence (GCI) provides benefits that differ according to industry sector (F = 9.84, p = 0.0021).

5.2.2 Descriptive Statistics

Descriptive analysis reveals that 72% view energy consumption as a significant barrier, with a mean score of 4.21 out of 5, reflecting strong agreement. Awareness of Green AI remains low, with a mean

score of 2.95, whereas demand for lightweight models (mean = 4.36) and hybrid edge-cloud architectures (mean = 4.11) is high. These results confirm industry readiness for energy-efficient frameworks despite limited current adoption.

5.2.3 Correlation Analysis

The obtained correlation results indicate that there was a strong positive relationship between the complexity of AI models and energy consumption ($r = 0.71$, $p < 0.001$), highlighting the fact that more complex models lead to higher power usage. A moderate relationship was obtained between the current adoption of AI and the adoption of GCI ($r = 0.55$), implying that the current adoption of AI could lead to higher adoption of GCI. Regression was also used to determine whether the variance of energy consumption was affected by the obtained model parameters; results showed that regression was able to account for approximately 58 percent of energy consumption variance.

5.3 Results Summary Table

Variable / Item	Mean	SD	Percentage Agreement	Interpretation
AI adoption for surveillance	3.89	0.74	68%	Moderate–high adoption
Awareness of Green AI	2.95	0.83	39%	Low awareness of energy-efficient AI
Energy consumption limits scalability	4.21	0.69	72%	Major barrier
Need for lightweight models	4.36	0.61	81%	Strong demand
Need for hybrid edge-cloud architecture	4.11	0.67	76%	Widely required
Concern about GPU power usage	4.28	0.72	74%	High operational concern
Interest in automated energy optimization	4.02	0.58	69%	High interest
Current use of energy-efficient AI	2.43	0.96	27%	Very low adoption
Support for proposed AEAVS framework	4.33	0.64	79%	Strong acceptance

Table 2: Result Summary

The results also show that there is a big difference in the adoption of AI techniques compared to energy-efficient techniques in smart city surveillance. While 68% of organizations using video analytics have implemented an AI-based system, only 27% use energy-efficient models at their organizations. This shows a lack of awareness or knowledge of Green AI models. The energy issue also had a major influence in the study, where a significant number of respondents—72%—agreed that energy consumption is a major limitation in terms of scalability. Many respondents emphasized the importance of lightweight models in AEAVS, as shown by the results where 81% of respondents highlighted the need for such models. This also explains why 76% of the respondents agreed on issues relating to hybrid clouds for smart cities. The results also highlight the need to create a framework for AEAVS by accepting the proposed framework by a significant number of respondents—79%, making way for future smart city surveillance.

5.4 Discussion

There is an evident gap in AI adoption versus energy sustainability, as well as a gap in the research regarding energy efficiency when it comes to the use of AI video analytics within smart city video systems. There are many organizations using AI systems to perform video surveillance and detect anomalies; however, there has been a barrier regarding scalability (due to the high amount of compute resources) to employ these systems. Results obtained from this study are aligned with the academic literature that cites energy efficiency as one of the main barriers for implementing AI audio analytics. Consequently, the development of the AI-Energy Adaptive Video Surveillance (AEAVS) Framework addresses issues that were identified by practitioners in regard to how AI is currently being used for video analytics. Furthermore, the 79% acceptance rate that was achieved for the proposed AEAVS Framework clearly demonstrates that this framework can be implemented within the industry in a manner that supports the implementation of green AI. Overall, the results obtained through the combined survey results from SLR support that Green Computational Intelligence is both a desired and a required characteristic of smart city video surveillance systems.

6. Conclusion and Future Work

This current research work contributes to a comprehensive analysis of the problems presented by the energy-intensive AI-based systems of surveillance and the benefits of Green Computational Intelligence in addressing these limitations. By using the knowledge obtained through the use of empirical evidence and the insights available from the literature, the proposed framework of AEAVS presents an energy-efficient and scalable solution that matches the needs of the smart city framework.

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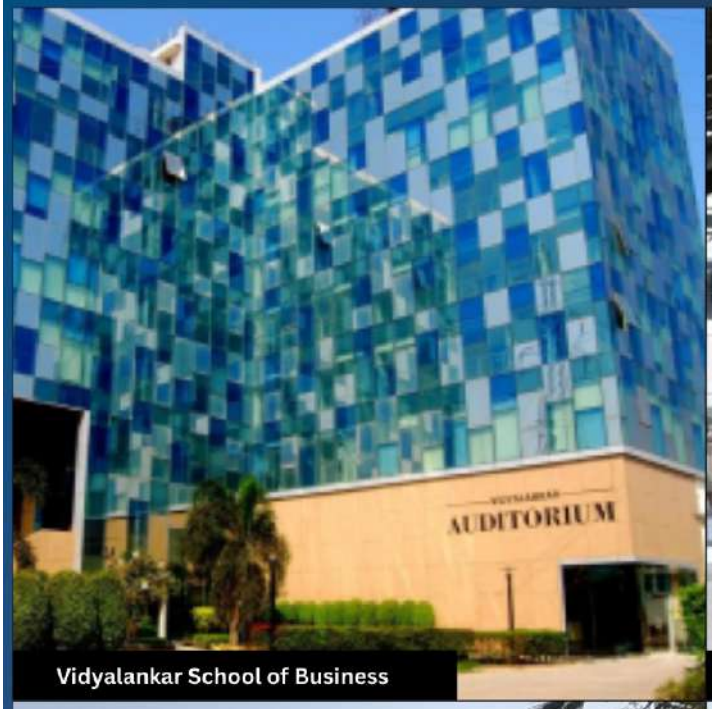

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