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SPRITUALITY AND SPIRITUAL CARE: AN ESSENTIAL DAILY NEEDS IN INTENSIVE CARE UNIT (ICU)

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ABSTRACT

Spirituality and spiritual care in Intensive Care Units (ICUs) are essential elements in addressing the fundamental needs of patients under nursing care, particularly in the face of life-threatening illnesses. Research indicates that incorporating spirituality and spiritual care should be a core aspect of Activities of Daily Living (ADLs) within the nursing framework. It is crucial to understand that 'spirituality and spiritual care' should not be treated as an extra task on nurses' already full agendas; they must be recognized as integral responsibilities embedded in the daily routines and practices of nurses. ***The objective of this article:*** *To explore the understanding and provision of spiritual care for critical care patients by ICU nurses. By taking the time to assess individual needs and purposefully engage with themes of meaning, hope, and peace, nurses can reconnect with the deeper essence of their profession.* ***Conclusion:****reconnecting with their spirituality can also empower nurses, enhancing their resilience in challenging roles. This article explores nursing care strategies for incorporating spiritual care into daily nursing practices and the important roles of intensive care nurses.*

KEYWORDS: *Spiritual care, spirituality, ICU nurse, Intensive Care Unit, spiritual needs.*

INTRODUCTION

Essential spirituality and spiritual care in ICU

More people are recognizing the deep importance of providing spiritual care in the intensive care unit (ICU) as a vital part of comprehensive patient care. Patients' coping strategies, emotional health, and overall quality of life during critical illness can be greatly affected by their spirituality, which includes a wide range of beliefs, practices, and cultural backgrounds. By incorporating spiritual care into their practice, healthcare providers can greatly improve the overall patient experience and effectively support the holistic well-being of those they care for, leading to more compassionate and patient-centered outcomes.

Spiritual care in clinical practice primarily emphasizes addressing the spiritual needs of patients and their families. This includes assisting in arranging for religious observance, providing existential support, and fostering a meaningful relationship with the transcendent. In the

intensive care unit (ICU), spiritual support continues to be an underachieved aspect of holistic care that is often overlooked. Assessment of spiritual and religious needs is essential and would serve as a crucial first step toward implementing effective spiritual care that truly supports patients and their families during challenging times (Eaton et al., 2022).

The absence of specific nursing interventions focused on spiritual care for critically ill patients reveals a significant gap in practice that requires attention (dos Santos et al., 2020). This issue is further intensified by the inadequate training healthcare professionals receive in spiritual care, which can undermine the holistic approach to patient care (dos Santos et al., 2020). The study indicates, that nurses with positive attitudes more ease to comply the spiritual care (Kang et al., 2021). This is corroborated by findings demonstrating a direct link between nurses' spiritual perceptions and their ability to deliver effective spiritual care (Elsayed, 2023).Additionally, incorporating spiritual care into nursing education is vital for enhancing nurses' skills and capacity to effectively meet patients' spiritual needs (Ramadhan et al., 2020).

Chaplains and spiritual caregivers are also essential in the ICU environment, as their involvement can improve the quality of care for patients and families, especially in end-of-life situations. Research indicates that proactive chaplaincy involvement can facilitate better decision-making and provide crucial support to surrogates (dos Santos et al., 2020). Nevertheless, there is a need for improved integration of chaplains within the multidisciplinary team, as their contributions are often underused (Giebner, 2017). The spiritual care assessment and intervention framework designed for ICU settings seeks to promote this integration, ensuring that spiritual care is a fundamental aspect of patient management rather than an afterthought(dos Santos et al., 2020). Family members of ICU patients endure considerable spiritual distress, necessitating attention to their spiritual needs alongside those of the patients. Research shows that family satisfaction with spiritual care is a strong predictor of overall satisfaction with ICU care(S. Willemse et al., 2020). However, misunderstandings about the role of spiritual health practitioners can impede the delivery of spiritual support to families(Ordons et al., 2020). Educating healthcare providers on the importance of spiritual care for families can increase receptiveness to such support and enhance the overall care experience. The relationship between spirituality and health outcomes is well-established, with evidence indicating that addressing spiritual needs can improve coping strategies, diminish psychological distress, and enhance patients' quality of life (Willemse et al., 2023).

Spiritual care has been shown to favorably affect patients' emotional well-being, particularly in high-stress settings like the ICU (Willemse et al., 2023). This highlights the importance of incorporating spiritual assessments into routine care practices, as they can guide care plans and improve patient-centered approaches(Badanta et al., 2021). Despite the acknowledged significance of spiritual care, barriers to its implementation continue to exist. Many healthcare professionals express feeling unprepared to address spiritual needs due to insufficient training and resources (dos Santos et al., 2020). This underscores the necessity for systematic reviews and training initiatives aimed at equipping clinicians with the essential skills for providing spiritual care(Ferrell et al., 2020). Furthermore, cultivating an environment that promotes open discussions about spirituality can help normalize these conversations within clinical settings, ultimately benefiting both patients and healthcare providers (Ahmadi et al., 2019).By doing so, the healthcare community can ensure that patients receive comprehensive care that respects their spiritual dimensions, ultimately leading to better outcomes and satisfaction in the ICU.

Spiritual care in the Intensive Care Unit (ICU) represents a comprehensive and compassionate approach that thoughtfully addresses the spiritual needs of both patients and their families during periods of critical illness. This vital care encompasses a wide range of diverse practices specifically designed to foster emotional support, enhance coping mechanisms, and holistically promote overall well-being. Spiritual care should not be regarded merely as an adjunct to medical treatment; it is, in fact, an essential and integral component of holistic patient care that acknowledges and recognizes the profound influence of spiritual health results of patients. The significance of spiritual care in the ICU is underscored by its potential to significantly improve both patient and family satisfaction levels during some of the most trying times. Research has consistently demonstrated that when spiritual needs are effectively and sensitively addressed, there is a remarkable and noticeable increase in overall satisfaction with the care received in the ICU setting (Cetın&Ozen, 2024). This is particularly crucial in high-stress environments where patients and their families are faced with overwhelming uncertainty, fear, and emotional turmoil. Spiritual care has the unique capacity to alleviate anxiety and depression, thereby enhancing life satisfaction even during the most challenging and distressing times (Klimasinski, 2021).

Spiritual care practices, which include fostering open and honest discussions about end-of-life preferences and concerns, have been associated with increased family satisfaction and enhanced experiences in the ICU setting(Burkhart et al., 2023). By addressing spiritual aspects, healthcare providers can cultivate a more supportive environment that respects the beliefs of patients and families while promoting peace and understanding during critical times. Providing effective spiritual care in the ICU necessitates that healthcare providers possess strong communication skills and a comprehensive understanding of the complexities involved. Nurses are crucial in this process, as they are often the primary caregivers who interact continuously with patients and their families. Spiritual communication, which involves active listening, nonverbal signals, and empathetic interaction, is essential for identifying and integrating patients' spiritual needs into their clinical care (Laili et al., 2019). However, many nurses feel unprepared to offer spiritual care due to inadequate training and unfamiliarity with spiritual health practices (dos Santos et al., 2020). This educational gap can hinder the ability to provide holistic care that effectively addresses both physical and spiritual health aspects.

The involvement of chaplains and spiritual care providers is also crucial in the ICU. Their participation can significantly improve the spiritual care provided to patients and families, especially during critical discussions about end-of-life decisions(VrMeer, 2021). Research shows that the proactive involvement of chaplains in the ICU not only enhances decision-making but also offers vital emotional support to families in challenging situations (Saeid et al., 2021). However, there is often a disconnect between chaplains and healthcare providers, which can limit the effectiveness of spiritual care interventions(RozeOrdons et al., 2018). Therefore, enhanced collaboration and communication among the multidisciplinary team are essential for effectively integrating spiritual care into standard clinical practice.

Barriers to effective spiritual care in the ICU include common misconceptions about the role of spiritual health practitioners and a general lack of awareness regarding the benefits of spiritual support (Smiechowski et al., 2021). Many healthcare professionals may not fully understand how spiritual care can positively affect patient outcomes, leading to the underutilization of available spiritual care resources. Educational programs focused on spiritual care can bridge this essential gap, equipping healthcare providers with the skills needed to address patients' and families' spiritual needs meaningfully (dos Santos et al., 2020). Additionally, fostering an environment

that promotes open conversations about spirituality can normalize these discussions and significantly improve the overall care experience for everyone involved.

The connection between spirituality and health outcomes is well-established, with evidence consistently indicating that addressing spiritual needs can enhance coping strategies and reduce psychological distress (Willemse et al., 2020). Spiritual care has been shown to positively influence patients' emotional well-being, particularly in high-stress settings like the ICU (Willemse et al., 2020). This underscores the importance of incorporating spiritual assessments into routine care practices, as these evaluations can guide care plans and improve patient-centered approaches(de Diego-Cordero et al., 2022).

In addition, spiritual care in the ICU is a vital component of comprehensive patient management, addressing both the emotional and spiritual needs of patients and their families. As healthcare providers deepen their understanding of the importance of spirituality in the healing process, it is crucial to develop training programs and frameworks that support the effective delivery of spiritual care. By doing so, the healthcare community can ensure that patients receive thorough care that honors their spiritual needs, ultimately leading to better outcomes and greater satisfaction in the ICU environment(Smiechowski et al., 2021).

What is spiritual care for ventilated ICU patients?

Spiritual care for patients on ventilators in the ICU is a crucial aspect of holistic healthcare, addressing the complex emotional, psychological, and spiritual needs of individuals who cannot communicate due to their medical conditions (S. J. Willemse et al., 2017). This care is particularly important in the ICU, where patients may be in life-threatening situations and experience deep existential anxiety. Offering spiritual support not only benefits the patients but also provides comfort to their families, who often grapple with intense worry and uncertainty about their loved ones' health(Klimasinski, 2021).

A key element of spiritual care for these patients is recognizing that they still have spiritual needs, even if they cannot express them verbally. Research shows that meeting these needs can significantly improve the quality of care and satisfaction for both patients and their families, as highlighted by(Papathanasiou et al., 2019). Spiritual care may involve various approaches, such as facilitating family communication, providing tailored emotional support, and creating opportunities for prayer or quiet reflection, even when the patient cannot actively engage(Burkhart et al., 2023) (Laili et al., 2020). For example, nurses can use nonverbal communication and active listening to gauge the patient's emotional state and provide comfort through their presence, fostering a sense of security and connection(Laili et al., 2020).

Chaplains and spiritual care providers play a vital role in this setting. They offer specialized support that enhances the medical care provided by the ICU team, improving the overall care experience. Research indicates that chaplains' involvement with ventilated patients can lead to greater family satisfaction and more productive end-of-life discussions(Ferrell et al., 2020). They can help facilitate important discussions about the patient's wishes and values, which is crucial when patients cannot communicate their preferences due to sedation or mechanical ventilation (Klimasinski, 2021). This proactive approach to spiritual care empowers families to navigate complex decision-making during critical times, providing guidance and reassurance.

Furthermore, the spiritual care needs of patients on ventilators often intersect with the cultural and religious beliefs of both the patients and their families. It is essential for healthcare providers

to recognize these beliefs and incorporate them into individualized care plans. A recent study emphasized that addressing patients' spiritual needs while respecting their cultural and religious backgrounds greatly enhances family satisfaction with ICU care (Nissen et al., 2021).This culturally sensitive approach ensures that care is respectful and tailored to the unique needs of each patient and family, promoting a more inclusive healthcare environment.

Despite the acknowledged significance of spiritual care, there are considerable barriers to its implementation within the ICU. Many healthcare professionals feel unprepared to address spiritual needs, often citing insufficient training and resources as contributing factors(Camacho-Montaño et al., 2021). This educational gap can impede the delivery of comprehensive spiritual care, particularly in the high-pressure environment typical of the ICU (Willemse et al., 2017). Therefore, it is crucial to offer targeted training for healthcare providers that highlights the importance of spiritual care and effective communication strategies, boosting their confidence in fulfilling these critical needs (Willemse et al., 2017).

Spiritual care for ventilated ICU patients is an essential part of holistic healthcare that addresses the deep spiritual and emotional needs of both patients and their families. Recognizing the crucial role of spirituality in the healing process and fostering collaboration among healthcare providers, chaplains, and families can create a nurturing environment within the ICU(S. Willemse et al., 2020). This atmosphere greatly enhances the care experience for everyone involved. It is vital to prioritize ongoing training and education for healthcare professionals to ensure that spiritual care is integrated into everyday practice. Ultimately, this collaborative effort improves satisfaction for patients and their families in the ICU, highlighting the importance of spiritual care in the overall healthcare journey(Hawthorne & Gordon, 2020).

Role ICU nurse of spiritual care

The role of ICU nurses in delivering spiritual care is increasingly recognized as a vital and indispensable component of holistic patient management in critical care settings. Spiritual care encompasses a wide array of practices aimed at addressing the emotional, psychological, and spiritual needs of patients and their families, particularly during times of crisis such as those experienced in the ICU(Cetın&Ozen, 2024). One of the primary responsibilities of ICU nurses in providing spiritual care is to establish a supportive and compassionate environment that fosters healing and comfort. This involves simple yet profound interventions, such as being fully present with the patient, actively listening to their concerns, and engaging in open-ended conversations about their spiritual beliefs and needs (Laili et al., 2019). Research indicates that when nurses initiate dialogues about spirituality, it can significantly enhance the emotional well-being of both patients and their families (Laili et al., 2019). By fostering an atmosphere of trust and openness, nurses can facilitate the expression of patients' fears, hopes, and spiritual concerns, which is crucial in the high-stress and often chaotic ICU environment (Oluma&Abadiga, 2020). Moreover, the understanding of patients' spiritual needs is essential for nurses to provide effective spiritual care that truly resonates with patients and their families. Studies have shown that nurses who possess a strong awareness of their patients' spiritual values and beliefs are better equipped to meet those needs effectively (Noome et al., 2017). This awareness can be cultivated through targeted education and training programs that emphasize the importance of spiritual care in nursing practice. For instance, ICU nurses often report a pressing need for more education regarding end-of-life care and the spiritual dimensions associated with it (Noome et al., 2017). By enhancing their knowledge and skills in spiritual care, nurses can significantly improve their

ability to support patients and families during these critical moments of vulnerability and uncertainty(Eaton et al., 2022).

Questions to Guide Self-Reflection

How do personal feelings and thoughts influence the delivery of spiritual care, fostering personal growth and alignment with holistic nursing practices?

- How do I feel when addressing the spiritual needs of patients and their families in critical situations?
- Does the responsibility of addressing spiritual care feel overwhelming, manageable, or fulfilling to me?
- How does providing spiritual care affect my emotional well-being and resilience as a nurse?
- How do I feel about collaborating with chaplains or other spiritual care providers in the ICU?
- How do I feel about engaging in self-reflection to deepen my own spiritual understanding?
- How does my own spirituality or lack thereof influence how I feel about providing spiritual care?
- Am I open to learning more about the diverse spiritual and cultural needs of my patients?

The integration of spiritual care into nursing practice also requires a genuine commitment to self-reflection and personal spiritual development among nurses. Research suggests that nurses who are attuned to their spirituality are more likely to recognize and effectively address the spiritual needs of their patients (Care, 2017). This self-awareness can lead to a more compassionate and empathetic approach to care, allowing nurses to connect with patients on a deeper and more meaningful level. Additionally, the emotional toll of working in the ICU can have a profound impact on nurses' spiritual well-being, making it imperative for them to engage in self-care practices that nurture their spiritual health and resilience (Burkhart et al., 2023). Nurses always serve as vital intermediaries between patients, families, and spiritual care providers, facilitating meaningful discussions about spiritual needs and preferences (Hawthorne & Gordon, 2020). By working together, nurses and chaplains can create a comprehensive care plan that addresses both the medical and spiritual dimensions of patient care holistically (Ferrell et al., 2020). This collaborative approach not only enhances the quality of care provided but also ensures that patients' spiritual needs are acknowledged and respected throughout their ICU stay (Abusafia et al., 2021).

Despite the recognized importance of spiritual care, several barriers to its implementation persist in the ICU setting. High workloads, time constraints, and a lack of adequate training in spiritual care can hinder nurses' ability to provide this essential aspect of patient care (Abusafia et al., 2021). Additionally, some nurses may feel uncomfortable discussing spiritual matters due to personal beliefs or a lack of confidence in their ability to address such sensitive topics. Addressing these barriers through targeted training programs and institutional support can empower nurses to incorporate spiritual care into their daily practice more effectively and meaningfully. In conclusion, ICU nurses play a crucial and transformative role in providing spiritual care to patients and their families. By fostering a supportive environment, enhancing their understanding of diverse spiritual needs, engaging in self-reflection, and collaborating with

spiritual care providers, nurses can significantly impact the emotional and spiritual well-being of those in their care (Camacho-Montaño et al., 2021).

CONCLUSION

Spiritual care in the ICU is an indispensable component of holistic patient care, addressing the emotional, psychological, and spiritual dimensions that are often overlooked in critical care environments. This paper highlights the profound impact that integrating spiritual care has on the well-being of both patients and their families, emphasizing the need for healthcare providers, particularly ICU nurses, to engage in compassionate, patient-centered practices. By fostering open communication, understanding diverse spiritual needs, and collaborating with chaplains and spiritual caregivers, nurses can create a supportive environment that enhances healing, reduces distress, and promotes peace.

The barriers to implementing spiritual care, including inadequate training and time constraints, underscore the urgent need for education and institutional support to empower healthcare professionals. By equipping nurses with the skills and confidence to provide spiritual care, healthcare systems can ensure that this critical aspect of care is no longer an afterthought but an integral part of everyday clinical practice. Ultimately, recognizing and addressing the spiritual needs of patients in the ICU not only improves satisfaction and outcomes but also reaffirms the humanity and compassion at the heart of nursing care.

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EMPIRICAL EVIDENCES OF MERGER, ACQUISITIONS AND ECONOMIC EFFEICIENCY IN INDIA- AN ANALYSIS ACROSS SECTORAL SELECTED INDUSTRIES

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ABSTRACT

Merger & Acquisitions (viz-corporate restructuring) plays a pivotal role in improvising financial, social and economic environment across the globe. Corporate restructuring is resorted to by numerous MNC's (multinational companies) all over the world due to globalization and cut throat competition in the market. Predominant strategic goals due to scarcity of time can be successfully accomplished with the aid of Merger and Acquisitions with a relatively secure and stable outcome. Significant sectors such as Banking, Finance, Pharmaceuticals, Manufacturing, Telecommunication and Information Technology Sectors etc have adopted merger and acquisitions (M&A) for business expansion and overcoming global challenges .So, it is very necessary to analyze that whether the firm opting for (M&A) have succeeded in improving financial performance and shareholder value. The current study aims analyzing whether there is significant and predominant trends and progress of merger and acquisitions on the Indian sectoral industries or not. The study is based on secondary data which was collected from capital market database called centre for monitoring Indian economy pvt ltd (Prowess, CMIE) various websites, journals and Capitaline database. The period under study is 7 years ranging from financial assessment year 2015-16 to 2021-22.Trend and Ratio Analysis has been used as a tool for computation of operating financial performance of the sample companies from the selected sample sectors under present study. The results of the overall analysis depicts that there is a significant trends and progress of MER AND ACQ on the Indian business.

KEYWORDS: *Merger & Acquisitions (M&A), Economic Efficiency, Financial Performance, Trend Analysis, Ratio Analysis.*

1. INTRODUCTION

The new-age business ecosystem **(Paulus-Rohmer et al., 2016; Rong et al., 2018)** is a complex and dynamic entity that fosters continuous innovation in a hyper-competitive world. Merger and Acquisitions (**M and A)** in India have evolved through a distinct phase of regulations.

The main reason for the necessity of M And A in today's economy is that it permits business to accomplish financial prudence of scales unifying with or obtaining another company could end in savings of cost and working efficacies which will not be probable for either business alone. Recently, the M and A has increased vastly in India then several growing strategy forms can be simply understood through several economic fronts. Moreover, there are many purposes for various M and A types witnessed in the corporate world. This research is an effort taken to deliver eye view of the bird for the M and a concept from the regulatory and industry perspective and different types of motives after M and A.

2. Review of Related Literature

The review of literature is concerned with the comprehensive summary of previous research activities. Investigators have studied on various sectors of mergers and acquisitions **(M&A).** Investigators have studied on various sectors of Mergers and Acquisitions **(M&A).** For more than thirty years, acquisitions have been a subject of tremendous study potential for all practicing educators as well as managers. A detailed assessment of the literature has been conducted in the current study among which some reviews are outlined here in brief from the sample sectors in India.

a. The purpose of this study was to find out how India's **Manufacturing Sector** firms' financial performance was affected by M&As. This study used a sample of 47 firms that merged between the year 2014 and 2015. These firms came under different manufacturing industries in India. BSE, financial statements of the firms and CMIE database were utilized for collecting data and tested with a non-parametric test called, Wilcoxon Signed Rank Test. The time period covered by this study was 2011-14 for before M&A process and 2015-18 for after M&A process. The paper's conclusion stated that it gave a perspective on the M&A process done in the manufacturing firms of India. **(Khatter & Yadav, 2022)**

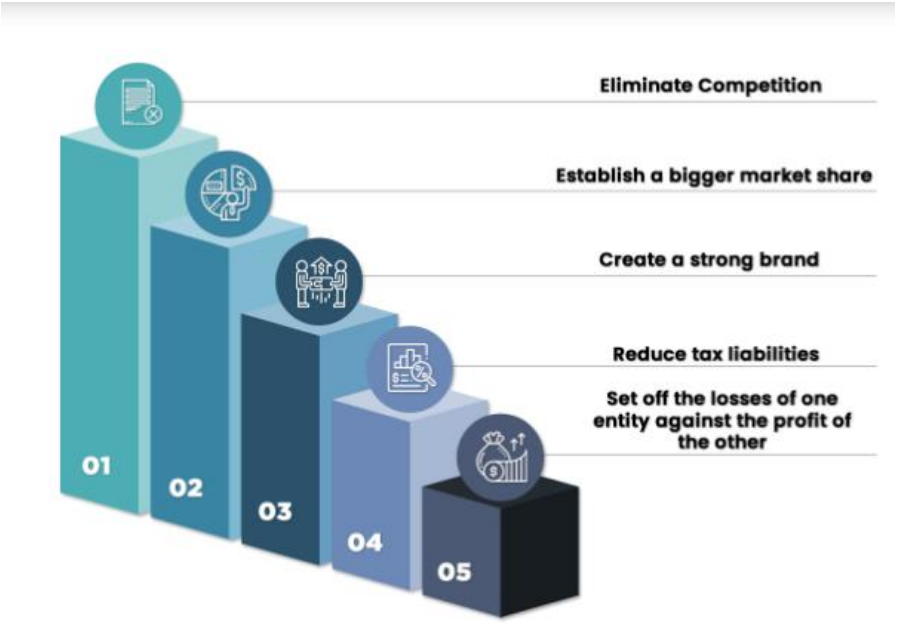
b. Similarly, the **M&A** strategies are followed in the **IT Companies** in India. In this perspective **Bhasin, Kar and Soni (2022)** offered the inferences of paradigm shift towards the merger and acquisitions strategies specifically in IT corporate in Indian context, using motive analysis from the year 2000 to 2015. In this Indian context, the research enunciated the patterns and trends of motives of (CBMA) of domestic M&A and cross-border M&A (CBMA), by Indian IT corporates and particularly seeks out in investigating the main CBMA motives. One such study, explored the empirical evidence, recommends the marked variations and corresponding dynamism in patters of motives for CBMA over the various sub-time periods.

c. The focus of this study was to examine the influence of M&As on various industrial sectors of India namely, **Pharmaceuticals, Banking and Telecommunications**. The aim of this study also focused on the type of M&As', namely domestic or cross-border, influence on the acquiring companies' performance. This study's findings stated that the influence of M&A differed between domestic as well as cross-border M&As, as indicated by the financial performance of acquiring firms. **(Sethi, 2021)**

d. The financial sector performance plays a significant role in economy development. But also the **Banking Industry's** performances in India over different time period were characterized by great regime of insolvency, crucial distress incidence, vulnerability towards macro-economic instability and systemic financial-crisis. By using, criterion of (CAMEL) Capital, Asset, Management, Earnings and Liquidity, researcher made utilise of secondary data, gained from accounts statements and annual reports of banks. The study to assess this objective, covered the time period of ten years from 2008 to 2018, research assessed bank's performance before merger and acquisition announcement and after this announcement as well through paired sample-test. The outcomes, deliberated that Merger and acquisition explored positive results, with significant impacts on private commercial bank's performance measures in comparison to public-banks **(R. Agarwal, Vichore, & Gupta, 2019**).

e. Further in era of new Companies Act, one of important mergers consummated, is the merger in **Telecommunication Sector** (viz Vodafone India Ltd and Idea Cellular Ltd) that led to form the new Vodafone Idea Ltd entity. This research proceeded with an analysis on the share price and financial performance of merger companies to assess the effectiveness of merger announcement. The study reveals that this M&A did not provide any positive outcome regarding the financial performance and share price. The study also states that the probable reason for this kind of outcome was due to high competition and the short time span selected by the study. **(Chatterjee & Dandapat, 2020)**

f. This paper focused on examining the influence of M&A on the **Pharmaceutical Companies'** financial performance, in India. This study made its foundation based on the fact that a firm's profitability is dependent on the firm's efforts for selling, imports and exports, and size; but not on the firm's product demand and market share. The results of this study stated that firms' profitability did not have any important influence. This was because of the resulting X-inefficiency and the emergence of new companies into the space of market. **(Mishra & Chandra, 2010**)



Significance of M&A in India (Corpbiz, 2023) (Fig 1)

3. Performance Measures and (M and A) In Indian Context

The pace of merger and acquisition phenomena in Indian context picked out in response towards different economic reforms, been introduced by Indian government after 1991, in pushing for globalization and economic liberalisation. The Indian-economy had undergone a primary transformation and unique structural change, preceding the economic reforms. **In this business and liberalised economic environment, Competence and size had turned out as the focus of each Indian business enterprise, since the firms realised the necessity in growing and expanding business, such that they have better understanding to tackle the firm's competition.** Mergers and Acquisition evolved as one of major efficient approaches of restructuring of corporate firms, and hence thereby to become the integral part of long-term business-strategy in Indian Corporates.

4. Why Need Multiple Sectoral Studies?

The present study would go to investigate the detail of mergers and acquisitions (M & A) with greater focus and aim in accordance with detailed sector like-Manufacturing, Information Technology, Banking And Finance, Telecommunications And Pharmaceutical Sectors and their respective pre and post acquisitions and mergers taking various sample companies from each sectors and analysing them with aid of various statistical tools and techniques and methodology for a period of 7 years.

5. Research Methodology

a. DATA COLLECTION

The study has intended to collect data specific to the selected **25 companies** those have gone through M&A in India. The data of last **7 years** have been accessed. The data related to **profitability ratio, liquidity ratio, leverage and activity ratio** have been collected. The study has planned to analyze the quantitative data in **IBM SPSS** and **Excel software**.. Based on the result, the study will provide further suggestions and recommendations for future enhancement. The data is collected from reliable and standard databases such as **Centre for Monitoring Indian Economy (CMIE) and Registrar of Companies (RoC)**. The company's balance sheets also are referred from Ministry of Corporate Affairs (MCA), Bombay Stock Exchange (BSE), And National Stock Exchange (NSE) and Company Annual Reports.

b. DATA METHODOLOGY

Ratio Analysis Technique calculates the economic strength of the organisation in terms of liquidity, operational efficacy, and profitability place. It is ended through the association of data available in the economic statements. It is an effectual method used for evaluation of economic performance of the various industries **viz (Manufacturing, Telecommunication, Information Technology, Banking and Finance, Pharmaceuticals). Trend Analysis** examination is a technique applied in practical analysis with intention to forecast future stock price movements based on currently attained trend data. This analysis utilizes historical data to test. Entirely, 9 ratios casing diverse sorts like liquidity, leverage, profitability and operational efficacy have been assessed for ascertainment of economic presentation.

c. RESEARCH QUESTION

Is there any significant trends and progress of MERGER AND ACQUISITIONS in the Indian business firms?

d. COMPANY PROFILE PARAMETERS AND DEMOGRAPHIC DETAILS

(Table 1) Pre-Merger and Acquisition

Descriptive Statistics						
SAMPLECOMPANIES	N	R	Minimum (Min)	Maximum (Max)	M	SD
Indus Towers & Bharti Infratel	8	3248	0	3248	455.33	1133.057
Indiabulls Housing Finance Limited (IBHFL) And India Bulls & Lakshmi Vilas Bank Limited (LVB)	8	10000	0	10000	1281.26	3523.038
Bank Of Baroda & Vijaya Bank And Dena Bank	8	46168	0	46168	5839.04	16295.579
Indusind Bank & Bharat Financial (SKS Microfinance)	8	16000	0	16000	2214.65	5597.598
Nbfc Capital First & Idfc Bank	8	5000	0	5000	711.63	1744.745
Vodafone India & Idea Cellular	8	105870	0	105870	13249.92	37424.181
TATA Steel &ThyssenKrupp	8	77000	0	77000	9644.14	27215.898
State Bank Of India & Bhartiya Mahila Bank	8	22000	0	22000	2788.82	7763.170
Flipkart & E-Bay India	8	30000	0	30000	3802.38	10585.968
Infosys & Kaleidoscope Innovation	8	29287	0	29287	3729.95	10328.344
Reliance Retail & Future Group's Retail Business	8	18000	0	18000	2329.73	6332.650
Ola & Etergo	8	1500	0	1500	207.87	523.131
Itc & Sunrise Foods	8	36500	0	36500	4619.19	12882.061
Zomato & Uber Eats	8	40000	0	40000	5106.42	14100.250
LIC & IDBI Bank	6	109999	1	110000	18508.83	44822.903
Walmart & Flipkart	8	2300000	0	2300000	287517.74	813165.630
Bharti Airtel & Tikona	8	66000	0	66000	8301.71	23313.827
Wipro Ltd& Info Server S.A.	8	150000	0	150000	18796.27	53014.379
Ebix &Yatra	8	10430	1	10431	1329.07	3677.887
Havells India & Lloyd Electric's Consumer Durable Business	8	5847	0	5847	812.80	2043.420
Dr. Reddy Laboratories Ltd & Imperial Credit Private Ltd	8	22175	0	22175	2776.02	7838.375
Taro Pharma & Canada's Thallion Pharmaceuticals	8	1407	0	1407	185.85	494.178

Bandhan Bank & Gruh Finance	8	66000	0	66000	8291.93	23317.829
Apple & Intel's Smartphone Modem	8	132000	0	132000	16520.05	46660.963
Tata Steel & Bhushan Steel	8	77000	0	77000	9656.51	27210.905
Valid N (Listwise)	**6**					

(Source-Authors Compilation)

From the tables above, it is observed that there are 6 and 9 count of observations inside the data group for pre-merger and acquisition. The data set value, calculated through totalling all the records and isolating through the sum of figures are considered to be normal. The value of mean in the data set splits the greater values from the minor values. The value of standard deviation should be above 0.5 and all the variables of our study matched the exposed range.

(Table 2) Post-Merger and acquisition

Descriptive Statistics					
SAMPLE COMPANIES	N	Min	Max	M	SD
Indus Towers & Bharti Infratel	9	0	3500	642.88	1260.997
Indiabulls Housing Finance Limited (IBHFL) And Indiabulls & Lakshmi Vilas Bank Limited (LVB)	9	0	26000	3019.16	8626.103
Indusind Bank & Bharat Financial (SKS Microfinance)	9	0	17000	2337.93	5568.620
NBFC Capital First & Idfc Bank	9	0	10000	1283.48	3281.439
Vodafone India & Idea Cellular	9	0	9226	1032.57	3072.615
TATA Steel & ThyssenKrupp	9	0	80500	9517.27	26667.757
State Bank Of India & Bhartiya Mahila Bank	9	0	245652	27859.53	81683.945
Flipkart & E-Bay India	9	0	22000	2472.08	7323.385
Infosys & Kaleidoscope Innovation	9	0	336294	38465.99	111717.451
Reliance Retail & Future Group's Retail Business	9	0	245581	28310.25	81504.023
Ola & Etergo	9	0	3000	335.23	999.292
ITC & Sunrise Foods	9	0	49824	6261.93	16454.535
Zomato & Uber Eats	9	0	67900	7562.60	22626.581
LIC & IDBI Bank	9	0	95700	11344.35	31680.531
Walmart& Flipkart	9	1	2200000	245571.20	732918.233
Bharti Airtel & Tikona	9	0	67774	7827.45	22486.781
Wipro Ltd & Info Server S.A.	9	0	201000	22748.90	66849.883
Ebix & Yatra	9	0	11000	1247.57	3657.524
Havells India & Lloyd Electric's Consumer Durable Business	9	0	6500	938.32	2141.475
Dr. Reddy Laboratories Ltd & Imperial Credit Private Ltd	9	0	22739	3345.43	7552.126
Taro Pharma & Canada's Thallion Pharmaceuticals	9	0	1550	368.37	654.873

Bandhan Bank & Gruh Finance	9	0	75000	8831.81	24851.207
Apple & Intel's Smartphone Modem	9	0	137000	15245.85	45657.840
Tata Steel & Bhushan Steel	9	0	80500	9511.15	26670.184
Valid N (List Wise)	**9**				

(Source-Authors Compilation)

From the tables above, it is observed that there are 6 and 9 count of observations inside the data group for post-merger and acquisition. The data set value, calculated through totalling all the records and isolating through the sum of figures are considered to be normal. The value of mean in the data set splits the greater values from the minor values. The value of standard deviation should be above 0.5 and all the variables of our study matched the exposed range.

6. Analysis of Sample Data (Is there any significant trends and progress of MERGER AND ACQ UISITIONS in the Indian business firms?)

MER&ACQ is a significant module for the development of large corporations across the globe. This has increase in every sector due to increasing competition in the business atmosphere, free drive of capital in nations' globalization and liberalization of frugality. MER&ACQ accelerate an organization growth particularly in a phase where companies are slow because of inadequate resources. This widely helps in diversification of risk of a firm.

In past few years, the Indian business environments have seen a significant rise in MER&ACQ activities across different sectors. There are some key trends and progress in MER&ACQ in Indian business including strategic acquisition, in which Indian companies are increasingly involving to expand their market presence, gain a competitive edge and diversify their service and product in the market. Particular sectors such as e-commerce, renewable energy, healthcare and technology have seen a rise in MER&ACQ activities because of technology advancement, regulatory changes and customer preference. Private equity firm are significant MER&ACQ activities through offering capital for acquisition and support companies in growth strategies.

7. HYPOTHESIS

H1: There is significant trends and progress of MERGER AND ACQ UISITIONS in the Indian business firms?

H_0: There is no significant trends and progress of MERGER AND ACQ UISITIONS in the Indian business firms?

Trend Analysis

Trend examination is a technique applied in practical analysis with intention to forecast future stock price movements based on currently attained trend data. This analysis utilizes historical data to test.

General Linear Model

PRE-MER&ACQ

Table 3 Within-Subjects Factors	
TIME	Dep Variable
1	OPERATING PROFIT PRE
2	CURRENT RATIO PRE
3	ASSET TURNOVER RATIO PRE
4	CASH EARNINGS RETENTION RATIO PRE
5	NET PROFIT PRE

Source: Author's Own creation

Table 4 Descriptive Statistics			
	M	SD	N
OPERATING PROFIT(PRE)	1.01	3.985	25
CURRENT RATIO(PRE)	1.14	.894	25
ASSET TURNOVER RATIO(PRE)	30.51	42.133	25
CASH EARNINGS RETENTION RATIO(PRE)	55.50	42.586	25
NET PROFIT(PRE)	24.60	31.303	25

Source: Author's Own creation

Table 5 Multivariate Tests							
Effect		Val	F	Hypo df	Err df	S.	Partial Eta Sq.
TIME	Pillai's Trace	.684	10.835[b]	4	20	.000	.684
	Wilks' Lambda	.316	10.835[b]	4	20	.000	.684
	Hotelling's Trace	2.167	10.835[b]	4	20	.000	.684
	Roy's Largest Root	2.167	10.835[b]	4	20	.000	.684

Source: Author's Own creation

If multivariate check is significant ($p < 0.05$), it specifies that there is a statistically substantial variance between groups for at least 1 of all the dependent variables. In the above table, all significant values are below the range of 0.05. Hence, the dependent variable proved the determination of specific variables driving the complete multivariate outcome.

Table 6 Mauchly's Sphericity[a] Test							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	App. Chi-Sq.	df	S	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	LB
TIME	.014	90.802	9	.000	.635	.720	.250

Source: Author's Own creation

Mauchly's Sphericity Test is stated as portion of the productivity when leading a recurrent measure in ANOVA. The assessment produces a p-value that designates whether the supposition of Sphericity has been disrupted. If the value of p related with Mauchly's Test is fewer than the

selected level of alpha (< 0.05), then the supposition of Sphericity has been disrupted. If Sphericity is disrupted, changes like the Greenhouse-Geisser, Huynh-Feldt corrections could be used to precise the violation and confirm the results' validity. But for the present hypothesis p values are below 0.05 which represents that Sphericity is not violated and rate of yield is high.

Table 7 Tests Within-Subjects Effects

Source		Type 3 Sos	df	M2	F	S.	Partial Eta Sq.
TIME	Sphericity Assumed	49829.191	4	12457.298	15.273	.000	.399
	Greenhouse-Geisser	49829.191	2.538	19630.560	15.273	.000	.399
	Huynh-Feldt	49829.191	2.880	17304.506	15.273	.000	.399
	Lower-bound	49829.191	1.000	49829.191	15.273	.001	.399
Error(TIME)	Sphericity Assumed	75037.066	92	815.620			
	Greenhouse-Geisser	75037.066	58.382	1285.277			
	Huynh-Feldt	75037.066	66.230	1132.983			
	Lower-bound	75037.066	23.000	3262.481			

Source: Author's Own creation

Table 8 Tests Within-Subjects Contrasts

Source	TIME	Type 3 Sos	df	M2	F	S.	Partial Eta Sq.
TIME	Linear	24756.132	1	24756.132	38.287	.000	.625
	Quadratic	7568.592	1	7568.592	12.850	.002	.358
	Cubic	17394.754	1	17394.754	24.792	.000	.519
	Order 4	109.713	1	109.713	.083	.006	.004
Error(TIME)	Linear	14871.674	23	646.595			
	Quadratic	13546.703	23	588.987			
	Cubic	16137.299	23	701.622			
	Order 4	30481.390	23	1325.278			

Source: Author's Own creation

Table 9 Tests of Between-Subjects Effects

Source	Type 3 Sos	df	M2	F	S.	Partial Eta Sq
Intercept	61032.852	1	61032.852	46.140	.000	.667
Err	30423.678	23	1322.769			

Source: Author's Own creation

Estimated Means of Marginal

Table 10 Estimates

TIME	M	Std. Err	95% Confidence Interval	
			Lower Bound(LB)	Upper Bound(UB)
1	1.005	.813	-.677	2.688
2	1.137	.183	.760	1.515
3	30.511	8.600	12.720	48.302
4	55.504	8.693	37.521	73.486
5	24.604	6.390	11.386	37.822

Source: Author's Own creation

Table11 Pairwise Comparisons						
					95% Confidence Interval for Difference[s]	
(I) TIME	(J) TIME	M Diff (I-J)	Std. Err	S.[b]	LB	UB
1	2	.132	.877	.000	2.853	2.589
	3	29.506	8.555	.002	56.059	2.952
	4	54.498	8.943	.000	82.257	26.740
	5	23.598	6.062	.005	42.414	4.782
2	1	.132	.877	.000	2.589	2.853
	3	29.374	8.598	.002	56.063	2.685
	4	54.366	8.695	.000	81.356	27.377
	5	23.466	6.377	.002	43.260	-3.672
3	1	29.506	8.555	.002	2.952	56.059
	2	29.374	8.598	.004	2.685	56.063
	4	24.992	11.718	.003	61.364	11.379
	5	5.908	8.065	.000	19.126	30.941
4	1	54.498	8.943	.000	26.740	82.257
	2	54.366	8.695	.000	27.377	81.356
	3	24.992	11.718	.003	11.379	61.364
	5	30.900	9.821	.004	.414	61.386
5	1	23.598	6.062	.000	4.782	42.414
	2	23.466	6.377	.001	3.672	43.260
	3	5.908	8.065	.000	30.941	19.126
	4	30.900	9.821	.005	61.386	.414

Source: Author's Own creation

Table 12 Multivariate Tests						
	Value	F	Hypo df	Err df	S.	Partial Eta Sq.
Pillai's trace	.684	10.835	4	20	.000	.684
Wilks' lambda	.316	10.835	4	20	.000	.684
Hotelling's trace	2.167	10.835	4	20	.000	.684
Roy's largest root	2.167	10.835	4	20	.000	.684

If multivariate check is important ($p < 0.05$), that specifies there is a statistically substantial difference among groups for at least 1 of all the dependent variables. In the above table, all significant values are below the range of 0.05. Hence, the dependent variable proved the determination of specific variables driving the complete multivariate outcome.

Profile Plots

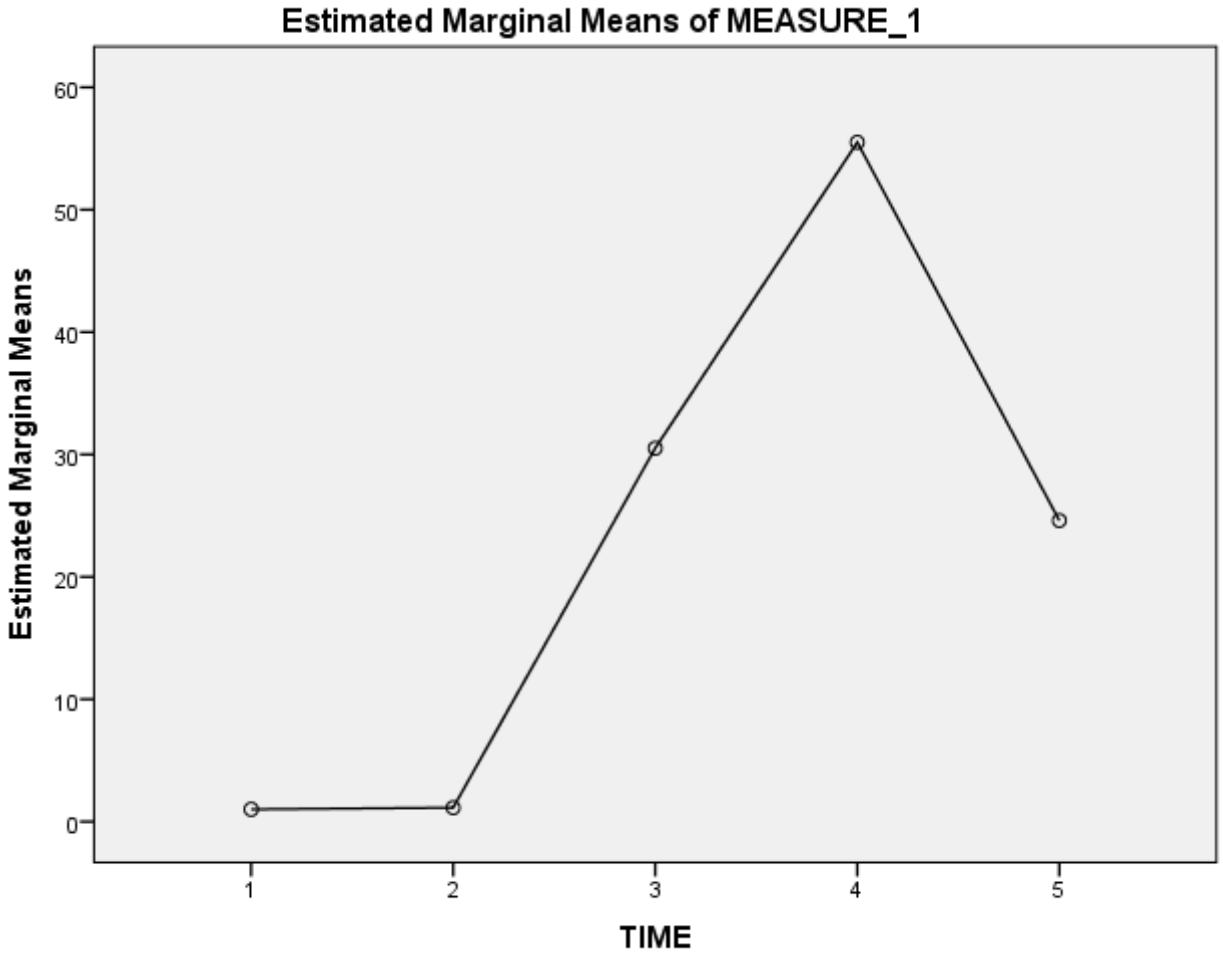


Figure 2 Profile Plots

The above tables and graph demonstrates the trend and progress of MER&ACQ in the Indian industries. The test tables reveal p value less than 0.005 which indicates the significance trends and progress of MER&ACQ in the business sector of India. Thus, the null hypothesis has been denied.

POST MER & ACQ

Table 13 Inside Subjects Factors	
TIME	Dep Variable
1	OPERATINGPROFITPOST
2	NETPROFITPOST
3	CURRENTRATIOPOST
4	ASSETTURNOVERRATIOPOST
5	CASHEARNINGSRETENTIONRATIOPOST

Table 14 Descriptive Statistics			
	M	SD	N
OPERATING PROFIT(POST)	17.55%	13.426%	25
NET PROFIT(POST)	43.30	66.715	25
CURRENT RATIO(POST)	34.31	153.426	25
ASSET TURNOVER RATIO(POST)	.74	.655	25
CASH EARNINGS RETENTION RATIO(POST)	53.18	38.675	25

Source: Author's Own creation

Table 15 Multivariate Tests[a]							
Effect		Value	F	Hypothesis df	Err df	S.	Partial Eta Sq.
TIME	Pillai's Trace	.814	23.021[b]	4	21	.000	.814
	Wilks' Lambda	.186	23.021[b]	4	21	.000	.814
	Hotelling's Trace	4.385	23.021[b]	4	21	.000	.814
	Roy's Largest Root	4.385	23.021[b]	4	21	.000	.814

Source: Author's Own creation

If multivariate check is significant ($p < 0.05$), it specifies that there is a statistically substantial variance between groups for at least 1 of all the dependent variables. In the above table, all significant values are below the range of 0.05. Hence, the dependent variable proved the determination of specific variables driving the complete multivariate outcome.

Table 16 Mauchly's Sphericity[a] Test							
					Epsilon[b]		
Inside Subjects Effect	Mauchly's W	App. Chi-Sq.	df	S.	Greenhouse-Geisser	Huynh-Feldt	LB
TIME	.003	130.337	9	.000	.345	.359	.250

Source: Author's Own creation

Mauchly's Sphericity Test is stated as portion of the productivity when leading a recurrent measure in ANOVA. The assessment produces a p-value that designates whether the supposition of Sphericity has been disrupted. If the value of p related with Mauchly's Test is fewer than the selected level of alpha (< 0.05), then the supposition of Sphericity has been disrupted. If Sphericity is disrupted, changes like the Greenhouse-Geisser, Huynh-Feldt corrections could be used to precise the violation and confirm the results' validity. But for the present hypothesis p values are below 0.05 which represents that Sphericity is not violated and rate of yield is high.

Table 17 Tests Within-Subjects Effects							
Source		Type 3 Sos	df	M2	F	S.	Partial Eta Sq
TIME	Sphericity Assumed	43591.982	4	10897.995	1.788	.137	.069
	Greenhouse-Geisser	43591.982	1.378	31628.491	1.788	.190	.069
	Huynh-Feldt	43591.982	1.435	30383.256	1.788	.189	.069
	Lower-bound	43591.982	1.000	43591.982	1.788	.194	.069
Error(TIME)	Sphericity Assumed	585066.363	96	6094.441			
	Greenhouse-Geisser	585066.363	33.078	17687.471			
	Huynh-Feldt	585066.363	34.434	16991.104			
	Lower-bound	585066.363	24.000	24377.765			

Source: Author's Own creation

Table 18 Tests Within-Subjects Contrasts							
Source	TIME	Type 3 Sos	df	M2	F	S.	Partial Eta Sq
TIME	Linear	2057.377	1	2057.377	2.883	.102	.107
	Quadratic	1480.559	1	1480.559	.190	.667	.008
	Cubic	36448.846	1	36448.846	15.147	.001	.387
	Order 4	3605.199	1	3605.199	.267	.610	.011
Error(TIME)	Linear	17124.513	24	713.521			
	Quadratic	186713.169	24	7779.715			
	Cubic	57751.111	24	2406.296			
	Order 4	323477.570	24	13478.232			

Source: Author's Own creation

Table 19 Tests of Between-Subjects Effects						
Source	Type 3 Sos	df	M2	F	S.	Partial Eta Sq
Intercept	111121.370	1	111121.370	21.009	.000	.467
Err	126939.008	24	5289.125			

Source: Author's Own creation

Estimated Means of Marginal

Table 20 Estimates				
			95% Confidence Interval	
TIME	M	Std. Error	LB	UB
1	17.552	2.685	12.011	23.094
2	43.298	13.343	15.759	70.837
3	34.314	30.685	-29.017	97.645
4	.737	.131	.467	1.008
5	53.176	7.735	37.212	69.141

Source: Author's Own creation

Table 21 Pairwise Comparisons						
					95% Confidence Interval for Difference[s]	
(I) TIME	(J) TIME	M Difference (I-J)	Std. Error	S.[b]	LB	UB
1	2	-25.746	13.621	.709	-67.840	16.349
	3	-16.762	30.745	1.000	-111.780	78.257
	4	16.815*	2.638	.000	8.663	24.967
	5	-35.624*	8.462	.003	-61.775	-9.473
2	1	25.746	13.621	.709	-16.349	67.840
	3	8.984	34.691	1.000	-98.230	116.198
	4	42.561*	13.341	.039	1.330	83.791
	5	-9.878	12.226	1.000	-47.663	27.906
3	1	16.762	30.745	1.000	-78.257	111.780
	2	-8.984	34.691	1.000	-116.198	98.230
	3	33.577	30.706	1.000	-61.321	128.474
	4	-18.862	33.645	1.000	-122.843	85.119
4	1	-16.815*	2.638	.000	-24.967	-8.663
	2	-42.561*	13.341	.039	-83.791	-1.330
	3	-33.577	30.706	1.000	-128.474	61.321
	4	-52.439*	7.772	.000	-76.458	-28.420
5	1	35.624*	8.462	.003	9.473	61.775
	2	9.878	12.226	1.000	-27.906	47.663
	3	18.862	33.645	1.000	-85.119	122.843
	4	52.439*	7.772	.000	28.420	76.458

Source: Author's own creation

Table 22 Multivariate Tests						
	Value	F	Hypothesis df	Error df	S.	Partial Eta Squared
Pillai's trace	.814	23.021[a]	4	21	.000	.814
Wilks' lambda	.186	23.021[a]	4	21	.000	.814
Hotelling's trace	4.385	23.021[a]	4	21	.000	.814
Roy's largest root	4.385	23.021[a]	4	21	.000	.814

Source: Author's own creation

If multivariate check is significant ($p < 0.05$), it specifies that there is a statistically substantial difference among groups for at least 1 of all the dependent variables. In the above table, all significant values are below the range of 0.05. Hence, the dependent variable proved the determination of specific variables driving the complete multivariate outcome.

Profile Plots

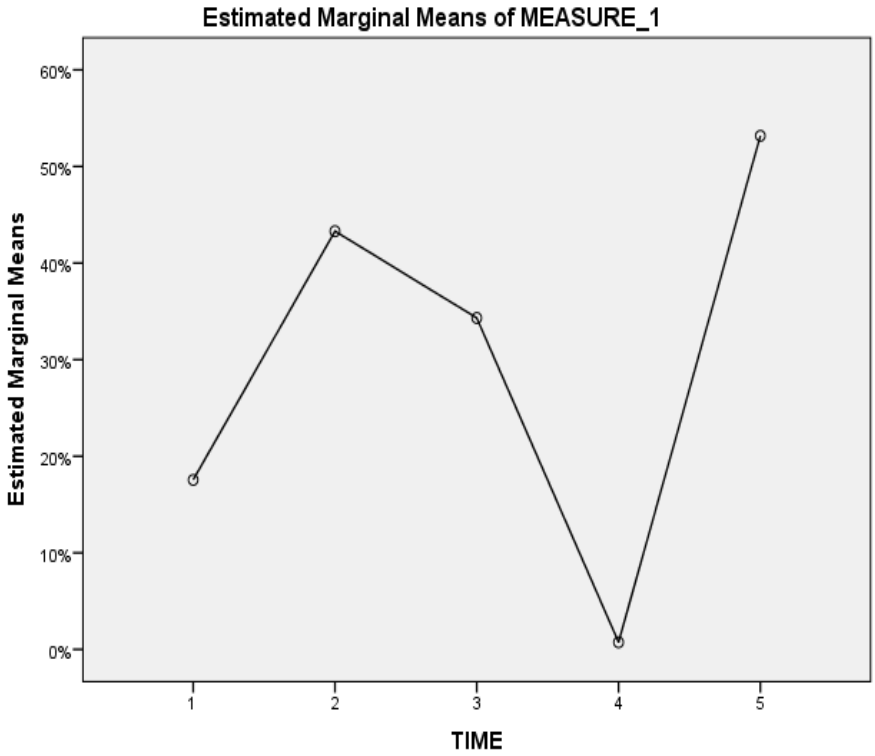


FIGURE 3

The above tables and graph demonstrates the trend and progress of MER&ACQ in the Indian industries. The test tables reveal p value less than 0.005 which indicates the significance trends and progress of MER&ACQ in the business sector of India. Thus, the null hypothesis has been denied.

8. IMPLICATIONS OF STUDY

The implication of the research could be based on the Mergers and Acquisitions (MER&ACQ) which is been influenced from operational performance and financial from the different sectors of selected industries in India. Economic performance ratios are categorized by the ratios which comprises Operating Profit ratio, Inventory turnover ratio, Current ratio, Asset turnover ratio, Cash earnings retention ratio, Net Profit ratio, Firm size ratio, Stock price ratio and Current tax ratio. Values which are utilized to perform the ratios are Mean, Range, Standard Deviation and Constant of the variation. Mean, Range, Standard Deviation and Coefficient of the variation is divided into pre-acquisition and post-acquisition.

Reliability was performed to analyze the assessment of the internal consistency. Cα value determines the reliability statistics. It was performed with the value of 0.827.

Company profile parameters and their demographic details are collected. Descriptive statistics method has been measured to denote the distributions, variability and the central tendency. For the descriptive statistics, totally 25 companies were measured with mean, median, minimum, maximum and standard deviation values for pre-merger and acquisition. The outcome of the result was that the 6th and 9th count of the observations which are present inside the data are

grouped for the pre-merger and acquisition. Data set value which was calculated through adding up all the records and isolated by means of the sum of figures which is considered as the normal. As for the same companies, post-merger and acquisitions were carried out for the descriptive statistics. The result presented with the output that the 6th and 9^{th} count of the observations which are present inside the data group was measured for the post-merger and acquisition.

9. DISCUSSION ON RESULTS

Hypothesis describes whether the Indian industries are with significant trends and progress of M and A are not. For the general linear model of pre M and A, different subject factors were analyzed namely operating profit, current ratio, asset turnover ratio, cash earnings retention ratio and net profit. Descriptive analysis was carried out with the factors of pre M and A such as operating profit, current ratio, asset turnover ratio, cash earnings retention ratio for mean, number of samples and standard deviation.

Multivariate tests were analyzed with the effects of Pillai's trace, Wilks Lambda, Hotelling's Trace and Roy's Largest Root. The significant values for these effects were less than 0.05. The dependent variable proved that the determination for specific variables drives with the complete multivariate outcome. **Mauchly's Sphericity test** was carried out to state the leading recurrent measures in ANOVA. It resulted that P-value which were below 0.05 represented that Sphericity was not violated and the rate of the yield was high. Tests within subject effects were examined for TIME and error. The sources for which it was calculated like sphericity assumed greenhouse-geisser, huynh-feldt and lower bound. Tests within the subject contrasts were calculated for various times such as linear, quadratic, cubic and order 4. Tests between the subject effects were calculated for the intercept and error.

Estimated Means of Marginal was calculated for five different interval times with 95% confidence interval. Pairwise comparisons were evaluated with five different times of 95% confidence interval. Multivariate tests were investigated for various tests such as Pillai's trace, Wilks lambda, hotel ling trace and Roy's largest root. All the significant values were presented below the range of 0.05. The dependent variable proved the determination of the specific variables which drives the complete multivariate outcome. Profile plots were revealed with the p-value that could be lower than 0.005 and the null hypotheses has been denied.

Inside the subject factors, post M and A were determined by operating profit, net profit, current ratio, asset turnover ratio and cash earnings retention ratio**. Descriptive statistics** was carried out for these factors with average, standard deviation and samples count. Multivariate tests were performed with the effects of Pillai's trace, Wilks lambda, hotelling trace and Roy's main root. It resulted that the significant values were below 0.05. P-values of the Mauchly's test were carried out with fewer levels of selected alpha. P- Value represents the sphericity was not violated and the rate of the yield was high. Tests within the subject effects were calculated by the source such as sphericity assumed, greenhouse-geisser, huynh-feldt and lower bound. Tests inside the subjects contrast for various times such as linear, quadratic, and cubic, order 4. Tests of the between the subjects belongings were analyzed for the intercept and for the error. Estimated means of marginal were analyzed with five different intervals of 95 percent confidence interval. Pairwise comparisons were carried out for five different time intervals with 95 percent confidence intermission for the variations. Multivariate tests were performed for Pillai's trace, Wilks lambda, hotelling trace and Roy's greatest root and the significant values were determined below 0.05. The dependent variable proved the determination of the specific variables in which it

drives the complete multivariate outcome. Profile plots were demonstrated with the p-value which was less than 0.005 and indicates the progress and significance trends of M and A. This null hypothesis was denied.

10. LACUNAS/BOTTLENECKS OF THE PRESENT STUDY

The present research, like any other study, has its own limitations. **In First hand**, one of the main drawbacks is that it solely relies on quantitative methods and does not incorporate a qualitative approach for its analysis. **Secondly,** the study has considered only limited sample size and secondary data pertaining to only last 7 years .**Last But Not The Least** only Indian companies were considered in the present study, the researcher has not taken into account any outbound companies or literature for the study. As a result, the findings may lack generalizability. However, despite this limitation, the research offers valuable insights into identifying mergers, acquisitions, and economic efficiency in India.

10. SCOPE FOR FURTHER RESEARCH

Future research in acquisitions, mergers and in economic efficiency in India is a great benefit obtained which is supplemented by the empirical evidence from the sectoral analysis. Investigating activities of **Mergers and Acquisitions (M&A)**, various industries are compressed within the economy of India. It is not only limited for the finance, healthcare, technology, telecommunication and manufacturing. From organizing empirical studies and in-depth studies in each sector, transactions of the acquisitions and mergers can reveal the effects on the trends and progress, economic efficiency, innovation, market welfare and competition in market.

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DEVELOPMENT OF ROAD INFRASTRUCTURE IN HARYANA

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ABSTRACT

The State of Haryana has seen rapid National Highway infrastructuredevelopment in the past four years. Till 2014 the length of NationalHighways was 1,659 km. In 2018 the length of National Highways hasbeen increased to reach 3,531 km. 38 development projects in the roadsector have been undertaken with investments worth Rs. 14,000 Cr, andare scheduled for completion in 2019.

Haryana being bordered by Delhi, a lot of effort has been made toensure smooth flow of traffic between these two States. The mostsignificant amongst these is the 135 km 6 lane Eastern PeripheralExpressway, built worth Rs. 11,000 Cr, connecting Kundli to Palwalvia Ghaziabad. In the coming years many new road developmentinitiatives will be undertaken in Haryana. The present research paper is an attempt to provide insights into development of Road infrastructure in Haryana.

KEYWORDS: *Roads, Infrastructure, National Highway, State Highway, Expressway*.

I. INTRODUCTION

The transport system in any economy is considered as nerve systemof the economy as nerve system follow blood in the body, thetransportation follows the resources such as labour, machinery,goods and services. Through better transport system size of marketget widen, this further led to increase in productivity and finallymake economies of scale possible. This is established fact thatmovement and prosperity moves together.Roads are the heart of Transport system of ant economy. The availability of Roadsbecomes very important as the state notonly connected with other major states of the country but alsosupport national capital too. Roads are fundamental need of connectivity for the development ofany economy. Haryana state has an efficient network of roads, whichis significantly contributing to its economic development.

II. Road length in Haryana

The totalroad length in Haryana is depicted in table 1.1. The table shows thatthe road length per 100 sq. km. of area is 80.40 km. While roadlength per lakh of population for the state is 122.68 km. The districtwise study of metalled roads shows that out of 19 districts in thestates 10 districts have above state average metalled road length,while 09 districts have below state average metalled road length.Kaithal district has the lowest road length, i.e. 66.71 km per 100 sq.km. of area. In Haryana all the villages are connected with metalledroads.

Type of Roads	Length in Kms. (upto 31.03.2023)	Length in Kms. (upto 31.10.2023)
National Highways	State PWD - 330	State PWD - 330
	NHAI - 2886	NHAI - 3061
State Highways	1676	1659
Major District Roads	1375	1375
Other District Roads	24996	24997
Total	**31263**	**31422**

Source: PWD (B&R), Haryana.

III. Upgradation of Road Network

Roads are the basic means of communication for the development of anyeconomy. In order to further strengthen the road network and making it more efficient as pertraffic requirements, the main emphasis has been laid on the improvement/up gradation ofexisting road network, construction of bye passes, bridges/ROBs and completion of roadconstruction works. The detail of road network under PWD (B&R) in the State is given inDuring 2023-24, a programme for improvement of roads by way of widening,strengthening, re-construction, raising, cement concrete, pavements/blocks, premix carpet,construction of side drains and culverts/retaining walls etc. were taken in hand. The financialand physical progress achieved up to October, 2023 is given in Table1.2

Table 1.2:Progress Under Roads Improvement Programmes (Financial Progress)

(A) Financial Progress **(₹ in crore)**

Sr. No.	Head of Account	Budget Allotment 2023-24	Expenditure (up to October, 2023)
1.	Plan-5054 (Roads & Bridge) including NABARD Loan & PMGSY	2555.00	1714.75
2.	Non Plan-3054	965.31	453.39
3.	Central Road Fund	150.00	58.30
4.	NH (Plan)	300.00	168.68
5.	NH (Non- Plan)	0.00	0.00
6.	Deposit works (Roads & Bridges)	190.00	31.25
Total		**4160.31**	**2426.37**

Table 1.2: Progress Under Roads Improvement Programmes (Financial Progress)

(B) Physical Progress

Sr. No.	Item	Length in Kms. (up to October, 2023)
1.	New Construction	209
2.	Premix Carpet (State Roads)	1180
3.	Widening &Strengthening (State Roads)	640
4.	Cement Concrete Blocks/Pavement	179
5.	Reconstruction & Raising	57
6.	(a) Widening } National Highways	0.00
	(b) Strengthening	86.09

Source: PWD (B&R), Haryana.

IV: Repair and Maintenance

Many roads/bridges works sanctioned during the year 2023-24. The detail ofsanctions works are given in Table 1.3. The detail of allocation for repair, maintenance andoriginal works of buildings are given in Table 1.4 The Department has taken steps forconstruction of ROBs/RUBs and Bridges to curtail delay and increase safety to passengers.The progress of ROBs/RUBs & Bridges completed and in progress are given in1.6

Table: 1.3- Road/Bridge Works Sanctioned during 2023-24

(₹ in crore)

Sr. No.	Head of Account	No. of Works	Amount (upto October, 2023)
1.	Plan -5054	86	155.32
2.	Non Plan-3054	188	536.95
3.	NABARD - Roads	07	122.57
	- Bridges	00	0.00
4.	Central Road Fund	11	724.46
5.	PMGSY/Bharat Nirman -Roads	00	0.00
6.	NH	02	182.73
7.	ROBs/RUBs (Plan 5054)	10	50.83
8.	Bridges – Plan 5054	23	183.74
	Non Plan 3054	03	3.81
	Total	**330**	**1960.41**

Source: PWD (B&R), Haryana.

Table 1.4Allocation for Repair, Maintenance and Original Works of Buildings

(₹ in crore)

Sr. No.	Head of Account	Budget Allotment 2023-24	Expenditure during 2023-24 (upto October, 2023)
1.	Revenue Buildings	179.98	112.16
2.	Capital Buildings	230.98	81.99
3.	Deposit Buildings	1118.00	179.58
	Total	**1528.96**	**373.73**

Source: PWD (B&R), Haryana.

Table 1.5 :ROBs/RUBs & Bridges Completed and in Progress

Sr. No.	Description	2023-24 (upto October, 2023)
1.	ROBs/RUBs (i) Completed and opened to traffic (ii) Under construction	 5= (3 HSRDC+ 2 NH) 37= (18 HSRDC+ 15 PWD State Scheme+4 NH)
2.	Bridges (i) Completed and opened to traffic (ii) Under construction	 1= (1PWD State Scheme) 21= (18 PWD State Scheme+3 NH)

Source: PWD (B&R), Haryana.

V: New Road Network

Haryana's road network has grown significantly in recent years, with the construction of new highways, expressways, and other roads. The state's road infrastructure development has been focused on improving connectivity between Haryana and neighboring states, especially Delhi.

(A) National Highways

- ✓ **NH-44, NH-352, NH-9, and NH-709:** Connect Haryana to northern India
- ✓ **NH-48:** Connects Haryana to northern Rajasthan
- ✓ **NH-919:** Connects Haryana to central and southern India
- ✓ **152D National Highway**: Shortens travel time from Jind to Ambala and Chandigarh

Rohtak-Jind and Narwana National Highway 352: Eases travel from Jind to Rohtak, Delhi, and Punjab

(B) Expressways

- ✓ **Delhi-Gurgaon Expressway:** Leads to Jaipur
- ✓ **Eastern Peripheral Expressway:** A 135 km, 6 lane expressway built to improve traffic flow between Haryana and Delhi
- ✓ **Western Peripheral Expressway (KMP):** A 135 km expressway under development

(C) Other roads

- ✓ **Sonipat to Jind 352A National Highway:** An 80 km highway that connects Sonipat and Jind
- ✓ **Jind-Panipat State Highway:** A highway that connects Jind and Panipat

- ✓ **Panipat-Dabwali National Highway**: An upcoming project that will connect Karnal, Jind, Panipat, Fatehabad, and Sirsa

VI Future of Road development of Haryana

The future of road infrastructure in Haryana looks promising, with several projects in the pipeline to enhance connectivity and improve the overall road network.

1. **Upcoming Projects:**

- o A proposed elevated road from the Gurugram-Jaipur National Highway to Vatika Chowk, along with four flyovers from Vatika Chowk to Ghata, is expected to ease traffic congestion in the region [1].
- o The Haryana government has also announced plans to develop a robust road network in the state, with a focus on improving connectivity between major cities and towns.
- o The Ministry of Road Transport and Highways has identified several national highway projects for development in Haryana, including the Delhi-Panipat and Ambala-Kaithal stretches [2].

2. **National Highway Development:**

- o The National Highway network in Haryana has grown significantly, with the total length increasing from 91,287 km in 2014 to 146,195 km currently [3].
- o The government has also launched several initiatives to improve road safety, including the identification and rectification of blackspots on national highways.

3. **Investment and Funding:**

- o The government has allocated significant funds for road development projects in Haryana, with an estimated investment of Rs. 800 crore for the proposed elevated road project in Gurugram [1].
- o The Ministry of Road Transport and Highways has also announced plans to monetize national highways through the Toll Operate Transfer (TOT) model, which is expected to generate significant revenue for road development projects [3].

We can conclude from above discussion that road infrastructure in Haryana is showing remarkable growth and in coming days the infrastructure is going to contribute more to growth of Haryana and India as a whole

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A REVIEW ON PHYTOCHEMICAL CONSTITUENTS, ANTI-OXIDANTS AND ANTI-DIABETIC ACTIVITY OF GRAPE (VITIS VINIFERA) SEED

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ABSTRACT:

Grape seed, a byproduct of the grape industry, is recognized for its high content of bioacztive polyphenols, particularly proanthocyanidins, which exhibit potent antioxidant and antidiabetic effects. These compounds have demonstrated significant potential in combating oxidative stress and managing blood glucose levels, two key factors implicated in the development and progression of diabetes mellitus. This review highlights current research on the antioxidant and antidiabetic properties of grape seed extract (GSE). Antioxidant activity in GSE is primarily attributed to its ability to scavenge free radicals, reduce oxidative stress, and prevent cellular damage. In the context of diabetes, GSE compounds are noted to improve insulin sensitivity, lower blood glucose, and inhibit carbohydrate-digesting enzymes, which together aid in controlling blood sugar levels. Both in vitro and in vivo studies indicate that GSE may help protect pancreatic beta-cells from oxidative damage, potentially preserving their function. These findings suggest that grape seed extract could serve as a promising natural supplement for the prevention and management of diabetes and related oxidative stress. However, further clinical studies are warranted to establish optimal dosages and long-term safety in human populations.

KEYWORDS: *Antioxidants, Proanthocyanidins, Oxidative Stress,Antidiabetic Activity, Insulin Sensitivity, Blood Glucose Control, Free Radicals, Polyphenols.*

INTRODUCTION:

Grapes (*Vitis vinifera*), one of the most widely cultivated fruit crops globally, are valued not only for their delicious flavor but also for their therapeutic potential. Among the various parts of the grape, grape seeds have gained significant attention in recent years due to their high content of polyphenolic compounds, particularly proanthocyanidins.Antioxidant and antidiabetic qualities are just two of the many health advantages that these natural antioxidants provide. A tiny but

powerful source of minerals and antioxidants, grape seed is made from the seeds of grapes, often the common grape *Vitis vinifera.*(Dan-Dan Zhou,et ,al.,2022) It has drawn notice due to its high concentration of potent substances that provide a number of health advantages, including as flavonoids, polyphenols, and proanthocyanidins. Grape seeds are frequently leftovers from the production of wine and are turned into supplements, extracts, and oil that are utilized in the food, cosmetic, and medical sectors.The seeds are also a source of healthy fatty acids and can be cold-pressed into grape seed oil, known for its light flavor and high smoke point, ideal for cooking and salad dressings. This oil is rich in vitamin E, which benefits skin health, and linoleic acid, an essential omega-6 fatty acid. (Muhamad Insanu ,et,*al*.,2022).The ability of grape seed extract (GSE) to neutralize free radicals, lower oxidative stress, and prevent cellular damage is primarily responsible for its antioxidant activity. This is important for managing a number of chronic diseases.

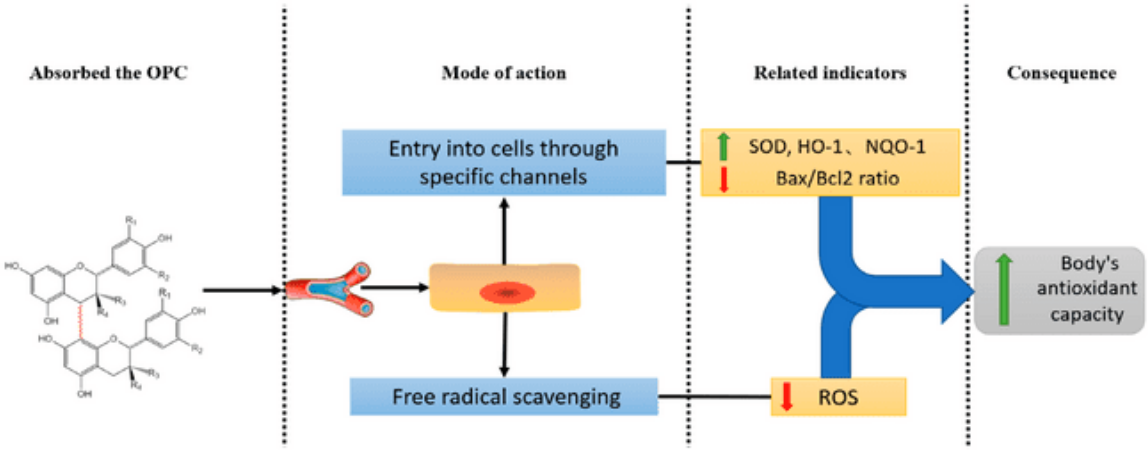
2. Biochemical Composition of Grape Seed

The biochemical structures of grape seed components, especially proanthocyanidins, flavonoids, and phenolic acids, are crucial for understanding their antioxidant and health-promoting properties. Below are the key components of grape seeds, their chemical structures, and some references for further reading.

2.1. Proanthocyanidins (Oligomeric Proanthocyanidins - OPCs)

Proanthocyanidins are flavonoid compounds composed of catechins or epicatechins. They are often found as dimers, trimers, or larger oligomers in grape seeds.The most prevalent polyphenols in grape seeds, oligomeric proanthocyanidin complexes (OPCs), are responsible for their powerful antioxidant properties.Basile, M., et al. (2001) Because of their potent ability to neutralize free radicals, proanthocyanidins can stop oxidative damage to tissues and cells. They lower blood pressure, increase blood circulation, and prevent cholesterol oxidation, which is associated with a lower risk of atherosclerosis. Because OPCs can strengthen collagen and elastin and protect against UV-induced skin damage, they are used in skin care products.

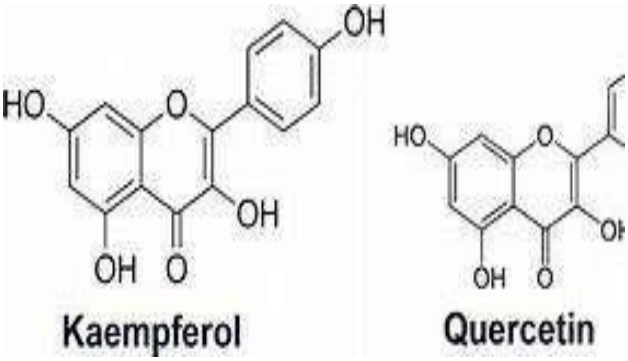
Structure of Proanthocyanidin (Dimer): Chemical formula of catechin: C15H14O6



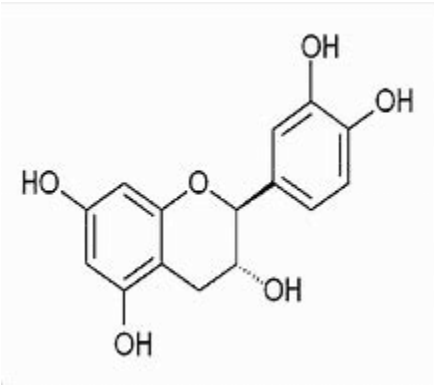
2.2 Flavonoids

Polyphenolic substances called flavonoids play a major role in grape seeds' antioxidant potential. Kaempferol and quercetin are important flavonoids found in grape seeds. These flavonoids have antioxidant qualities and are comparable to those in chocolate and green tea. Conditions like arthritis and cardiovascular illnesses can benefit from flavonoids' ability to control inflammatory pathways. (D'Archivio, M., et al. (2010))According to recent studies, epicatechins and catechins may shield brain tissue, which could help treat neurodegenerative diseases. Certain flavonoids included in grape seeds have the ability to stop bacteria from growing, which may boost immunity and encourage a balanced microbiome. Including the well-known health benefits of myricetin and quercetin-3-β-D-glucoside.(Roychowdhury, et *al*., (2001))

Structure: Kaempferol &Quercetin



2.3. Tannins are polyphenolic chemicals that give many plant-based foods and drinks their astringent flavor. Gallo tannins and ellagitannins are examples of hydrolysable tannins that give grape seeds their astringent flavor. Tannins, like other polyphenols, aid in scavenging free radicals and shielding cells from harm.(Li, S., et *al.,* (2009)) According to studies, tannins may have anti-cancer properties by causing apoptosis, or programmed cell death, and preventing the proliferation of cancer cells. By influencing gut flora, tannins may promote gut health by enhancing digestion and lowering gastrointestinal tract inflammation.

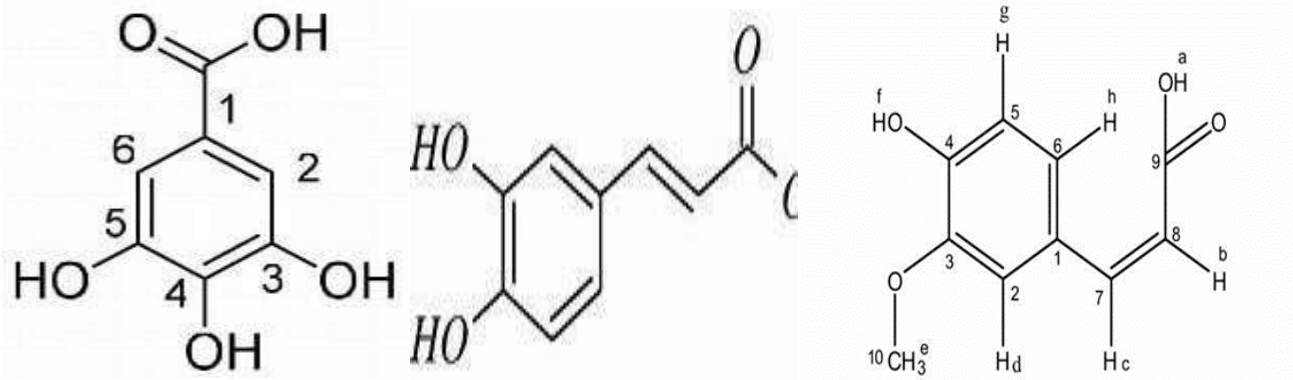


4.4. Phenolic Acids (Gallic Acid, Caffeic Acid, Ferulic Acid)

Phenolic acids are another class of antioxidant compound in grape seeds, contributing to their broad-spectrum health benefits.These compounds help prevent oxidative stress and reduce inflammation in the body, which are linked to chronic diseases.Studies have shown that phenolic

acids can protect the liver from toxin-induced damage.Gallic acid, in particular, has shown promising anti-cancer effects in lab studies, with the potential to inhibit tumor growth.Gallic acid is a phenolic compound commonly found in grape seeds. It contributes to the seeds' antioxidant and anti-inflammatory properties. (MontagutG,et.*al* 2010)

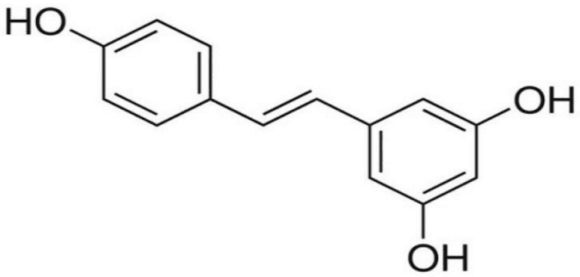
Structure of Gallic Acid **Caffeic Acid** **Ferulic Acid**



2.5. Resveratrol

Resveratrol, which has significant health advantages, is found in modest amounts in grape seeds but is more prevalent in grape skins.Resveratrol is well known for supporting the longevity and health of cells. It causes certain aging-related cellular proteins (sirtuins) to become active.By decreasing inflammation and shielding blood vessels from harm, this substance enhances heart health.In animal models, resveratrol has been investigated for its capacity to suppress tumor formation and stop the growth of cancer cells.

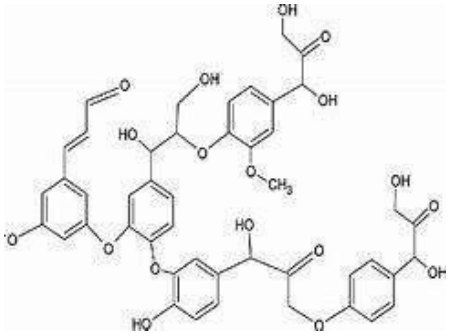
Resveratrol chemical structure



2.6. Lignans

Lignans are a class of phytoestrogens, plant compounds with estrogen-like effects, contributing to hormone balance.Lignans can help modulate estrogen activity in the body, potentially benefiting conditions related to hormone imbalance, such as menopausal symptoms.They help reduce oxidative stress and inflammation, supporting cardiovascular and overall health.Lignans have shown anti-cancer effects, particularly in hormone-sensitive cancers like breast cancer, by modulating hormone metabolism and activity.

Structure of Lignans



3.1. Antioxidant Activity of Grape Seed Extract

The seeds of *Vitis vinifera* grapes are used to make grape seed extract (GSE), which is high in bioactive substances, mostly polyphenols including proanthocyanidins, flavonoids, and other antioxidants. These substances have garnered interest due to their potential in the treatment of diabetes and oxidative stress. Here's a closer look at how GSE demonstrates these advantageous qualities:

The antioxidant and antibacterial qualities of grape (Vitis vinifera L.) stem phenolics during long-term storage are the main topics of the study by MatthausS . (2008) in Industrial Crops and Products. According to the study, grape stems are an excellent source of flavonoids, ortho-diphenols, and total phenols, among other phenolic components. These substances effectively inhibited the development of both Gram-positive and Gram-negative bacteria and shown consistent antioxidant action.The antioxidant capacity of grape seed extract is one of its most notable benefits. GSE has been shown to have a higher antioxidant potential compared to vitamins C and E due to its high proanthocyanidin content. These compounds scavenge free radicals and inhibit lipid peroxidation, which protects cells and tissues from oxidative damage. Studies have shown that regular consumption of grape seed polyphenols can help lower oxidative stress markers, which in turn reduces the risk of developing oxidative-stress-related diseases.

Polyphenol Content: GSE is highly valued for its concentrated polyphenols, especially proanthocyanidins, which are powerful antioxidants. These compounds scavenge free radicals, reduce oxidative damage, and protect cells from reactive oxygen species (ROS) which contribute to aging and chronic diseases.The effect of N ε-carboxymethyllysine (CML), its precursor glyoxal, and AGE-modified BSA on serotonin release from human parietal cells in culture is examined in the work by Holik et al. (2018). According to the results, AGE-modified BSA has a lowering effect on serotonin release, whereas CML can considerably boost it. This study sheds light on the intricate relationships between serotonin release and advanced glycation end products (AGEs), which may help us comprehend how dietary AGEs affect health.

Oxidative Stress Reduction: By reducing ROS, GSE helps lower oxidative stress in the body. Since oxidative stress is linked to cellular damage and inflammation, this protective effect can aid in maintaining cellular integrity.

Lipid and DNA Protection: Studies indicate that GSE's antioxidants not only protect cells but also stabilize cellular membranes, reduce lipid peroxidation, and prevent DNA damage, contributing to the prevention of oxidative stress-related conditions.

3.2. Antidiabetic Activity of Grape Seed Extract

Research in Phytotherapy Research (2014) indicated that grape seed extract, particularly its proanthocyanidin content, exhibited anti-inflammatory and anti-oxidant effects, which contributed to improving insulin sensitivity and reducing diabetes-induced complications.The positive effects of grape seed extract in the treatment of diabetes have been the subject of numerous investigations. By increasing insulin sensitivity, boosting glucose absorption, and lowering postprandial glucose spikes, grape seed polyphenols may aid in blood sugar regulation. There are several different ways that GSE works to prevent diabetes. First off, oxidative damage is a major factor in the development of diabetes, and its antioxidant qualities aid in shielding pancreatic beta cells from this harm. GSE has also demonstrated promise in blocking enzymes such as alpha-glucosidase, which slows the breakdown and absorption of carbohydrates and aids in blood glucose regulation.

Blood Glucose Control: Research shows that GSE may lower blood glucose levels by inhibiting carbohydrate-digesting enzymes, particularly alpha-amylase and alpha-glucosidase. By slowing carbohydrate absorption, GSE helps reduce postprandial (post-meal) blood sugar spikes.**Anti-Diabetic** activity. The insulin resistance index and the homeostasis model evaluation improved in Wister female rats given a daily dose of 25 mg grape seed procyanidin extract/kg body weight for 30 days, according to Montagut et al. Furthermore, the primers Glut4, Irs1, and Pparg2 were downregulated in the mesenteric white adipose tissue (WAT), suggesting that grape seed procyanidin has a long-term positive effect on glucose homeostasis. The oligomeric structures of the grape seed procyanidin extracts accelerated the absorption of glucose by binding to the insulin receptor and triggering its autophosphorylation, according to another study by Montagut et al.

Insulin Sensitivity: Grape seed polyphenols are suggested to enhance insulin sensitivity by improving insulin receptor function and signaling pathways, helping the body utilize glucose more effectively and potentially reducing insulin resistance. Given its potential benefits, GSE is being studied as a natural supplement to assist in the management of type 2 diabetes. By inhibiting digestive enzymes related to carbohydrate breakdown, GSE reduces the rapid release of glucose into the bloodstream.The suppression of the digestive enzymes α-amylase and α-glucosidase is one of the best-established processes. In the digestive system, these enzymes are in charge of converting complex carbs into glucose.According to Samir Felhi. et.al(2016)grape seed extracts can reduce the rate at which glucose is absorbed by blocking these enzymes, hence averting sharp increases in blood sugar levels after meals. Research has demonstrated that grape seed extracts, especially those high in proanthocyanidins, have strong inhibitory effects on both enzymes, which suggests that they could be used to treat postprandial hyperglycemia.

Protection of Beta Cells: Pancreatic beta cells, responsible for insulin production, are vulnerable to oxidative stress, which is heightened in diabetic conditions. GSE has shown protective effects on beta cells by neutralizing ROS and reducing inflammation, which could help preserve insulin production over time.A study published in the Journal of Food Science (2012) found that grape seed extract significantly inhibited the activity of α-amylase and α-glucosidase, which helped reduce blood glucose levels in vitro.Another study in Molecules (2018) highlighted that grape seed extract prevented β-cell apoptosis in diabetic rats, showing its potential to protect the pancreas from the damage caused by prolonged high blood sugar.

Anti-Inflammatory Effects: Chronic inflammation is closely associated with diabetes, and the anti-inflammatory properties of grape seed polyphenols help reduce inflammatory markers, providing a complementary benefit in managing diabetes.Several animal studies and limited human trials have supported the antidiabetic potential of grape seed extract.Sano, A, et.*al*,. (2016). For instance, animal studies have shown that GSE supplementation can improve glucose tolerance, reduce fasting blood glucose levels, and enhance antioxidant enzyme activities. In clinical studies, while more research is needed, some evidence suggests that GSE can lower blood glucose and improve lipid profiles in diabetic patients.

CONCLUSION

Overall, grape seed extract holds promise as a natural antioxidant and antidiabetic agent. Its high polyphenolic content offers protection against oxidative stress and supports blood glucose regulation, potentially reducing the risk of diabetes complications. However, further human clinical trials are necessary to solidify its efficacy, establish proper dosages, and fully understand the long-term effects of GSE in diabetic patients. Animal studies highlight that GSE can improve glucose tolerance, reduce insulin resistance, and protect against diabetes-induced oxidative damage.Although limited, some clinical trials indicate GSE's potential in managing blood glucose levels and improving oxidative stress markers in individuals with diabetes, suggesting promising outcomes for future research. Due to its antioxidant properties, GSE may help prevent or delay complications related to chronic diseases by combating oxidative stress.Overall, GSE presents an interesting natural approach to diabetes management, but further clinical studies are needed to determine optimal dosages and confirm its long-term effects.

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EFFECT OF VOLATILITY OF SUSTAINABLE INDICES ON SHARE PRICE OF SELECT INDICES OF BOMBAY STOCK EXCHANGE

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ABSTRACT

According to the reports of world economic forum, India has proposed to reach zero emission by 2070 and 50 percent of energy from renewable sources by 2030. Developing sustainable development goals and aiming towards a sustained environment has made its way towards sustained investment, the investment made in clean energy is need for the hour as a global scenario. These forms of investments are launched at different intervals through the stock market Greenex indices in 2013, Carbonex in 2015 and ESG in 2017, which are considered sustainable indices under BSE for environmental protection in accordance with controlling carbon and green house gases leading to global warming and to increase the use of renewable source, this study has been carried to understand the effect and fluctuation of these indices on the indices such as energy, oil & gas and power which are directly connected to energy and resources. The analysis has been conducted using pairwise granger causality, ARCH and GARCH to identify the effect of volatility caused by these sustainable indices on the selected indices and also its effect on the overall indicating indices of BSE. The results are proved significantly concluding that there is cause and effect with fluctuations caused by the sustainability indices on the selected indices which is reflected in the changes in the share prices of the indices is a clear indication.

KEYWORDS: *Cause, Effect, Greenex, Carbonex, ESG, Energy, Oil And Gas, Power, BSE500 And BSE Sensex, Effect Of Volatility.*

INTRODUCTION

Top stocks from the S&P Global BMI are included in the Dow Jones Sustainability World Index. These stocks are chosen based on economic, environmental, and social characteristics. The United Nations Development Programme (UNDP) Human Development Index (HDI), the Global Footprint Network and its partner organizations' ecological footprint assessment, the Environmental Sustainability Index (ESI), and the experimental Environmental Performance

Index (EPI) are some of the notable metrics that influenced this choice. There are several benefits to sustainability reporting, including improved risk management tactics, cost and savings optimization, decision-making process simplification, and enhanced corporate reputation and trustworthiness**.**

The survey stated that, in accordance with the Working Group's recommendations, a framework for educating NPOs and FPEs about the SSE-mandated disclosure requirements pertaining to financials, governance, and performance as well as details about social impact, social audits, and information repositories, among other things, must be developed.According to the report, eight mutual funds focused on environmental, social, and corporate governance (ESG) were introduced in India as of December 24, 2020. SEBI published guidelines on green bonds in 2017, including the listing of green bonds on Indian stock exchanges, in an effort to encourage the issuing of green bonds in India. Introduction of green indices: S&P BSE 100 ESG Index (in 2017), MSCI ESG India (in 2013), and S&P BSE CARBONEX (in 2012). In 2020, the total amount of green bonds issued globally surpassed $1 trillion USD. According to the poll, "green bond issuance in the first half of 2020 slowed down from 2019 despite overall growth in the global bond markets."

Review of Literature

Dr.Renu Choudhary and Vandana Jain (2018) In order to help investors make better informed decisions about India's green theme, BSE introduced BSE-GREENEX, the country's first environmentally friendly stock index. It uses carbon emissions to gauge how well the business is performing. Based on turnover, market size, and a minimum carbon footprint, the Index consists of 20 equities. The creation of the index and the GREENEX idea are explained in this publication. In order to determine how stock market fluctuations, affect GREENEX, a comparison of SENSEX and GREENEX is conducted.

Ravneet Kaur (2018) This study aims to provide a detailed discussion of one such unique step that our country has taken in this direction: the BSE GREENEX, India's first Green Index and the 25th dynamic BSE index that evaluates stocks' carbon performance based on quantitative performance. The report also includes a list of some of the top green stocks on the Indian Capital Market along with a timeline of their results.

Tripathi and Kaur (2021) Noted that in emerging nations, the sustainable strategy might offer investors a secure investment vehicle in times of hardship. To the best of our knowledge, however, there are very few studies on the state of investments in India taking into account environmental and energy-related challenges in light of the UN-declared PRI. Our work is an attempt to close this significant research gap on the situation of green investing in India today in comparison to energy-intensive, carbon-emitting investments.

Debabrata Mukhopadhyay and Nityananda Sarkar (2021) Furthermore, in the context of the GARCH-in-mean model, the two green indices and BSESENSEX exhibit a large presence of risk premium, but the risk premium for the two carbon-emitting energy indices is negligible. Thus, all things considered, the study concludes that certain green funds, such the ones that represent BSE Carbonex, beat the benchmark stock index for investors, BSESENSEX, and the two energy indices that represent regular funds in India. A cursory examination of the risk and return term structure supports the BSE Carbonex green investment index. The results of this research thus

support the adoption of carbon-efficient practices by larger Indian businesses, even after taking into account the governance, social, and environmental implications of responsible investing.

Swati Sharma (2022) The performance of the BSE GREENEX is examined in this study. Analysis of the performance has also been done for the pre- and post-COVID periods. The outcome implies that returns have been consistent throughout time, and the index's post-covid performance has outperformed its pre-covid performance. The study shows that incorporating sustainable finance not only attracts greater profit but also stabilizes the financial market and economy because the post-COVID return outperforms the pre-COVID return.

Swagato Roy Chowdhury(2023) With regard to the two green indices of the Bombay Stock Exchange (BSE), CARBONEX and GREENEX, this study has sought to assess the state of the economic recovery. Up until July 20, 2021, these indices have been compared during the lockdown and unlock down periods. This study looked at whether there were any appreciable differences in the indices during the lockout and unlocking periods. An increase in these values would encourage greater investment in the Indian stock market going forward, even in the face of additional moderate COVID waves and partial lockdowns. A high mean variance would show progress in sustainable corporate operations since the lockdown period. The groups' one-way relationship An ANOVA has been conducted to see if the aforementioned phases show notable variations in the means of the GREENEX and CARBONEX indexes. The expectation of Indian investors on the post-COVID economic recovery will be enhanced by a notable deviation.

Statement of the Problem

India being one of the largest economies and fastest growing economies, with large number of industries, is third global level greenhouse gases emitter as per 2011 followed by China and USA, which is the main intention to legally obligate the aim towards reducing the carbon and green house gas emissions with respect to Kyoto protocol aiming to reduce by 20-25 percent. Country like is has taken measures through socially responsible investment by launching indices concentrating on lowering the emissions by making investments in sustainability indices such as Greenex, Carbonex and ESG focusing on the sustainable investments, the current study also focuses on understanding the effect and cause of these indices on the selected indicators indices subject to energy and natural resources. The study helps in investigating the effect of volatility on the selected indicator indices in long and short term with the help of suitable tools such as pairwise granger, ARCH and GARCH. And the results are found to be relatable.

The above problem is discussed with the help of research question:

- How will be the future trend of the selected sustainable indices in Bombay stock exchange.
- Is there any cause and effect of these sustainable indices on the selected indices of Bombay stock exchange
- Whether sustainable indices cause any effect of volatility on the share price of selected indices in Bombay stock exchange.

Objectives of the Study

- To examine the future trends of share price of select sustainable indices and share price of select indices of Bombay stock exchange in India.

- To study the cause and effect of share price of select sustainable indices on share price of select indices of Bombay stock exchange in India.
- To elucidate the effect of volatility of share price of select sustainable indices on share price of select indices of Bombay stock exchange in India.

Hypothesis of the Study

- There is no significant cause and effect of share price of select sustainable indices on share price of select indices of Bombay stock exchange in India.
- There is no significant effect of volatility of share price of select sustainable indices on share price of select indices of Bombay stock exchange in India.

Research Methodology

The study is found to be analytical. **Source of Data**

The source of information is gathered from the official website of Bombay stock exchange. They are secondary source of information and other relevant data are collected from the journal, news articles and official reports of Government of India.

Period of Study

The period of study covers five years from 2018-2022 monthly data has been taken for analyzing the study.

Tools used for the study

The gathered information is analyzed using the statistical tools such as forecast analysis, pairwise granger causality, ARCH and GARCH model.

Analysis and Interpretation

Analysis of forecast of share prices of select indices in Bombay Stock Exchange with respect to sustainability

Table 1

Year	Greenex	Carbon	ESG	Power	Oil and Gas	Energy	BSE500	SENSEX
2018	33437.41	444434.3	41813.19	512787.9	3569740	1037370	3613783.86	8708317.47
2019	32889.2	460474.5	43903.03	477159.5	3522537	1156118	3642328.05	9397822.94
2020	32447.8	458852.5	45404.65	426664.7	3208026	1348074	3667023.01	9568525.73
2021	49003.58	654664.9	66153.71	702787.3	4074111	1718034	5374475.72	13341294.9
2022	55465.76	707932.3	71755.39	1096876	4701375	2035663	5838311.94	14344937.6
2023	58700.07	761627.6	78446.52	1061396	4659611	2226603	6281545.66	15637193.4
2024	68093.2	112037.1	89763.97	1304582	5163380	2545466	7195654.13	17634500.8
2025	77038.27	796328.4	100608.3	1552795	5710163	2845774	8060701.74	19633645.1
2026	82269.22	847271.4	107420.9	1716004	5981961	3103893	8569076.11	20880593.4
2027	89896.84	352650.8	117646.8	1865227	6326815	3378169	9361263.24	22746503
2028	98170.38	663624.6	127594.6	2105726	6814283	3678448	10153505.3	24545900.7
2029	104997.5	-232655	136416.8	2283282	7174857	3949858	10832919.3	26168925.9
2030	112020.3	3237214	145474.7	2459816	7530129	4226045	11534152.4	27815874.3
2031	119851.7	-4209036	155374.1	2657714	7948923	4512081	12310725.9	29619454.9
2032	127115.2	9347589	164501.8	2856072	8347020	4793546	13022384.9	31284095

Source: computed using excel

The performance of selected indexes on the Bombay Stock Exchange is forecasted over the next 10 years and is shown in the following table for the years 2018–2022. Of particular note is the Greenex indexes' persistent rising trend in share prices within the given time frame. After initially rising, the Carbonex indices show a fall in 2029 and 2031, which suggests that the price of Carbonex shares has fluctuated. On the other hand, the share prices of the ESG indices are expected to continue rising. Furthermore, the BSE's energy, power, and oil & gas indices, which highlight renewable energy sources, show a continued growth prognosis. Lastly, there has been an overall rise in share prices as seen by the Bombay Stock Exchange's major indices, the BSE500 and BSE Sensex.

Pairwise granger causality between share price of select sustainable indices and select indices of Bombay stock exchange in India

Table 2

Pairwise Granger Causality Tests			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
GREENEX does not Granger Cause CARBON		23.8329	**0.0004**
ESG does not Granger Cause GREENEX	58	1.02336	0.3664
GREENEX does not Granger Cause ESG		17.0513	**0.0002**
ENERGY does not Granger Cause GREENEX	58	1.42211	0.2503
GREENEX does not Granger Cause ENERGY		7.79598	**0.0011**
OIL_AND_GAS does not Granger Cause GREENEX	58	2.02455	0.1421
GREENEX does not Granger Cause OIL_AND_GAS		16.4244	**0.0003**
POWER does not Granger Cause GREENEX	58	0.54266	0.5844
GREENEX does not Granger Cause POWER		12.7028	**0.0003**
ESG does not Granger Cause CARBON	58	4.25706	**0.0193**
CARBON does not Granger Cause ESG		4.21757	**0.0200**
ENERGY does not Granger Cause CARBON	58	1.71769	0.1893
CARBON does not Granger Cause ENERGY		0.63671	0.5330
OIL_AND_GAS does not Granger Cause CARBON	58	1.14562	0.3258
CARBON does not Granger Cause OIL_AND_GAS		2.52387	0.0897
POWER does not Granger Cause CARBON	58	0.95248	0.3923
CARBON does not Granger Cause POWER		0.89848	0.4133
ENERGY does not Granger Cause ESG	58	1.15841	0.3218
ESG does not Granger Cause ENERGY		0.47288	0.6258
OIL_AND_GAS does not Granger Cause ESG	58	1.52805	0.2264
ESG does not Granger Cause OIL_AND_GAS		3.04017	0.0562
POWER does not Granger Cause ESG	58	0.77989	0.4636
ESG does not Granger Cause POWER		1.40092	0.2553
OIL_AND_GAS does not Granger Cause ENERGY	58	1.66848	0.1983
ENERGY does not Granger Cause OIL_AND_GAS		2.73848	0.0738
POWER does not Granger Cause ENERGY	58	0.80056	0.4544
ENERGY does not Granger Cause POWER		1.45230	0.2432
POWER does not Granger Cause OIL_AND_GAS	58	6.55605	**0.0029**
OIL_AND_GAS does not Granger Cause POWER		0.79927	0.4550

Source: computed using EViews

The pairwise Granger causality test results on the share prices of particular sustainability indices and other energy-related indices are explained in the above table. Interestingly, it is discovered that the Granger cause and aid in the prediction of the share prices of Carbonex indices are shared by the Greenex indices. On the other hand, the idea that the share price of Greenex indices is influenced by the price of ESG indices is unsupported by any data. Moreover, it is found that there is a reciprocal relationship between the share prices of Greenex indices Granger and ESG indices; in the same way, the share prices of Greenex indices Granger and energy and oil & gas indices are caused by each other. Furthermore, the Granger share price of Greenex

indices is a direct cause of the shareFurthermore, the price of electricity indices is determined by the Granger share price of Greenex indices, and the price of Carbonex indices is determined by the Granger share price of ESG indices. The hypothesis is rejected as a consequence of the Granger causality test results, which show a causal relationship between the share prices of sustainable indices and certain energy indices, such as those for power, oil & gas, and energy.

Analysis of ARCH and GARCH Model for share price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

Table 3

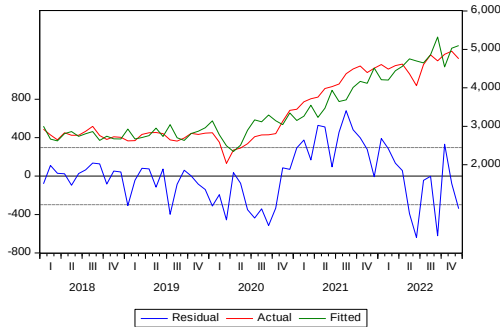
Least square for share price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: GREENEX				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1106.229	364.8432	3.032067	0.0037
ENERGY	**0.011847**	0.002359	5.021193	**0.0000**
OIL_AND_GAS	**-0.000989**	0.001843	-0.536885	**0.5935**
POWER	**0.021552**	0.004838	4.455141	**0.0000**
R-squared	0.884696	**Mean dependent var**		3387.396
Adjusted R-squared	0.878519	**S.D. dependent var**		853.2632
S.E. of regression	297.3979	**Akaike info criterion**		14.29236
Sum squared resid	4952950.	**Schwarz criterion**		14.43198
Log likelihood	-424.7708	**Hannan-Quinn criter.**		14.34697
F-statistic	143.2237	**Durbin-Watson stat**		0.918049
Prob(F-statistic)	0.000000			

Source: computed using EViews

A simple least squares regression involving the share prices of Greenex Indices and a few selected indices of the Bombay Stock Exchange in India is thoroughly analyzed in the table. The correlation coefficient between the Greenex indexes and the share prices of electricity and energy is positive, suggesting a comparatively weak association. On the other hand, the oil and gas index share prices have a negative coefficient, indicating a negative association.While the T-statistics for oil and gas are negative, indicating an unacceptable scenario, the T-statistics value for the share prices of the energy and power indices exceeds 2, indicating a satisfactory result. Furthermore, the p-value is significant for the energy and power index share prices but not for the oil and gas index share prices. As a result, there appears to be a relationship between the Greenex indices and the share prices of energy and power indices, supporting the rejection of the null hypothesis regarding the former.

Residual chart representing the clustering volatility for the period of 2018-2022



Clustering volatility is depicted in the graph, which shows alternating stages of low volatility followed by high volatility and high volatility followed by low volatility. The conditions for performing an ARCH effect test are met by this pattern. In particular, the first thirty to forty-eight months show minimal volatility, with the next thirty to forty-eight months showing increased volatility.

There is no ARCH effect among theshare price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

Table 4 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	4.279885	**Prob. F (1,57)**		**0.0431**
Obs*R-squared	4.120654	**Prob. Chi-Square (1)**		**0.0424**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	62242.40	17681.47	3.520206	0.0009
RESID^2(-1)	0.263421	0.127331	2.068788	0.0431
R-squared	0.069842	**Mean dependent var**		83839.98
Adjusted R-squared	0.053523	**S.D. dependent var**		112670.3
S.E. of regression	109613.6	**Akaike info criterion**		26.08062
Sum squared resid	6.85E+11	**Schwarz criterion**		26.15105
Log likelihood	-767.3783	**Hannan-Quinn criter.**		26.10811
F-statistic	4.279885	**Durbin-Watson stat**		1.951642
Prob(F-statistic)	**0.043112**			

Source: computed using EViews

Using a heteroskedasticity test, the table illustrates the existence of the ARCH effect and displays an observed R-square value of 4.1206. The null hypothesis is rejected when the p chi-square value is less than the significance level of 0.05. This result shows that the ARCH effect is unquestionably present in the model.

Table 5
Test for Auto Regression Conditional Heteroskedasticity test betweenshare price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: GREENEX				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	1693.603	270.6191	6.258255	0.0000
ENERGY	0.006543	0.001525	4.291744	**0.0000**
OIL_AND_GAS	-0.002452	0.001119	-2.191938	**0.0284**
POWER	0.028813	0.002992	9.630476	**0.0000**
Variance Equation				
C	13222.95	6685.736	1.977785	0.0480
RESID (-1) ^2	**1.096670**	0.476566	2.301191	**0.0214**
R-squared	0.838097	**Mean dependent var**		3387.396
Adjusted R-squared	0.829424	**S.D. dependent var**		853.2632
S.E. of regression	352.4053	**Akaike info criterion**		14.04269
Sum squared resid	6954612.	**Schwarz criterion**		14.25212
Log likelihood	-415.2806	**Hannan-Quinn criter.**		14.12461
Durbin-Watson stat	0.460915			

Source: computed using EViews

The table shows that an ARCH model is present in the link between Greenex Indices' share prices and the chosen indices of the Indian Bombay Stock Exchange. The coefficient value of 1.0966 for RESID (-1) indicates how the Greenex indices internally affect volatility. Additionally, a substantial ARCH influence on the volatility of Greenex indices with respect to certain Bombay Stock Exchange indices—namely, those in the Energy, Oil & Gas, and Power sectors—is indicated by the p-value being less than 0.05. This implies that the volatility of share prices in these specific indices is influenced by the ARCH effect.

There is no GARCH effect between share price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

TABLE 6

Test for GARCH effect between share price of Greenex Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: GREENEX				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	1123.094	406.8494	2.760467	0.0058
ENERGY	0.011906	0.003026	3.934533	**0.0001**
OIL_AND_GAS	-0.001085	0.002253	-0.481745	0.6300
POWER	0.021668	0.004617	4.693647	**0.0000**
Variance Equation				
C	49523.92	103943.5	0.476450	0.6338
GARCH(-1)	0.419886	1.231252	0.341023	**0.7331**
R-squared	0.884689	**Mean dependent var**		3387.396
Adjusted R-squared	0.878512	**S.D. dependent var**		853.2632
S.E. of regression	297.4060	**Akaike info criterion**		14.34773
Sum squared resid	4953217.	**Schwarz criterion**		14.55717
Log likelihood	-424.4319	**Hannan-Quinn criter.**		14.42965
Durbin-Watson stat	0.910587			

Source: computed using EViews

The relationship between the share prices of Greenex indexes and some indexes of the Bombay Stock Exchange in India is explained by the table, which also offers clarification on the GARCH effect. The corresponding P-value for the GARCH (-1) coefficient, which is reported as 0.419, is less than 0.05, suggesting statistical significance. The oil and gas industry is notably an exception to this rule. This suggests a long-term volatility influence of Greenex Indices on certain indices of the Bombay Stock Exchange, such as the energy, oil & gas, and power indices, even if the bulk of sectors have significance levels below 0.05. As a result, the GARCH effect is confirmed to exist and the null hypothesis is rejected.

Analysis of ARCH and GARCH Model for share price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Table 7

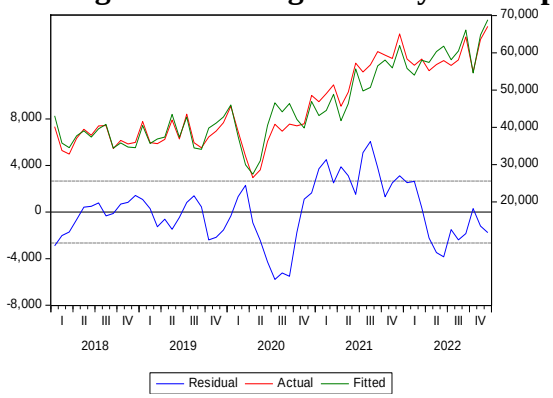
Least square for share price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: CARBON				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1391.263	3261.497	-0.426572	0.6713
ENERGY	0.188074	0.021091	8.917221	**0.0000**
OIL_AND_GAS	0.075464	0.016472	4.581381	**0.0000**
POWER	-0.000544	0.043245	-0.012584	**0.9900**
R-squared	0.938843	**Mean dependent var**		45439.31
Adjusted R-squared	0.935567	**S.D. dependent var**		10473.56
S.E. of regression	2658.573	**Akaike info criterion**		18.67331
Sum squared resid	3.96E+08	**Schwarz criterion**		18.81293
Log likelihood	-556.1992	**Hannan-Quinn criter.**		18.72792
F-statistic	286.5596	**Durbin-Watson stat**		0.346988
Prob(F-statistic)	0.000000			

Source: computed using EViews

The share prices of Carbonex Indices and a few other indices from the Bombay Stock Exchange in India are subjected to a basic least squares regression, which is thoroughly examined in the table. The correlation coefficient value shows that the share prices of Carbonex Indices, energy, and oil and gas are positively correlated. On the other hand, the power index share prices have a negative coefficient, indicating the opposite link. While the T-statistics for electricity indices are negative, indicating an unsatisfactory performance, the values for the energy and oil and gas indices are greater than 2, suggesting a satisfactory result. Power indices do not exhibit a significant p-value, although the energy and oil & gas indices do. As a result, the energy and oil and gas indices reject the null hypothesis, confirming the influence of Carbonex Indices on their share price.

Residual chart representing the clustering volatility for the period of 2018-2022



The clustering volatility chart satisfies the requirements for additional testing of the ARCH effect by showing instances of low volatility followed by high volatility and vice versa. In particular, there is a low-volatility phase that lasts for the first thirty to forty months, followed by a high-volatility phase that lasts for the next twenty to thirty months.

There is no ARCH effect among theshare price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Table 8 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	35.19452	**Prob. F(1,57)**		0.0000
Obs*R-squared	**22.52278**	**Prob. Chi-Square(1)**		**0.0000**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	2449900.	1156664.	2.118073	0.0385
RESID^2(-1)	**0.618461**	0.104250	5.932497	**0.0000**
R-squared	0.381742	**Mean dependent var**		6566423.
Adjusted R-squared	0.370895	**S.D. dependent var**		8961874.
S.E. of regression	7108211.	**Akaike info criterion**		34.42471
Sum squared resid	2.88E+15	**Schwarz criterion**		34.49513
Log likelihood	-1013.529	**Hannan-Quinn criter.**		34.45220
F-statistic	35.19452	**Durbin-Watson stat**		1.733898
Prob(F-statistic)	0.000000			

Source: computed using EViews

A heteroskedasticity test is used in the table to explain the ARCH effect, and the result is an observed R-square value of 22.5227. The null hypothesis is rejected since the p chi-square value is less than the crucial threshold of 0.05. This result indicates that there is an ARCH effect in the model.

Test for Auto Regression Conditional Heteroskedasticity test betweenshare price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Table 9

Dependent Variable: CARBON				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	1578.432	1596.362	0.988768	0.3228
ENERGY	**0.279730**	0.022561	12.39906	**0.0000**
OIL_AND_GAS	**0.050685**	0.009026	5.615538	**0.0000**
POWER	**-0.099905**	0.036062	-2.770394	**0.0056**
Variance Equation				
C	1900036.	639491.0	2.971169	0.0030
RESID(-1)^2	**0.643085**	0.337409	1.905951	**0.0507**
R-squared	0.906423	**Mean dependent var**		45439.31
Adjusted R-squared	0.901410	**S.D. dependent var**		10473.56
S.E. of regression	3288.596	**Akaike info criterion**		18.31142
Sum squared resid	6.06E+08	**Schwarz criterion**		18.52086
Log likelihood	-543.3427	**Hannan-Quinn criter.**		18.39334
Durbin-Watson stat	0.280190			

Source: computed using EViews

The table shows that there is an ARCH model in the link between the selected indices of the Bombay Stock Exchange in India and the share prices of Carbonex Indices. The internal influence of Carbonex indices on volatility is indicated by the ARCH, which has a coefficient value of 0.643 for RESID (-1). The P-value, which is less than 0.05, suggests that there is a substantial ARCH influence on the volatility of Carbonex indices with respect to certain Bombay Stock Exchange indices, particularly those related to the energy, oil and gas, and power sectors. This suggests that the volatility of share prices in these particular indices is influenced by the ARCH effect.

There is no GARCH effect between share price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Table 10 Test for GARCH effect between share price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: CARBON				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-1262.983	4154.973	-0.303969	0.7612
ENERGY	**0.189579**	0.022992	8.245272	**0.0000**
OIL_AND_GAS	**0.074358**	0.020964	3.546955	**0.0004**
POWER	**-1.71E-05**	0.047734	-0.000359	**0.9997**
Variance Equation				
C	3958085.	42353218	0.093454	0.9255
GARCH(-1)	**0.404407**	6.393371	0.063254	**0.9496**
R-squared	0.938834	**Mean dependent var**		45439.31
Adjusted R-squared	0.935557	**S.D. dependent var**		10473.56
S.E. of regression	2658.783	**Akaike info criterion**		18.74006
Sum squared resid	3.96E+08	**Schwarz criterion**		18.94949
Log likelihood	-556.2017	**Hannan-Quinn criter.**		18.82198
Durbin-Watson stat	0.344773			

Source: computed using EViews

The GARCH effect between the share prices of Carbonex Indices and specific indices on the Bombay Stock Exchange in India is explained in the table. It is found that the GARCH (-1) coefficient is 0.4044, and the associated P value is greater than 0.05. Significantly, with the exception of power indices, significance is found below 0.05. This suggests that the GARCH influence of Carbonex indices on some Bombay Stock Exchange indices—namely, the energy, oil & gas, and power indices—may exhibit long-term volatility. As a result, the GARCH effect's existence is confirmed by the null hypothesis' rejection.

Analysis of ARCH and GARCH Model for share price of ESG Indices and Share price of select indices of Bombay stock exchange in India

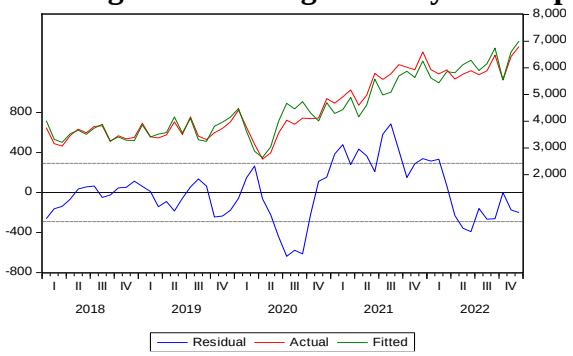
Table 11 Least square for share price of ESG Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: ESG				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-250.5654	356.8372	-0.702184	0.4855
ENERGY	**0.024103**	0.002308	10.44516	**0.0000**
OIL_AND_GAS	**0.005477**	0.001802	3.039340	**0.0036**
POWER	**0.001163**	0.004731	0.245874	**0.8067**
R-squared	0.939301	**Mean dependent var**		4483.833
Adjusted R-squared	0.936050	**S.D. dependent var**		1150.218
S.E. of regression	290.8719	**Akaike info criterion**		14.24798
Sum squared resid	4737963.	**Schwarz criterion**		14.38761
Log likelihood	-423.4395	**Hannan-Quinn criter.**		14.30260
F-statistic	288.8632	**Durbin-Watson stat**		0.337486
Prob(F-statistic)	0.000000			

Source: computed using EViews

The share prices of ESG Indices and particular indices on the Bombay Stock Exchange in India are analyzed in depth using a basic least squares regression, as shown in the table. The positive coefficient value indicates a weak correlation between the share prices of ESG indexes and the energy, oil and gas, and power sectors. While the T-statistics for electricity indices are negative, indicating an unacceptable scenario, the T-statistics values for the share prices of the energy and oil & gas indices surpass 2, indicating a satisfactory level. Furthermore, the p-value is not significant for electricity indices but substantial for the share prices of the energy and oil & gas indices. As a result, the null hypothesis about the influence of the energy and oil & gas indices' share prices on the share prices of ESG indices is rejected. This suggests that the share prices of the energy and oil & gas indices are impacted by ESG indexes.

Residual chart representing the clustering volatility for the period of 2018-2022



The clustering volatility chart satisfies the requirements for the ARCH effect test by showing instances of low volatility followed by high volatility and vice versa. To be more precise, there is minimal volatility over the first thirty to forty months, followed by a period of increased volatility during the next twenty to thirty months.

There is no ARCH effect among theshare price of ESG Indices and Share price of select indices of Bombay stock exchange in India

Table 12 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	36.28867	**Prob. F(1,57)**		0.0000
Obs*R-squared	**22.95061**	**Prob. Chi-Square(1)**		**0.0000**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	29432.18	14020.83	2.099175	0.0402
RESID^2(-1)	**0.624317**	0.103638	6.024008	**0.0000**
R-squared	0.388993	**Mean dependent var**		79141.30
Adjusted R-squared	0.378274	**S.D. dependent var**		110423.8
S.E. of regression	87068.72	**Akaike info criterion**		25.62009
Sum squared resid	4.32E+11	**Schwarz criterion**		25.69052
Log likelihood	-753.7928	**Hannan-Quinn criter.**		25.64758
F-statistic	36.28867	**Durbin-Watson stat**		1.739821
Prob(F-statistic)	0.000000			

Source: computed using EViews

The table uses the heteroskedasticity test to explain the ARCH effect and shows an observed r-square value of 22.9506. The null hypothesis is rejected by the p chi-square value, which is less than the significance threshold of 0.05, indicating that the model shows an ARCH effect.

Test for Auto Regression Conditional Heteroskedasticity test betweenshare price of Carbonex Indices and Share price of select indices of Bombay stock exchange in India

Table 13

Dependent Variable: ESG				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	272.8539	199.6954	1.366350	0.1718
ENERGY	**0.021363**	0.001847	11.56479	**0.0000**
OIL_AND_GAS	**0.003779**	0.000961	3.933679	**0.0001**
POWER	**0.006073**	0.003134	1.937669	**0.0527**
Variance Equation				
C	7194.328	4753.246	1.513561	0.1301
RESID(-1)^2	**0.902660**	0.457029	1.975061	**0.0483**
R-squared	0.927580	**Mean dependent var**		4483.833
Adjusted R-squared	0.923701	**S.D. dependent var**		1150.218
S.E. of regression	317.7173	**Akaike info criterion**		13.62120
Sum squared resid	5652880.	**Schwarz criterion**		13.83063
Log likelihood	-402.6359	**Hannan-Quinn criter.**		13.70312
Durbin-Watson stat	0.196937			

Source: computed using EViews

The association between the share prices of ESG Indices and the share prices of particular indices on the Bombay Stock Exchange in India can be seen in the table as supporting the existence of an ARCH model. RESID (-1) has a coefficient value of 0.902, indicating that ARCH has an impact on the internal dynamics of volatility in ESG indexes. An ARCH effect is clearly present on the volatility of ESG indices with respect to a subset of the Bombay Stock Exchange's indexes (energy, oil & gas, and electricity, for example), with a P-value of less than 0.05. This implies that the volatility of the share prices in these particular indices is influenced by the ARCH effect.

There is no GARCH effect between share price of ESG Indices and Share price of select indices of Bombay stock exchange in India.

Table 14 Test for GARCH effect between share price of ESG Indices and Share price of select indices of Bombay stock exchange in India

Dependent Variable: ESG				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(5) + C(6)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	237.9554	322.7834	0.737198	0.4610
ENERGY	**0.024375**	0.001539	15.84175	**0.0000**
OIL_AND_GAS	**0.001923**	0.001582	1.215726	**0.2241**
POWER	**0.012602**	0.005841	2.157465	**0.0310**
	Variance Equation			
C	-279.4086	1391.518	-0.200794	0.8409
GARCH(-1)	**1.069432**	0.051178	20.89642	**0.0000**
R-squared	0.929578	**Mean dependent var**		4483.833
Adjusted R-squared	0.925806	**S.D. dependent var**		1150.218
S.E. of regression	313.3035	**Akaike info criterion**		13.99704
Sum squared resid	5496910.	**Schwarz criterion**		14.20647
Log likelihood	-413.9111	**Hannan-Quinn criter.**		14.07896
Durbin-Watson stat	0.230616			

Source: computed using EViews

The GARCH effect for the share prices of ESG indices and other selected indices on the Bombay Stock Exchange in India is explained in the table. There is significance as the GARCH (-1) coefficient is 1.0694 and the P value is less than 0.05. The P value for the oil and gas indexes, however, is higher than 0.05, indicating an anomaly. This indicates that ESG indices have a long-term volatility GARCH influence on the chosen Bombay Stock Exchange indices, with the exception of the oil and gas indices. As a result, the GARCH effect is confirmed to exist and the null hypothesis is rejected.

Table 15 Pairwise granger causality between share price of select sustainable indices and share price of BSE 500 & BSE Sensex

Pairwise Granger Causality Tests			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
CARBON does not Granger Cause GREENEX	58	0.22054	0.8028
GREENEX does not Granger Cause CARBON		23.8329	**0.0004**
ESG does not Granger Cause GREENEX	58	1.02336	0.3664
GREENEX does not Granger Cause ESG		17.0513	**0.0003**
BSE500 does not Granger Cause GREENEX	58	0.32248	0.7258
GREENEX does not Granger Cause BSE500		24.0087	**0.0004**
SENSEX does not Granger Cause GREENEX	58	0.31911	0.7282
GREENEX does not Granger Cause SENSEX		16.4922	**0.0003**
ESG does not Granger Cause CARBON	58	4.25706	**0.0193**
CARBON does not Granger Cause ESG		4.21757	**0.0200**
BSE500 does not Granger Cause CARBON	58	0.97388	0.3843
CARBON does not Granger Cause BSE500		0.78456	0.4615
SENSEX does not Granger Cause CARBON	58	0.22341	0.8005
CARBON does not Granger Cause SENSEX		0.32131	0.7266
BSE500 does not Granger Cause ESG	58	0.68527	0.5084
ESG does not Granger Cause BSE500		0.86513	0.4269
SENSEX does not Granger Cause ESG	58	3.79981	**0.0287**
ESG does not Granger Cause SENSEX		4.54987	**0.0150**
SENSEX does not Granger Cause BSE500	58	0.14805	0.8627
BSE500 does not Granger Cause SENSEX		0.35128	0.7054

Source: computed using EViews

The Granger causality correlations between the share prices of the BSE 500 and BSE Sensex and certain sustainability indexes are shown in the table. Granger causation between Greenex indices and the share prices of BSE 500, BSE Sensex, Carbonex indices, and ESG indices is demonstrated. Furthermore, there is a reciprocal relationship between the share prices of Carbonex indices and the ESG indices Granger. ESG index share prices are a consequence of BSE Sensex Granger, and vice versa: BSE Sensex share prices are a consequence of ESG index Granger. This means that a definitive conclusion that there is a causal relationship between the chosen sustainable indices and the BSE 500 and BSE Sensex follows from the rejection of the null hypothesis.

Analysis of ARCH and GARCH Model for share price of Greenex Indices and Share price of BSE500 and BSE Sensex in India

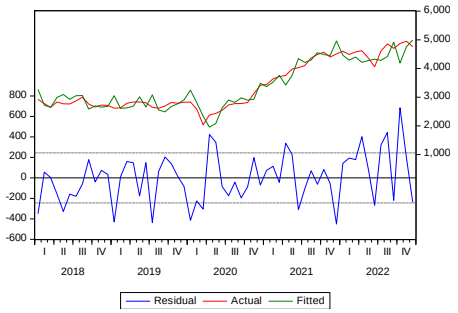
Table 16 Least square for share price of share price of Greenex Indices and Share price of BSE500 and BSE Sensex indices in India

Dependent Variable: GREENEX				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	178.2604	148.6340	1.199325	0.2354
BSE500	**0.014730**	0.002888	**5.099468**	**0.0000**
SENSEX	**-0.002412**	0.001216	**-1.983020**	**0.0522**
R-squared	0.920610	**Mean dependent var**		3387.396
Adjusted R-squared	0.917825	**S.D. dependent var**		853.2632
S.E. of regression	244.5983	**Akaike info criterion**		13.88582
Sum squared resid	3410215.	**Schwarz criterion**		13.99054
Log likelihood	-413.5745	**Hannan-Quinn criter.**		13.92678
F-statistic	330.4891	**Durbin-Watson stat**		1.821551
Prob(F-statistic)	0.000000			

Source: computed using EViews

The table provides a thorough breakdown of a basic least squares regression incorporating the Indian share prices of the BSE500, BSE Sensex, and Greenex Indices. The coefficient values show that there is little correlation between the share prices of the Greenex indexes and the BSE500 and BSE Sensex. The share price of the BSE Sensex indexes has a negative T-statistic, indicating an unsatisfactory scenario, whereas the share price of the BSE 500 index has a satisfactory T-statistic value above 2. The share prices of the BSE Sensex and BSE 500 indexes have both significant p-values. As a result, there appears to be a visible effect of Greenex indices on the share prices of the BSE500 and BSE Sensex indexes when compared to Greenex indices, rejecting the null hypothesis.

Residual chart representing the clustering volatility for the period of 2018-2022



The graph demonstrates clustering volatility, meeting the requirements for additional testing the ARCH effect by showing times of low volatility followed by high volatility and vice versa. In particular, the first thirty to forty-eight months show minimal volatility, with the next thirty to forty-eight months showing increased volatility.

There is no ARCH effect among theshare price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India.

Table 17 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	0.046971	**Prob. F(1,57)**		0.8292
Obs*R-squared	**0.048579**	**Prob. Chi-Square(1)**		**0.8256**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	57329.22	12940.12	4.430346	0.0000
RESID^2(-1)	-0.028524	0.131610	-0.216729	0.8292
R-squared	0.000823	**Mean dependent var**		55707.87
Adjusted R-squared	-0.016706	**S.D. dependent var**		80432.06
S.E. of regression	81101.13	**Akaike info criterion**		25.47809
Sum squared resid	3.75E+11	**Schwarz criterion**		25.54852
Log likelihood	-749.6037	**Hannan-Quinn criter.**		25.50558
F-statistic	0.046971	**Durbin-Watson stat**		1.965049
Prob(F-statistic)	0.829193			

Source: computed using EViews

Using a heteroskedasticity test, the table shows the ARCH effect and displays an observed R-square value of 0.0485. The null hypothesis is accepted since the p chi-square value is greater than the significance level of 0.05. This result implies that the model does not include an ARCH effect. As a result, the model cannot be expanded to investigate GARCH and ARCH effects because there is no ARCH impact.

Analysis of ARCH and GARCH Model for share price of Carbonex Indices and Share price of BSE500 and BSE Sensex in India

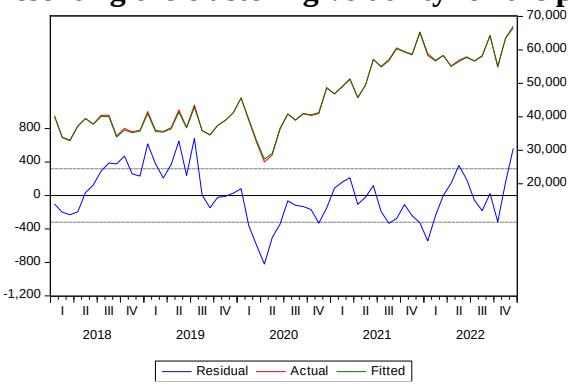
Table 18 Least square for share price of share price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India

Dependent Variable: CARBON				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1733.833	193.8062	8.946221	0.0000
BSE500	**0.073517**	0.003766	**19.51974**	**0.0000**
SENSEX	**0.017972**	0.001586	**11.33390**	**0.0000**
R-squared	0.999104	**Mean dependent var**		45439.31
Adjusted R-squared	0.999073	**S.D. dependent var**		10473.56
S.E. of regression	318.9357	**Akaike info criterion**		14.41656
Sum squared resid	5798038.	**Schwarz criterion**		14.52128
Log likelihood	-429.4969	**Hannan-Quinn criter.**		14.45752
F-statistic	31784.47	**Durbin-Watson stat**		0.552864
Prob(F-statistic)	0.000000			

Source: computed using EViews

The table provides a thorough examination of a basic least squares regression incorporating the share prices of the Indian BSE500 and BSE Sensex indices, as well as the share prices of Carbonex Indices. The coefficient values show that there is little correlation between the share prices of the Carbonex indexes and the BSE500 and BSE Sensex. The share prices of the BSE500 and BSE Sensex have T-statistics values greater than 2, which indicates a desirable level. The p-values for the BSE500 and BSE Sensex index share prices are also noteworthy. This suggests that there is a noticeable effect of Carbonex indices on share prices, as the null hypothesis is rejected for the share prices of the BSE500 and BSE Sensex indices in respect to the share prices of Carbonex indices.

Residual chart representing the clustering volatility for the period of 2018-2022



In order to meet the requirements for additional testing of the ARCH effect, the chart illustrating clustering volatility reveals a pattern of alternating between low and high volatility. In particular, there is little volatility during the first thirty to forty months, followed by a period of increased volatility during the next twenty to thirty months.

There is no ARCH effect among theshare price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India

Table 19 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	6.233104	**Prob. F(1,57)**		0.0155
Obs*R-squared	**5.815832**	**Prob. Chi-Square(1)**		**0.0159**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	68346.69	20732.08	3.296664	0.0017
RESID^2(-1)	0.320196	0.128252	2.496619	0.0155
R-squared	0.098573	**Mean dependent var**		98097.54
Adjusted R-squared	0.082759	**S.D. dependent var**		136063.8
S.E. of regression	130312.0	**Akaike info criterion**		26.42656
Sum squared resid	9.68E+11	**Schwarz criterion**		26.49699
Log likelihood	-777.5835	**Hannan-Quinn criter.**		26.45405
F-statistic	6.233104	**Durbin-Watson stat**		1.986241
Prob(F-statistic)	0.015453			

Source: computed using EViews

The observed r-square value of 5.8158 is revealed in the table, which uses the heteroskedasticity test to highlight the ARCH effect. When the p chi-square value is less than the significance level of 0.05, the null hypothesis is rejected. This implies that the ARCH effect is present in the model in a definitive way.

Test for Auto Regression Conditional Heteroskedasticity test betweenshare price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India

Table 20

Dependent Variable: CARBON				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(4) + C(5)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	1395.543	92.09881	15.15268	0.0000
BSE500	**0.072452**	0.006918	10.47270	**0.0000**
SENSEX	**0.018679**	0.002789	6.698470	**0.0000**
Variance Equation				
C	32145.21	17325.67	1.855351	0.0635
RESID(-1)^2	**0.891002**	0.447801	1.989730	**0.0466**
R-squared	0.999016	**Mean dependent var**		45439.31
Adjusted R-squared	0.998982	**S.D. dependent var**		10473.56
S.E. of regression	334.2377	**Akaike info criterion**		14.24522
Sum squared resid	6367747.	**Schwarz criterion**		14.41975
Log likelihood	-422.3567	**Hannan-Quinn criter.**		14.31349
Durbin-Watson stat	0.432117			

Source: computed using EViews

The table shows the relationship between the share prices of the BSE500 and BSE Sensex indexes in India and the share prices of Carbonex Indices according to the ARCH model. The result of 0.891 for the coefficient indicates how the Carbonex indexes affect volatility in the RESID (-1) calculation. The BSE 500 and BSE Sensex index share prices are impacted by the substantial ARCH influence on the volatility of Carbonex indexes, as indicated by the P value, which is less than 0.05. This implies that the volatility of the share prices of the chosen indices is significantly shaped by the ARCH effect.

There is no GARCH effect between share price of Carbonex Indices and share price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India.

Table 21 Test for GARCH effect between share price of Carbonex Indices and share price of Carbonex Indices and Share price of BSE500 and BSE Sensex indices in India

Dependent Variable: CARBON				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(4) + C(5)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	1682.782	226.9262	7.415550	0.0000
BSE500	**0.071838**	0.005065	14.18308	**0.0000**
SENSEX	**0.018698**	0.002165	8.634562	**0.0000**
Variance Equation				
C	18675.95	56352.41	0.331414	0.7403
GARCH(-1)	**0.817355**	0.584774	1.397728	**0.1622**
R-squared	0.999101	**Mean dependent var**		45439.31
Adjusted R-squared	0.999069	**S.D. dependent var**		10473.56
S.E. of regression	319.5363	**Akaike info criterion**		14.45984
Sum squared resid	5819895.	**Schwarz criterion**		14.63437
Log likelihood	-428.7952	**Hannan-Quinn criter.**		14.52811
Durbin-Watson stat	0.532172			

Source: computed using EViews

The GARCH effect between the share prices of Carbonex Indices and certain indices of the Bombay Stock Exchange in India is explained in the table. 0.8173, the GARCH (-1) coefficient, is found, and the associated P value is greater than 0.05. With the exception of power indices, significance is seen below 0.05, suggesting long-term volatility in the GARCH effect of Carbonex indices on the share prices of particular BSE indices in India (BSE500 and BSE Sensex). Thus, the existence of the GARCH effect is confirmed by the rejection of the null hypothesis.

Analysis of ARCH and GARCH Model for share price of ESG Indices and Share price of BSE500 and BSE Sensex in India.

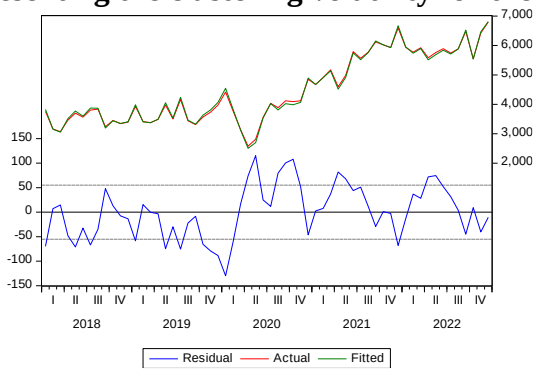
Table 22 Least square for share price of share price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India

Dependent Variable: ESG				
Method: Least Squares				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-367.4929	33.52006	-10.96337	0.0000
BSE500	**0.005287**	0.000651	**8.115522**	**0.0000**
SENSEX	**0.003144**	0.000274	**11.46393**	**0.0000**
R-squared	0.997778	**Mean dependent var**		4483.833
Adjusted R-squared	0.997700	**S.D. dependent var**		1150.218
S.E. of regression	55.16201	**Akaike info criterion**		10.90713
Sum squared resid	173442.3	**Schwarz criterion**		11.01185
Log likelihood	-324.2140	**Hannan-Quinn criter.**		10.94809
F-statistic	12797.82	**Durbin-Watson stat**		0.704198
Prob(F-statistic)	0.000000			

Source: computed using EViews

In comparison to the share prices of the BSE 500 and BSE Sensex indexes in India, the table presents a thorough examination of the simple least squares regression for the share prices of ESG indexes. A minor correlation has been observed between the share prices of ESG indices and the BSE500 and BSE Sensex, as indicated by the coefficient values. For the BSE500 and BSE Sensex share prices, the T-statistics values are both over 2, which indicates a favourable condition. The BSE500 and BSE Sensex index share prices both have large p-values. The share prices of the BSE500 and BSE Sensex indices in respect to the share prices of ESG indices thus reject the null hypothesis, suggesting that there is a noticeable influence of ESG indices on the share price.

Residual chart representing the clustering volatility for the period of 2018-2022



The chart displays the clustering volatility that elucidates the low volatility followed by high volatility and high volatility followed by low volatility which fulfills the conditions fir ARCH effect test further. There is low volatility for first 36 months and high volatility in the period of next 20 to 30 months

There is no ARCH effect among theshare price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India.

Table 23 Testing for ARCH effect using Heteroskedasticity test

Heteroskedasticity Test: ARCH				
F-statistic	6.268153	**Prob. F(1,57)**		0.0152
Obs*R-squared	**5.845295**	**Prob. Chi-Square(1)**		**0.0156**
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1930.298	579.2383	3.332476	0.0015
RESID^2(-1)	0.315604	0.126059	2.503628	0.0152
R-squared	0.099073	**Mean dependent var**		2857.493
Adjusted R-squared	0.083267	**S.D. dependent var**		3573.032
S.E. of regression	3421.041	**Akaike info criterion**		19.14659
Sum squared resid	6.67E+08	**Schwarz criterion**		19.21701
Log likelihood	-562.8243	**Hannan-Quinn criter.**		19.17408
F-statistic	6.268153	**Durbin-Watson stat**		1.873011
Prob(F-statistic)	0.015181			

Source: computed using EViews

The table explains the ARCH effect using the heteroskedasticity test, the observed r-square value 5.845, where the p chi square value is below the significant value of 0.05, which rejects the null hypothesis concluding that there isARCH effect in the model.

Test for Auto Regression Conditional Heteroskedasticity test betweenshare price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India

Table 24

Dependent Variable: ESG				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(4) + C(5)*RESID(-1)^2				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-362.5161	34.40600	-10.53642	0.0000
BSE500	**0.005297**	0.000653	8.117423	**0.0000**
SENSEX	**0.003127**	0.000276	11.32659	**0.0000**
Variance Equation				
C	1672.246	634.0683	2.637327	0.0084
RESID(-1)^2	0.427518	0.318816	1.340955	0.1799
R-squared	0.997740	**Mean dependent var**		4483.833
Adjusted R-squared	0.997661	**S.D. dependent var**		1150.218
S.E. of regression	55.63177	**Akaike info criterion**		10.88985
Sum squared resid	176409.0	**Schwarz criterion**		11.06438
Log likelihood	-321.6955	**Hannan-Quinn criter.**		10.95812
Durbin-Watson stat	0.664338			

Source: computed using EViews

The table exhibits that ARCH model betweenshare price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India. The RESID (-1) is coefficient value of 0.4275 ARCH indicates the internal effect of ESG indices in volatility. And the P value is above 0.05 which explains that there is no ARCH effect of volatility of ESG indices on Share price of BSE500 and BSE Sensex indices meaning that ARCH effect influences the volatility of share prices of the select indices.

There is no GARCH effect between share price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India.

Table 25 Test for GARCH effect between share price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India

Dependent Variable: ESG				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(4) + C(5)*GARCH(-1)				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-379.5681	40.23287	-9.434280	0.0000
BSE500	0.004950	0.000617	8.019511	0.0000
SENSEX	0.003289	0.000265	12.40622	0.0000
Variance Equation				
C	261.8576	1037.976	0.252277	0.8008
GARCH(-1)	0.918216	0.361795	2.537946	0.0112
R-squared	0.997762	**Mean dependent var**		4483.833
Adjusted R-squared	0.997684	**S.D. dependent var**		1150.218
S.E. of regression	55.35755	**Akaike info criterion**		10.96383
Sum squared resid	174674.1	**Schwarz criterion**		11.13836
Log likelihood	-323.9150	**Hannan-Quinn criter.**		11.03210
Durbin-Watson stat	0.724949			

Source: computed using EViews

The table elucidates the GARCH effect between share price of ESG Indices and Share price of BSE500 and BSE Sensex indices in India. GARCH (-1) coefficient shows a value of 0.9182 and the P value is found to below 0.05 and the significant is below 0.05 for BSE500 and BSE Sensex indices, which means there is long-term volatility the GARCH effect of ESG indices on Share price of BSE500 and BSE Sensex indices in India, hence the null hypothesis is rejected confirming the GARCH effect.

Findings of the Study

- The share prices of sustainable indices, like Greenex, and some energy indices covering the electricity, oil & gas, and overall energy sectors are found to be causally related.
- There is evidence that the Greenex indices are not correlated with the share prices of the energy and power indices, which refutes the null hypothesis related to the former.
- The Indian Bombay Stock Exchange's chosen indices and Greenex Indices' ARCH effect have an effect on the share price volatility of these specified indices.
- The GARCH impact is confirmed, demonstrating the long-term volatility effects of Greenex Indices on the energy, oil and gas, and power indices of the Bombay Stock Exchange.
- As a result, the energy and oil and gas indices' share prices attest to the impact of Carbonex Indices on their market values.

- ARCH has a major impact on the volatility of Carbonex indices, especially when it comes to certain Bombay Stock Exchange indexes associated with the electricity, energy, and oil and gas industries.
- The GARCH influence of Carbonex indices may cause long-term volatility in some Bombay Stock Exchange indexes, including those related to energy, oil & gas, and power. The GARCH effect is confirmed to exist when the null hypothesis is rejected.
- It is implied that ESG indices have an impact on the share prices of energy and oil & gas indices since the impact of share prices in these indices on ESG indices is not supported.
- Regarding a subset of Bombay Stock Exchange indexes, there is a definite ARCH effect on the volatility of ESG indices, suggesting that the ARCH effect affects the share prices in these particular indices.
- With the exception of the oil and gas indices, certain Bombay Stock Exchange indices are GARCH-influenced by ESG indices. The null hypothesis is rejected as a result of this validation of the GARCH effect.
- When compared to Greenex indices, the share prices of the BSE500 and BSE Sensex indexes show a discernible impact from Greenex indices, refuting the null hypothesis.
- The fact that the null hypothesis pertaining to Carbonex indices was rejected suggests that there is a discernible impact on share prices, especially when comparing the BSE500 and BSE Sensex indices to Carbonex indices.
- Share prices of the BSE 500 and BSE Sensex indices are impacted by a significant ARCH influence on the volatility of Carbonex indexes. This implies that the volatility of the share prices of the chosen indices is substantially shaped by the ARCH effect.
- The existence of long-term volatility is confirmed by the GARCH effect of Carbonex indexes on the share prices of particular BSE indices in India (BSE500 and BSE Sensex), as shown by the rejection of the hypothesis.
- In regards to ESG indices, the share prices of the BSE500 and BSE Sensex indexes have a discernible impact on share prices, hence refuting the null hypothesis.
- The lack of an ARCH effect on the volatility of ESG indices implies that the BSE500 and BSE Sensex indexes' share price volatility is unaffected by the ARCH effect.
- The rejection of the null hypothesis highlights the long-term volatility in the GARCH effect of ESG indices on the share prices of the BSE500 and BSE Sensex indexes in India, confirming the existence of the GARCH effect.

CONCLUSION

Socially responsible investment that is sustainability indices of Bombay Stock Exchange, focuses on the investing in securities that meets sustainability investments. The indices under the BSE sustainability indices which contains Greenex, Carbonex and ESG Indices, and the selected indices which is exactly a representation of sustainable indices such as Energy, Oil and Gas along with power indices. And theoverall index from BSE500 and BSE Sensex has been taken for the analysis concludes the cause, effect and the fluctuation with respect to volatility is been elaborately found in the study. There is cause and effect of the share price of select sustainable

indices. And almost all the selected indices representing the sustainable indices has been related and influenced by the sustainable indices over the period and the long term volatility and short term volatility has been clearly identified in the stock market. Even though there is volatility in the share price due to the sustainable indices there is chance of high risk and return. But a fluctuation in share price if it is cause hike that is lead to increase in value of investment, but in turn the return may be less than the actual one with a increased risk, so the socially responsible investment as its nature the risk is mandatorily involved and return is expected in long term not in short term.so it is a social responsibility of a person with sustainable motive to make investment based on the investment decisions can be a game changer for sustainable development goals to control the emissions and environmentally sustaining the resources which can be done through the investments with sustainability indices in Bombay stock exchange can help in making a chance in society.

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FORMULATING SUSTAINABLE FEEDS: UNDERSTANDING NUTRIENT AND ENERGY REQUIREMENTS IN FINFISH AQUACULTURE

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ABSTRACT

Fish foods are known for their long standing health benefits to humans.Feed qualityenhancement provides an opportunity to improve sustainable aquaculture productions contributing to matchable fish demandsand consequent consumer gain.Preparation of balanced, cost effective feed based on the nutrition and health needs of fish is thus an essential precondition. Forcost-compliant production, diets must be formulated based on accurate apportionment of essential nutrients and energy gains according tofundamental needs of the species. Present study describes dietary requirements of finfish in terms of proteins, amino acids, lipids, constituent fatty acids, carbohydrates, and energy. The work also evaluates importance of feed processing in improvingdietary parameters for sustainable quality aquaculture productions.

KEYWORDS: *Aquafeeds, Protein, Finfish, Nutrition Quality, Sustainability.*

INTRODUCTION

Fish and fish foods are known for promoting human health. Dietary supplementation of fish proteins canprevent malnutrition, fish oils are good source of essential fatty acids with antioxidant, anti-inflammatory effects (Chen et al., 2022).Feed is the foremost important input for fish welfare in sustainable intensive aquaculture productions. It is a source of nutrients and energy, fundamental for growth, reproduction, and fish health (NRC, 1993). Quality feed is important for scaling up fisheries outturn by fulfilling the balanced nutritional requirements of fish (Puri et al., 2022). Sustainable, quality feeds can confer health benefits to aquaculture and consequently to humans (consumers). In terms of quantity as well as quality, dietary requirements of fish vary as per life stage of the species, feeding habits and environmental fluctuations of temperature, salinity and natural food availability in the culture environment (Giri, 2017). Formulating balanced, least expense feed based on the nutrition and health needs of fish is thus an essential prerequisite (Ahmed and Ahmad, 2020). For cost-effective, economical production, diets must be formulated in agreement with the elementary nutritional needs of the specific species, containing accurate apportionment of protein, lipid, carbohydrate as well as energy gains. Present study describes dietary requirements of finfish in terms of proteins, amino acids, lipids, constituent fatty acids, carbohydrates, and energy gained from feed.

1. Protein and Amino Acid Requirement

Protein comprise most treasuredconstituent in fish feed compositions in terms of quality it offers andin directing the feed cost (Fatma and Ahmed, 2020). Protein requirements of fish is for growth accretion and survival. Proteins comprise 50% of dietary constituents in fish feeds (Benitez,1989).Dietary needs of protein for fish is nearly 2 to 4-fold higher than other vertebrates (Wilson, 2003). Carnivorous species havegreater protein requirements (40-50% crude protein), than omnivore and herbivore (25-35%) fishes (Jauralde et al., 2021; NRC,1993; Gatlin, 2010). For maximal growth, dietary crude protein requirement of cultured fish varies between 300-550 g kg^{-1} of diet (Tacon and Cowey, 1985; Wilson, 1989). In a meta-analysis approach, Teles et al. (2020)enlist requirement of 624g protein for fish to achieve 1kg weight gain,accomplishing protein retention efficiency(PER) of 32%. Dietary protein necessities are relatable to trophic level, salinity, rearing temperature, stock size, frequency of feeding, non-protein source of dietary energy, diet quality of protein (Fatma and Ahmed, 2020; Teles et al., 2020). Proteins comprise mix of amino acids (AAs) as building blocks. According to Nunes et al. (2014), nutritional and economic gains from a protein are dynamics of protein digestibility and AA composition. Moreover, Peres and Oliva-Teles (2008), suggest AA profile of whole body of fish to be largely interrelated to their essential amino acid (EAA) needs.EAA include arginine (arg), methionine (met), leucine (leu), lysine (lys), histidine (his), isoleucine (ile), threonine (thr), phenylalanine (phe), tryptophan (tryp) and valine (val). EAAs are nutritionally essential and obtainedfrom extraneous dietary source. Table 1 lists indispensable EAA requirements of juvenile stages of *Labeo rohita, Ictalurus punctatus, Catla catla, C. carpio, Oncorhynchus niloticus, Anguilla japonica, O. tshawytscha, Salmo salar and O. mykiss* (FAO, 2013; Kaushik, 1995; NRC, 1993). In an "ideal protein", ratio between EAA to non-EAA (NEAA) remains constant despite variations in each AA requirement across life stages of fish (Bicudo and Cyrino, 2014; Ogino, 1980). NEAA in fish nutrition includes alanine (ala), proline (pro), asparagine (asn), cystine (cys), aspartate (asp), glycine (gly), serine (ser), glutamine (gln), tyrosine (tyr) and glutamate (Li et al., 2011). NEAAs such as cys can be synthesized from met; tyrosine (tyr) synthesis occurs from phe. Thus, appropriate EAAs can supplement NEAA requirement (Wilson, 2003; Nunes et al., 2014). High amounts of NEAA present in animal origin proteins can reduce energy cost and EAA requirements for their de novo synthesis in animals, causing improved feed efficiencies (Li and Wu 2018, 2020).Dietary protein is a source of both EAA and NEAA Together EAA and NEAA comprise proteinogenic amino acids (PAAs). Since NEAA biosynthesis is energy driven, dietary proteins that suffice the requirements of fish for both EAA and NEAA will contribute to most efficient fish growth (NRC,1993; Li and Wu, 2020). Amino acids have fundamental role in fish functions involving protein synthesis, growth, metabolic processes, synthesis of neurotransmitters (val, leu, ile, phe, tyr, tryp, gln); ammonia detoxification (ornithine orn; gln, arg), lipid oxidation (arg), inhibition of protein degradation (val, leu, ile); immunostimulation, antioxidant (met, cys) and osmolytic properties (sarcosine, sar; taurine, tau) (Andersen et al., 2016; Ahmed and Khan, 2006; Waarde, 1988). High quality fishmeal (FM) has balanced amount of all EAAs predominantly lys (Miles and Chapman,2006); n3 omega polyunsaturated FAs chiefly, DHA as well as EPA; essential minerals andvitamins; with 85% of aquaculture species relying on fish meal (FM), from feed (Jeyasanta and Patterson, 2020). Fishmeal replacement owing to its scarcity and incremental feed cost (Naylor et al.,2009) has shifted focus to marine, plant-based sources of equivalent protein provisions. Although, many plant based feedstuffs and harshly processed ingredients of animal origin (used in

preparation of artificial diets for fish) are deficient in met and lys enlisted to be initial-limiting AA (Gatlin et al., 2007; NRC, 2011).

Table1 Indispensable amino acid, EAA requirements of fishes (as g $100g^{-1}$ diet = % of diet,dryweight basis).

Amino Acids	*L. rohita*	*C. catla*	*C. carpio*	*I. punctatus*	*S. salar*	*A. japonica*	*O. niloticus*	*O. mykiss*	*O. tshawytscha*
Arginine	2.30	1.9	1.6	1.0	2.0	1.7	1.18	2.0	2.4
Histidine	0.90	1.0	0.8	0.4	0.7	0.8	0.48	0.7	0.7
Isoleucine	1.20	0.9	0.9	0.6	0.8	1.5	0.87	0.8	0.9
Lysine	1.50	2.5	2.2	1.2	1.8	2.0	1.43	1.8	2.0
Leucine	2.27	1.5	1.3	0.8	1.4	2.0	0.95	1.4	1.6
Methionine	1.42	1.4	1.2	0.6	1.0	1.2	0.75	1.0	1.6
Phenylalanine	1.48	1.5	2.5	1.2	1.2	2.2	1.05	1.2	2.1
Threonine	1.71	2.0	1.5	0.5	0.8	1.5	1.05	0.8	0.9
Tryptophan	0.45	0.4	0.3	0.12	0.2	0.4	0.28	0.2	0.2
Valine	1.50	1.4	1.4	0.71	1.3	1.5	0.78	1.3	1.3

2. Lipid and fatty acid requirement

Lipids help accomplish essential fatty acid (EFA) and energy needsof fish to perform physiological functions.Lipidshave significant role in determiningfish health, reproductive success, immune state and survival (Arts and Kohler, 2009). Fatty acids (FAs) are components of lipids as organic acids with a carbon chain containing terminal carboxyl group. According to the presence, inclusion of total double bonds, FAs are classified assaturated, monounsaturated (SFAs, MUFAs) and polyunsaturated (PUFAs) (Chen and Liu, 2020); depending on chain length of C1-C6 carbons as short chain (SC), C7-12 medium chain (MC), more than C14 as long or highly chained (LC or HC) FAs (Schönfeld and Wojtczak, 2016; NRC,1989).Among types of PUFA, n3,n6,n9 are found in all animals, including fish. Fishes have regulated ability to synthesize *de novo* only n9 PUFAs Thusboth n3, n6 PUFA are essential FAs (EFAs) and need to be obtained from diet sources to fish. EFA needs of fish vary across species. Marine fish require n3LC-PUFAdocosahexaenoic acid (DHA, 22:6) and eicosapentaenoic acid (EPA, 20:5); rainbow trout requires n3FAs such as alpha-linolenic acid (ALA, 18:3 n3) and n3HC-PUFA; carp nutrition needs are for both n3, n6 FAs and tilapia requires n6 linoleic acid (LA,18:2 n6) (Takeuchi et al., 1991; Hasan, 2001; Opstvedt, 1985). Incorporation of lipids in dietary formulations can expand sparing effect on dietary protein (Hasan, 2001; Watanabe, 1982).

Plant-derived oils used in aquafeeds (such as sunflower, linseed, soybean) are rich sources of n6-series of SC-PUFA, and MC-PUFAs (LA C18:2, n6). n3 LC-PUFAs (= heavy chain PUFA, HC-PUFA) of larger interest DHA 22:6 and EPA 20:5 are opulently found in marine origin oils (such as fish oils, algal oils) and animal fats (Gonzalez-Silvera et al., 2016). n3PUFA, EPA and DHA

are important for growth, cardiovascular health, anti-inflammatory response, neural and brain development. PUFAs have biological role in plasma membranes composition and fluidity, gene transcription regulation, cell signal modulation (Czumaj and Sledzinski, 2020; Arts and Kohler, 2009). Table 2 lists EFA deficiency symptoms reported in fishes. All fishes require EFA at 1-2% of diet, as per dry weight (Hasan, 2001). Recommended intake of EPA and DHA for humans lies between 200-500 mg per day (Strobel,2012) with need of dietary n3:n6 ratio above or at least equal to 1:1 (Simopoulos,1991). Dietary percentage of lipids required by fish is dependent on lipid type as well as digestible energy to protein ratio, DE:P in diet (NRC,1993).

Table 2 EFA deficiency symptoms reported in fishes.Source: Tacon (1992); Takeuchi et al. (1990, 1991)

Fish	Deficiency symptom
C. carpio	High mortality, fatty liver
Ctenopharyngodon idella	Lordosis, decreased growth and feed efficiency,shock syndrome
O. mykiss	shock syndrome, liver degeneration, high mortality
O. niloticus	Swollen pale liver
Lates calcarifer	Effects growth, feed efficiency, fin reddening
Scophthalmus maximus	High mortality, decreased growth, gill epithelium degeneration

3. Carbohydrate Requirements

Fish do not have any preciserequirement for dietary carbohydrates(NRC, 2011). Yet,being least expense source of energy, digestible forms of carbohydrates are frequently appended in commercial diets to essentially counter retaindietary lipids and proteins (=sparing effect) (Gatlin, 2010). Soluble forms of carbohydrates, specifically starch also help in pellet binding and stability improving dietary properties (Hardy and Barrows, 2002; Kamalam et al., 2017). Proficiency to utilize dietary carbohydrate depends on composition of feed, processing technique and fish physiology,varying substantiallyamong finfish species.Commercial feeds for carnivorous species allow 20% carbohydrate inclusion, lesser compared to herbivore and omnivore requirements 25-45%. This is due to limited capability of carnivorous fishes to efficiently utilize dietary carbohydrates as energy source.

4. Energy Requirements

Energy itself is a non-nutrient and is obtained from metabolization of dietary nutrient sources of fats, proteins and carbohydrates (NRC,1993). Gross energy (GE) value of feed, is the heat generated on complete ignition of feed compounds. GE is a measure of absolute energy offered from organic dietary constituents to the organism. Estimation ofGE helpevaluate other feed energyvalues,namely metabolizable (ME) and digestible energy (DE) (Weiss and Tebbe, 2018). Total intake energy (IE) from diet of fish is relatable to GE content of feeds. In a compounded diet GE is contribution of its constituents each with their mean energy contribution; protein comprising 23.6 kJg^{-1} diet, lipids 39.5,and carbohydrates 17.2 kJ g^{-1} (NRC, 2011). It is measured by burning compounded feed under controlled oxygen pressure in a thick metal walled container known as ‘bomb’ through which the technique finds name as bomb calorimetry (NRC, 2011). It

is important to evaluate energy estimates of diet available for utilization by fish.Formulation of feed based on knowledge of energy utilizations of fish at various stages of life history would be cost effective approach preventing over addition of nutrients (NRC,1993). GE of feed ingredients is fundamental to precise feed formulation for fish performance and sustainable environment effects (Sayed et al., 2018). Retention of energy by fish for growth and other physiological functions (ME) is partly dependable on available energy from feed (GE), along with type, life history stage and culture conditions of fish. Feed formulations ideal for one species may not be optimal for other species and is also a function of culture conditions for fish development (Sales, 2009). Optimization of digestible protein (DP) and DE content (DE = GE of feed subtracting GE lost to faeces) of fish diet is the foremost consideration in feedformulation (Zuidhof, 2019; White, 2013; Happel,2020). For cultured fish species, these ratios range between 81 -117 mg DPkcal^{-1}DE (NRC, 2011). DE requirements for fry to fingerling stage of fishes such as carp, rohu, mrigal, silver and grass carp scopes between 3500 to 4500 Kcalkg^{-1} of diet at level of 37%- 47% protein, 30% carbohydrate, and 7% lipid in diet (FAO, 2017; Giri, 2017). Energy values are important considerations in choice of dietary ingredients for optimizingcost effective feed formulations.

5. Processing of fish feeds: Extrusion and Pelletization

Processing of feeds can improve organoleptic properties, improve digestibility, reduce negative impacts of non-nutrients, pathogensthus yielding sustainable, good quality aquaculture diets. Extrusion is a sought after technique for aquafeed processing with merits of feed nutritional quality improvement. During extrusion process feed is mixed, sheared and heated under high temperature, high pressure with extrudate leaving the die of proper dimension. Extruder parameters temperature, shear, screw type, pressure, size of die; and diet composition have great influence of physical and nutritional quality of extruded feed (Sorensen et al., 2005). Extruded diets provide enhanced feed digestibility owing to diminution of anti-nutritional factors (tannins, phytates, phenols) and pathogenic interferences from diet. Hot-extrusion is performed at temperatures above 100°C forming floating diets for surface feeders such as, *O. niloticus*; cold extrusion identifies at ambient temperatures producing sinking pellets for bottom dwelling finfish including *Clarius gariepinus* (Choton et al., 2020). Were et al. (2021), demonstrated benefits of hot extrusion processing of feeds in reducing microbial interferences in insect and larval meal replacement of FM diet for Nile tilapia and African catfish.Extrusion cooking affects nutritional quality of diet at various degrees. In its beneficial aspect, in addition to destruction of antinutrient factors, extrusion diets contain gelatinized starch, improved soluble dietary fiber; increasing its digestibility to fish and feed physical properties in water (Welker et al., 2018; Glencross et al., 2011). On the contrary, depending on extrusion conditions heat susceptible vitamins can be lost, with protein-sugar reactions at high extrusion temperatures deteriorating feed nutrient profiles (Singh et al., 2007). Even coated forms of ascorbate are largely lost at high rates to extrusion. Most susceptible vitamins to extrusion are thiamine (due to high shear rates of extrusion), vit. A, C and folate. Yang et al. (2020), evaluated impact of extrusion temperatures and encapsulation procedure on vitamin stability to conclude high stability of micro-encapsulated vitamin compared to un-encapsulated forms in feed. Storage loss of vit A is reported due to oxidative influences (Harper,1988). Since many parameters need to be optimized for extrusion processing of feeds, the technique require precise controlled operating conditions to restore maximal nutrient benefits from feeds. Extruded feed are more resilient to dissociation in water and produces low density floatable diets (Khater et al., 2014), that allow aqua culturist to

account amount of feed consumption by fish. Extrusion can produce durable and stable aquafeeds abating problems of aquatic pollution in farming environment (Liu et al., 2021).

Pelleting aggregates ingredients into large homogenized particles under effect of heat, pressure and moisture (Lovell,1980). Riaz et al. (2009) evaluated vitamin stability due to extrusion, and pelleting procedures at three months storage, reporting extrusion loss of thiamine (88%) compared to pelleting loss ranging between 60-96%. Pelleted diets in comparison to extruded diets are dense with low floatability.Pelletization process require steam water addition to diet mixture and have high moisture content that must be reduced for their use as fish diets.Pelleted diets are less costly than extruded feeds thus provides cost effective feeds.

CONCLUSIONS

Fed aquaculture has contributed to significant growth in fisheries productions besides fulfilling basic nutritional requirements forhumans. Nutrition and feeding are primary themes in sustainable aquaculture paradigm.Adequatelyformulated nutrient rich feeds can safeguard significant amount of the total production costs of fed-aquaculture. Since,feeds have essential role in aquafarming development appropriate knowledge followed by astute evaluation of nutritional quality of feed and feedstuffs is important for sustaining aquaculture welfare and health.

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NOTABLE NOVEMBER- GEOGRAPHICAL BEHAVIOUR OF 2015 AND 2021 FLOODING IN TAMIL NADU (INDIA)

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ABSTRACT

The unprecedented monsoonal rainfall of 2021 and subsequent flooding in Tamil Nadu has initiated a reminiscence of a similar abnormal event of 2015. The month of November observed the maximum input of rainfall during both years. The unprecedented rainfall and flooding have sparked debates ranging from climate change to urbanization. The current study is a spatial examination of rainfall in the state for November of 2015 and 2021. It also tends to observe this rainfall behavior in the backdrop of existing and altering land uses. It has been observed that this unprecedented rainfall exhibited a correlation with urbanization with a geographical concentration of the phenomena in the coastal, northeastern part of the statein both years. Such a regional level analysis can help identify vulnerability in the light of climate change and extreme event concerns.

KEYWORDS: *Tamil Nadu, Monsoon, Rainfall, Land Use, CHIRPS, Urban.*

INTRODUCTION

The Indian rainfall season is majorly the monsoon season and is a major rainfall system in itself (Krishnamurti, 2015). It can be further divided into the South West Monsoon (SWM) from June to September (Centre, 2021) and North East Monsoon (NEM) from October to December (Centre, 2021). India receives maximum (Krishnamurti, 2015), around an average of 75% of its rainfall during the southwest monsoon season which ranges from June to September (Desk, 2021b.). During this period, the central and western parts of the country receive more than 90% of their annual rainfall (Halpert & Bell, 1996). The NEM is the main cyclone season for the North Indian Ocean basin and the primary rainfall season for the Tamil Nadu subdivision (Centre, 2021). India's southwestern tip intercepts the first monsoonal rains in May (Centre, 2021). NEM is mainly confined to the meteorological sub-divisions of Tamil Nadu, Puducherry, and Karaikal (TN); Coastal Andhra Pradesh and Yanam, Rayalseema, Kerala and Mahe, and South Interior Karnataka during October and December on the windward side (Centre, 2021). Tamil Nadu state is located on the leeward side of the Western Ghats (Centre, 2021).

The current study focusses on the exceptionally high rainfall and flooding experienced by the state of Tamil Nadu in the years of 2015 (DHNS, 2015; NDMA; Desk, 2017) and recent, 2021 (Kuchi, 2021; Nath, 2021); and for both the years the month of November has been exceptionally notable, recording this excessive rainfall (PTI, 2015 a.; Lakshmi, 2015; NDMA;

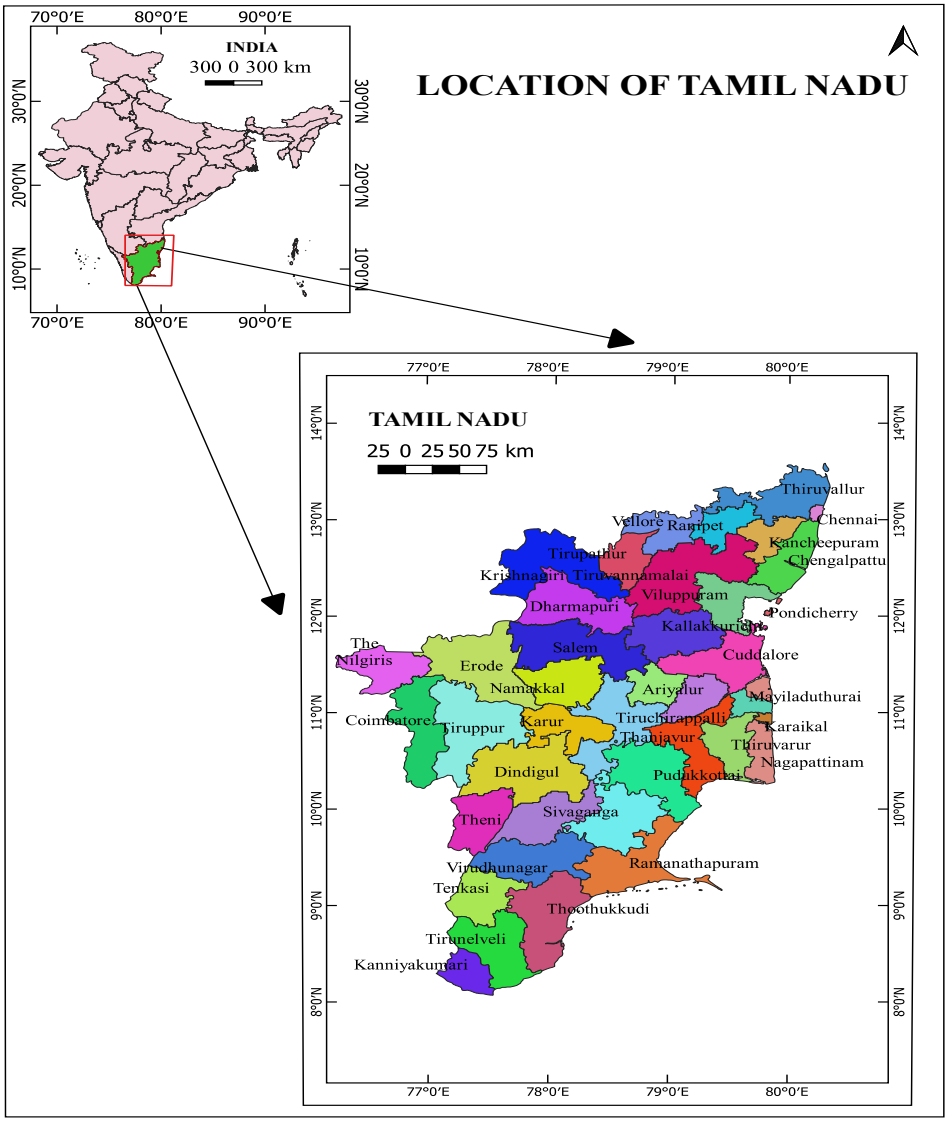
Desk, 2021a. ; Nath, 2021). In both the years, there was a loss of life and property as well (NDMA, n.d.; PTI, 2018; Krishna, 2021; Koushik and Sriram, 2021; Nath, 2021) causing massive large scale destruction (Bureau, 2015; Janardhaan, 2015; Janardhan, 2016; PTI, 2015 b.; Sathyanarayana, 2015; Vishu & Sridharan, 2016). The Chennai flash floods were ranked amongst the topmost disasters of the year for Asia with one-day rainfall nearing a month's average (Express, 2015).

In 2021, NEM was very excessive with 68% more rain than normally received from 1st October to 11th December (Team, 2021). The intensification of low-pressure systems during NEM was attributed to this immense rainfall (Centre, 2021; Desk, 2021b.; Network, 2021; Now, 2021). The reasons for the devastating impact of this rainfall have been attributed to numerous human activities in the state (Cann,2021; Davies, 2021; Gautham, 2021; Pielke, et al., 2007; Sahu, 2021). Chennai recorded the wettest November with incessant rains paralyzing the city (Chandrababu, 2021).

While statistical analysis is available in detail (Centre, 2021), an analysis that involves observing this data spatially stands significant. The current study first examines the land use and observes land-use changes in the State of Tamil Nadu in 2015 and 2020 through remote sensing data. It then diversifies further to examine how and where the daily rates of rainfall have varied daily and weekly through remote sensing data for the notable months of November of 2015 and 2021 for the State to draw a geographical patterning of this rainfall.Further, its correlation with land use is also examined. South Indian states of Tamil Nadu, Kerala, Telangana all have observed increased rates of precipitation owing to altering land use, more urbanization, and specific climatological factors that have played an important role in causing these changes in rainfall intensity (Boyaj, *et al*., 2020). As of 2021, the State has 38 districts (Government, 2021).

Study Area- The state of Tamil Nadu covers an area of 130,058 sq. km. One of the southernmost two states of India, Tamil Nadu faces the Bay of Bengal to the east, the Western Ghats and the state of Kerala in the west, Nellore and Chittoor districts of Andhra Pradesh, in north and Kolar, Bangalore and Mysore districts of Karnataka on its northwest; and the Indian Ocean in its south (Pune, 2020). The average height of Western Ghats is 1200 m and that of Eastern Ghats is 600m; these two ranges meet further southward in the state and rise remarkably in the form of Nilgiri hills (Pune, 2020). The Eastern Ghats also have peaks that are lower in height in the outlying hills. The major rivers are—the Kaveri, the Ponnaiyar, the Palar, the Vaigai, and the Tambraparni flowing eastward. The enclaves of Puducherry and Karaikal are located on the north-central coast of the State and are a part of the Puducherry Union territory(Aiyappan, 2021). The maximum range of temperature during the hottest months can be between 20 degrees Celsius to about 38 degrees Celsius while during the coolest months it can range from 21 degrees to 30 degrees Celsius (Aiyappan, 2021). The capital of Tamil Nadu in Chennai is located on the north-easternmost side of the State (Aiyappan, 2021). The State is largely agricultural with an industrial core in Chennai (Aiyappan, 2021).

Fig.1. India- Location and Administrative Divisions of Tamil Nadu State (2021)



Source-Author, 2021

Methods- The following methodology was attempted:

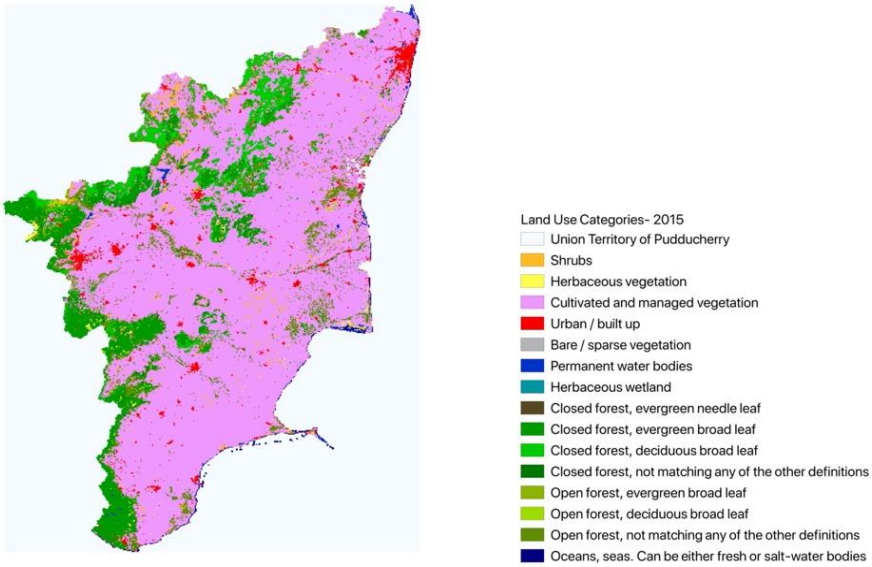
For land use information for the years 2015 and 2020 has been derived from satellite imageries. Google Earth Engine has been accessed for it. The map for 2015 has been extracted from a database- Copernicus Global Land Cover Layers: CGLS-LC100 Collection 3. It is described as a World Cover product comes whch shows 11 land cover classes which have been generated within the framework of the European Space Agency (ESA) World Cover project. It is a part of the 5th Earth Observation Envelope Programme (EOEP-5) of ESA(Engine, n.d.). For the spatial analysis of rainfall for the selected month of November for 2015 and 2021, the data source is CHIRPS Daily: Climate Hazards Group InfraRed Precipitation With Station Data (Version

2.0 Final). The Climate Hazards Group InfraRed Precipitation with Station Largely, satellite data, useful for weather and climate analysis gridded in nature (Gandhi, 2020). These are, further, examined to observe the spatial variation and regions where this variation is taking place and to observe its relationship with land use if any. The methodology of examination followed here is that of 'Visual Interpretation Method' of Change Detection'. To further observe the differentiation in rainfall trend for November, Sen's slope analysis has also been spatially depicted for the period from all November months from 2015 to 2021. All processing of extracted satellite data has been done in QGIS 3.16. software.

Results - Following observations were recorded:

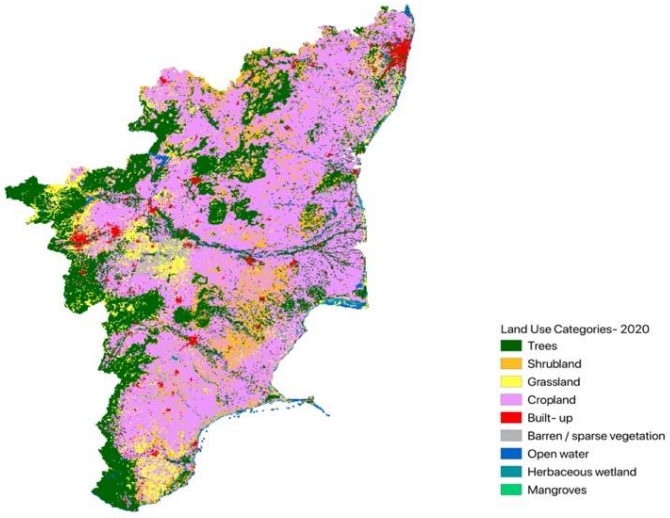
Observations on Land Use – As mentioned earlier, the land use of the state is predominantly agricultural and this can be observed for both the years of examination. The urban built-up area predominated in the northeast as the Chennai Metropolitan region with the capital city of Chennai. Other centers of the urban built-up area were also observed across the state. The southwestern part is composed of forested land in a narrow zone and some patches in the north-central part. In 2020 as well, no significant change can be observed in the agricultural zone, while the shrub and grassland have exhibited a marked increase for the state. Open water has also shown an increased proportion in 2020 as can be observed from Fig.3. A slight increase in a forested area is also observed. A major increase is reported in herbaceous vegetation in 2020 as compared to 2015 as per Fig.2. and 3. An increase in grassland can be attributed to a decline in agricultural land in that portion of the state.

Fig.2. Tamil Nadu- Land Use- 2015



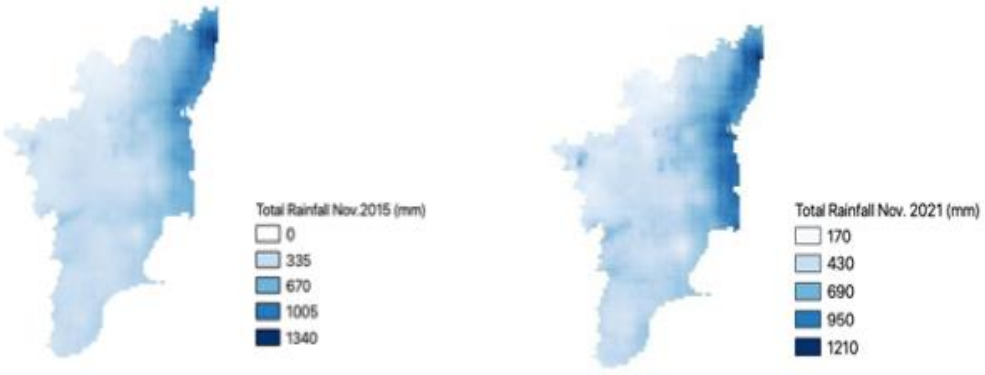
Source- Author, 2021; derived from Copernicus Global Land Cover Layers: CGLS-LC100 Collection 3, Google Earth Engine Code Editor

Fig. 3. Tamil Nadu- Land Use- 2020



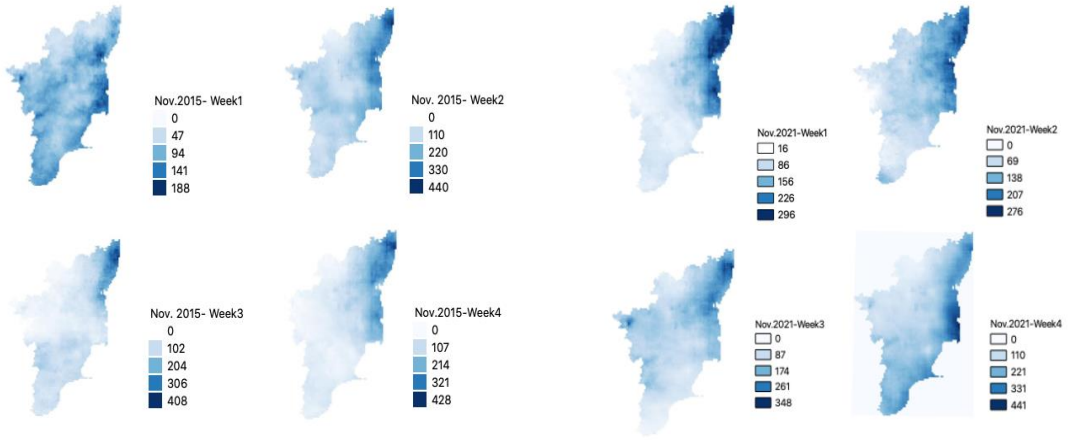
Source- Author, 2021; derived from ESA World Cover 10m v100, Google Earth Engine Code Editor

Fig. 4. Tamil Nadu An Overview of Total Rainfall for November- 2015 and 2021



Source- Author, 2021; derived from CHIRPS Daily Rainfall Data, Google Earth Engine Code Editor.

Fig.5. Tamil Nadu- Rainfall for November- 2015 and 2021



***All data is in mm**

Source- Author, 2021; derived from CHIRPS Daily Rainfall Data, Google Earth Engine Code Editor

Analysis of Rainfall-This examination has been attempted in two parts to observe the geographical distribution of rainfall in the state in the two notable episodes of 2015 and 2021.

As can be observed very clearly, maximum rainfall in both years was concentrated in the northeastern part of the state, with the urban conurbation of the Chennai Metropolitan area as the core of this high rainfall. Further, in the west, around Coimbatore, another center of high rainfall can be observed. Extending this analysis to the weekly trends of rainfall in November of 2015 and 2021, observed in Fig. 5, indicates a pattern too.

DISCUSSIONS

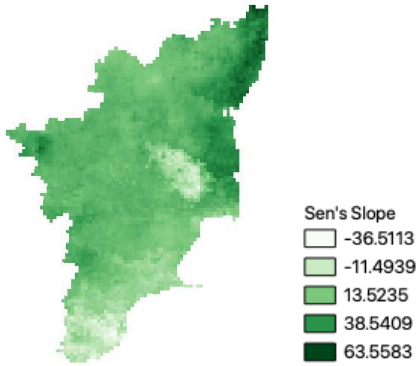
A weekly analysis as a detailed one for November has been attempted through remote sensing for both the years and it brings out a direct correlation of intense rainfall episodes with urbanization in particular. In both 2015 and 2021, it can be observed that the Chennai Metropolitan region experienced the highest concentration of rainfall along with the Coimbatore city region in the west in all weeks of November. On the whole, rainfall decreased towards the interiors, also indicating the possible meteorological factors and topography. Thus, it is convenient to mention that urbanization has a significant role to play in the disastrous rainfall episodes of 2015 and 2021 November and human activities around this region need to be monitored. The district of Kanyakumari also depicts heavy rainfall during these periods, probably due to its location in the extreme south.

In 2015, three synoptic low-pressure systems were formed over the Bay of Bengal in November which caused floods in Tamil Nadu (NDMA, n.d.). In 2021, low-pressure systems and cyclonic circulations were responsible for this flooding (Centre, 2021). As of 2021, the trend of rainfall recorded for November, by the Meteorological Centre at Chennai also indicate similarity of observations. For week 1, the Chennai station recorded the maximum departure from normal at 212% (Centre, 2021). For week 2 of November, Kanyakumari emerged as the district with the

maximum deviation from normal rainfall at a departure of 560% (Centre, 2021). In terms of land use, this is largely a forested district (Centre, 2021). For week 3 of November 2021, large excesses of rainfall were observed in the state and the district of Tirupathur showed a maximum deviation of 1349% (Regional Meteorological Centre, 2021). The last week of November was highly significant in records as large excesses were recorded across the state for all districts (Centre, 2021) and Madurai district in the eastern part of the state recording the maximum departure of 699% (Centre, 2021).

The analysis has been extended further to observe the spatial trend through the Man-Kendall and Sen Slope trends. Mann-Kendall's test is a non-parametric test used frequently in meteorological and hydrological examinations. In the current study, the parameters have been extracted for spatial analysis from Climate Engine at 1.0 value showing all trends (Roy & Chakravarty, 2021). Sen's slope is observed as the median of all slopes (Gocic & Trajkovic, 2013).

Fig. 6. Sen's Slope and Mann- Kendall p-Value for rainfall of November months from 2015-2021



Source- Author, 2021; derived from Climate Engine

CONCLUSIONS

It can be observed that negative values, which indicate a declining trend of rainfall, are concentrated geographically in the central and southernmost part of the state while an increasing trend of rainfall in November is largely observed from 2015-to 2021. Further, the two clusters where the concentration of excessive rainfall was observed in 2015 and 2021 November are the urban centers which can help lead to the conclusion that urban areas indicate an increasing spatial concentration of rainfall. It can be forwarded that while maximum amounts of rainfall are observed in the northeastern parts of the state, the recent trend of 2021 also indicates that in terms of departure from normal, there is no specific land use that is contributing to it. Land use, therefore, does indicate a certain correlation with changing and evolving trends of rainfall in the state.

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