



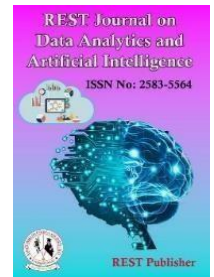
REST Journal on Data Analytics and Artificial Intelligence

Vol: 4(3), September 2025

REST Publisher; ISSN: 2583-5564

Website: <http://restpublisher.com/journals/jdaai/>

DOI: <https://doi.org/10.46632/jdaai/4/3/4>



Machine Learning Approaches for Predicting Early-Stage Alzheimer's Disease

*Priyanka K. P, R. Devi

Vel's Institute of Science, Technology & Advanced Studies, Chennai, Tamil Nadu, India.

*Corresponding Author Email: priyankap57@gmail.com

Abstract: The primary cause of dementia in older adults is Alzheimer's disease (AD). Nowadays, there is a lot of focus on using machine learning to detect metabolic diseases that impact many people globally, such as diabetes and Alzheimer's. Every year, the occurrence rates rise at an astonishing amount. There are neurodegenerative fluctuations in the brain associated with Alzheimer's disease. A growing number of people, their families, and the healthcare system will be affected by diseases that hamper memory and functioning as our aging population grows. On the social, financial, and economic fronts, these consequences will be significant. Alzheimer's disease is unpredictable when it is first developing. Early AD treatment is more beneficial and results in less minor damage than a later treatment. This study aims to contribute to the field by exploring machine learning models for the early-stage prediction of Alzheimer's Disease, providing a more efficient and accurate approach to diagnosis.

Keywords: Alzheimer's disease (AD), Machine learning, Healthcare, Prediction.

1. INTRODUCTION

A degenerative neurological disorder, Alzheimer's disease (AD) is typified by short-term memory loss, mental disorders, and delusions that are frequently confused with the symptoms of aging or stress. Currently, there are about 6.7 million people with Alzheimer's disease; if nothing changes in the medical profession, this figure could rise to 13.8 million. A degenerative neurological disorder, Alzheimer's disease (AD) is typified by short-term memory loss, mental disorders, and delusions that are frequently confused with the symptoms of aging or stress. Currently, there are about 6.7 million people with Alzheimer's disease; if nothing changes in the medical profession, this figure could rise to 13.8 million by 2060.[1]. So AD poses a significant public health challenge. Unfortunately, there is no definitive medical treatment for AD, making continuous medication crucial for its management. Given its chronic nature, lasting for years or a lifetime, timely prescription of medication is essential to prevent extensive brain damage. The diagnostic process of early AD detection is difficult and expensive, requiring extensive data collection and sophisticated predictive tools, often involving experienced medical professionals. Automated systems, known for their accuracy and freedom from human errors, are emerging as valuable assets in medical decision support. The use of many data sources, such as images (MRI scans), biomarkers (chemicals, blood flow), and numerical data taken from MRI scans, to identify the existence of dementia has been investigated in earlier AD research.

Early-stage Alzheimer's patients can frequently function independently, they may experience subtle difficulties, such as memory loss like not remembering familiar words and places and challenges in social settings or the workplace. Identifying these challenges through detailed medical interviews is crucial for early intervention. As the disease progresses, symptoms become more persistent, impacting communication, adaptability to the environment, and eventually, mobility. In order to improve diagnosis efficiency and accuracy, this study looks into machine learning models for early-stage Alzheimer's disease prediction.

Causes and Risk Factors of Alzheimer's Disease

Alzheimer's disease is thought to be caused by the abnormal build-up of proteins in and around brain cells. One of the proteins involved is called **amyloid**, deposits of which form **plaques** around brain cells. Plaques disrupt communication between brain cells. The other protein is, called **tau** deposits of which form **tangles** within brain cells. The tangles disrupt the transport system and cause damage to cells. Alzheimer's disease causes the brain to shrink and brain cells to eventually die. Alzheimer's disease is the most common cause of dementia — a gradual decline in memory, thinking, behavior and social skills. These changes affect a person's ability to function.

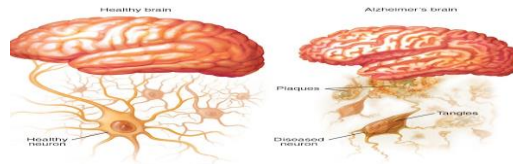


FIGURE1. Healthy brain and Brain with Alzheimer

It's unclear what exactly causes Alzheimer's disease. However, brain proteins malfunction on a fundamental level. This interferes with the function of neurons, which are brain cells, and sets off a chain of events. The neurons sustain harm and stop communicating with one another. They pass away eventually.[2]

2. MOTIVATION OF THE WORK

In the current scenario, there is often a misalignment between human instinct and standard measurements, presenting a challenge in addressing various issues effectively. To overcome this disparity, there is a compelling need to explore innovative approaches, particularly those that are computationally intensive and non-traditional. Machine learning, with its sophisticated techniques, emerges as a pivotal solution to bridge this gap. To enhancing the quality of life for patients, machine learning model shift positively influences medical practitioners in their treatment decision-making processes and supports health economists in conducting more nuanced analyses.

Traditional methods of reviewing medical reports, such as those by radiologists, may inadvertently overlook certain disease conditions, focusing on only a limited set of causes and conditions. The objective of this work is to address this limitation by leveraging machine learning frameworks and electronic health record (EHR) derived data. By doing so, we aim to not only identify existing knowledge gaps but also uncover potential opportunities for enhancing disease prediction and medical decision support systems.

3. RELATED WORK

Alzheimer's disease (AD) is a progressive neurological condition with a significant impact on individuals and society. The use of machine learning (ML) and deep learning (DL) techniques for predicting and diagnosing AD has gained traction in recent research. This review highlights key studies that employ various methodologies and datasets to advance our understanding of AD prediction.

Fuse et al. [2] research study offers an approach for identifying Alzheimer's disease (AD) through MRI image shape analysis. The authors offer a method for identifying the structural alterations in the brain that are indicative of AD by using shape analysis. The Alzheimer's disease Neuroimaging Initiative (ADNI) dataset is used in the study, and machine learning algorithms are applied to classify patients according to MRI data.

The study conducted by Palacios-Navarro et al.[3] aims to identify cognitive decline in individuals with Alzheimer's disease by analyzing how they perform Activities of Daily Living (ADLs). Activity-quantification sensors were used to record a variety of routine functions, such as social interactions and movement. Patient autonomy and data privacy were two ethical issues that supported the methodical approach to identifying mental decline in Alzheimer's patients.

Firouzeh Razavi et al. [4] present a creative approach to Alzheimer's disease diagnosis based on unsupervised learning methods.. An uncontrolled two-layer neural network was used to directly learn features from raw data In this work, training was carried out, followed by an assessment procedure that produced a 91% accuracy rate.

The use of machine learning techniques to predict Alzheimer's disease (AD) from textual data, such as patient records and clinical notes, is investigated by R.Sivakani et al.[5]. The study highlights how text data analysis can improve patient care and AD prediction by providing insights into the disease's progression and early detection.

Most people with Alzheimer's disease (AD) are 65 years of age or older. The hippocampus region of interest (ROI) has been the subject of much research on neurological conditions, the course of stress, and memory function. Furthermore, a link has been shown between the beginning of Alzheimer's disease and a reduction in hippocampus volume. S. Kim, S. Noh et al.[6] presents a novel method of diagnosing AD using structural magnetic resonance imaging (MRI) data that incorporates slice-wise volumetric features from the left [6].

An automated method for utilizing structural MRI (sMRI) data to diagnose Alzheimer's disease (AD) was presented by A. Basher, B. Kim, K. Lee et al.[7]. The strategy put forth by the authors uses deep neural networks (DNN) and convolutional neural networks (CNN) to extract volumetric features from the left and right hippocampi, two important brain regions linked to AD.

Using modern deep learning techniques, Logan et al.[8] present a novel method for classifying Alzheimer's disorders classification using 3D CNN architectures for multi-modal PET/MRI data and examine viable interdisciplinary approaches for early detection. Using data from brain imaging studies in particular, the authors combine Deep Convolutional Neural Networks (CNNs) with Ensemble Learning and Generative Adversarial Networks (GANs) to increase the accuracy of image-based classification.

For AD classification, Xusheng Fang et al.[9] presented a novel framework that combines three cutting-edge deep convolutional neural networks (DCNNs) with multi-modality images..When using the MRI and PET modalities for AD classification, the Adaboost algorithm's effectiveness has a 99.27 classification accuracy.

AD data analysis was studied by Martinez-Murcia et al. [10] using deep convolutional auto encoders. Using a data-driven decomposition of MRI images, they are able to extract MRI features that represent both the underlying neurodegenerative process and an individual's cognitive symptoms. Next, a variety of feature combinations are used to analyze the distribution of the extracted features through regression and classification analysis, and the effects of each coordinate of the auto encoder manifold on the brain are calculated

A deep learning strategy is proposed by Hadeer A. Helaly et al.[11] for the early diagnosis of Alzheimer's disease and The AD spectrum has four multi classified stages.. To identify AD and categorize the medical images, two techniques are employed. According to experimental results, the first method uses simple CNN architectures based on 2D and 3D convolution. The second approach makes use of diagnosing AD that separates longitudinal brain MRI data into two categories—demented and non-demented—using supervised learning.

pre-trained models, like the VGG19 model, for medical image classifications by applying the principle of transfer learning.

Venugopalan J et al.[12] also shows how combining several modalities with deep learning models can help identify Alzheimer's disease stages early.. In this model, classify patients into AD, MCI, and controls (CN), this study uses deep learning (DL) to analyze imaging (MRI), genetics (SNPs), and clinical test data in an integrated manner.

Khan et al.[13] examine recent developments in deep learning (DL) and machine learning (ML) techniques for diagnosing brain diseases, with an emphasis on Parkinson's, Alzheimer's, and brain tumors. Using a variety of machine learning (ML) and deep learning (DL) algorithms and the study examines twenty-two

widely used datasets. Saratxaga et al.[14] analysis of brain MRI scans, the study investigates the efficacy of convolutional neural networks (CNNs) and other deep learning techniques in the early detection of Alzheimer's disease.

A binary classifier based on deep neural networks and intended for the classification of Alzheimer's disease (AD) is presented by Prajapati et al.[15]. The authors concentrate on developing a powerful model (DNN) that uses brain imaging data to discriminate between Alzheimer's patients and cognitively normal (CN) people.

The study by Sudharsan and Thailambal [16] shows improvements in classification accuracy when Principal Component Analysis (PCA) is combined with machine learning models, particularly in differentiating between AD, Mild Cognitive Impairment (MCI), and healthy control participants..

Uddin, K.M.M., Alam, M.J., Jannat-E-Anawar *et al.* [17] research focuses on employing machine learning models to predict Alzheimer's disease (AD) using the OASIS dataset. The study applied several machine learning classifiers among these, the Voting Classifier achieved the highest average classification accuracy of 96%.

In 2022 Lama, R.K; Kim et al.[19] aims to distinguish between healthy controls and Alzheimer's disease (AD) and mild cognitive impairment (MCI) by analyzing changes in large-scale brain networks, particularly the Default Mode Network (DMN).

Khan.A et al. [22] suggest a broad paradigm for diagnosing AD that separates longitudinal brain MRI data into two categories—demented and non-demented—using supervised learning.. The suggested pipeline reports the whole AD monitoring and is completely automated.

C.Kavitha et al.[23] study focuses on predicting early-stage Alzheimer's Disease using machine learning models and utilizes the OASIS dataset for training and testing.

Nishant Chauhan et al.[24] proposed a novel method for an extreme learning machine . The training results in this paper demonstrate that non-linear FC features outperformed linear features in terms of classification accuracy.

Sudarsan et al.[25] suggest a deep learning-based model that uses MRI imaging data to predict the phases of Alzheimer's disease (AD). The model was created in Keras and includes dense layers for classification and Conv2D and MaxPooling2D layers for feature extraction. A high accuracy of 99.3% was attained by the binary classification and 95.96% by the multi-class classification. The model's potential to improve AD is highlighted in this study fostering advancements in the field

TABLE 1. Recent work related to Alzheimer's Disease

SI NO	Research Study	Year	Dataset	Models	Average classification accuracy
1	Fuse, H., Oishi, K., Maikusa, N., & Fukami, T.	2018	ADNI dataset	Machine learning models	87.5% accuracy achieved by using SVM
2	Razavi, F., Tarokh, M.J. & Alborzi, M.	2019	ADNI dataset	Machine learning models	91%
3	Logan R, Williams BG, Ferreira da Silva M, Indani A, Scholnicov N, Ganguly A, Miller SJ.	2019	ADNI dataset	Unsupervised Machine learning models	91%
4	R. Sivakani and G. A. Ansari,	2020	ADNI dataset	Machine learning models	Gaussian NB-95% SVM-89%
5	Martinez-Murcia FJ, Ortiz A, Gorriz JM, Ramirez J, Castillo-Barnes D.	2020	ADNI dataset.	Deep learning using convolutional autoencoders	80%
6	Xusheng Fang, Zhenbing Liu, Mingchang Xu et al	2020	ADNI dataset	Machine learning models	Adaboost-99.27%

7	Venugopalan J, Tong L, Hassanzadeh HR, Wang MD	2021	ADNI dataset	Multimodel deep learning models	90.3%
8	Helaly HA, Badawy M, Haikal AY.	2021	ADNI dataset	Convolutional neural networks.	97% for multiclass AD stages
9	Khan P, Kader MF, Islam SR, Rahman AB, Kamal MS, Toha MU, et al..	2021	Image modality	Machine learning & deep learning models	93% for multiclass AD stages
10	Saratxaga CL, Moya I, Picón A, Acosta M, Moreno-Fernandez-de-Leceta A, Garrote E, et al..	2021	OASIS dataset	Deep learning and image processing technique	35% of Alzheimer's risk factors can be modified.
11	Basher, Abol & Kim, Byeong & Lee, Kun Ho & Jung, Ho Yub.	2021	ADNI dataset	Machine learning models	92.85%
12	Basheer S, Bhatia S, Sakri SB.	2021	OASIS dataset	Deep neural networks	92%
13	Prajapati R, Khatri U, Kwon GR.	2021	ADNI dataset	Deep neural network binary classifier	85%
14	Manu Subramoniam, Aparna T.R. Anurenjan P.R., and Sreeni K.G.	2020	ADNI dataset	pre-trained VGG16 deep learning model	This model ,achieving sensitivity of 88.24% and a specificity of 72.73%.
15	Sudharsan M, Thailambal G.	2021	ADNI dataset	Machine learning models	75%.
16	Ramesh Kumar Lama, Ji-In Kim and Goo-Rak Kwon	2022	ADNI dataset	Machine learning models	98.38%
17	Kavitha C, Mani V, Srividhya SR Khalaf OI and Tavera Romero CA,	2022	OASIS dataset	Machine learning models	86.92%
18	Khan, A., & Zubair, S.	2022	OASIS dataset	Machine learning models	87.2%
19	Lama, Ramesh Kumar, Ji-In Kim, and Goo-Rak Kwon.	2022	ADNI dataset	Machine learning models	96.75%
20	Uddin, K.M.M., Alam, M.J., Jannat-E-Anawar et al	2023	OASIS dataset	Machine learning models	96%
21	Nishanth chuhan and Byung-Jae Cho	2023	ADNI dataset	Machine learning models	ELM-95%
22	Sudarsan, K., Abhishiek, B., Jeeva, D., & Nisha Devi, K.	2023	ADNI dataset OASIS dataset	Machine learning models	99.3%

4. CONCLUSION

Addressing the pressing issue of Alzheimer's disease, this study emphasizes the significance of risk reduction, early intervention, and accurate symptom diagnosis rather than a cure. Despite numerous endeavors in the literature to detect Alzheimer's using diverse machine learning algorithms and micro-simulation methods, the challenge persists in identifying pivotal attributes for early detection.

Although there have been notable advancements in the body of research on the prediction of Alzheimer's disease (AD) using machine learning (ML), together with deep learning (DL) models, a number of important research gaps still exist. One notable gap is the limited exploration of integrating multi-modal data sources. Combining genetic, imaging, biomarker, and neuropsychological data. Another area that requires attention is the scarcity of research employing longitudinal data analysis. Lastly, research should delve into early detection in atypical cases, assessing model performance in scenarios with comorbidities or unusual

presentations of AD. Addressing these research gaps will contribute to the refinement and broader applicability of ML and DL models for AD prediction. The research outcome underscores the need for future work, which will concentrate on extracting and analyzing new features that hold potential for aiding in the early detection of Alzheimer's disease.

REFERENCES

- [1]. 2023 Alzheimer's disease facts and figures. *Alzheimers Dement.* 2023 Apr;19(4):1598-1695. doi: 10.1002/alz.13016. Epub 2023 Mar 14. PMID: 36918389.
- [2]. Fuse, H., Oishi, K., Maikusa, N., & Fukami, T. "Detection of Alzheimer's Disease with Shape Analysis of MRI Images." *2018 Joint 10th International Conference on Soft Computing and Intelligent Systems (SCIS) and 19th International Symposium on Advanced Intelligent Systems (ISIS)*, Toyama, 2018, pp. 1031–1034. doi: 10.1109/SCIS-ISIS.2018.00171
- [3]. G. Palacios-Navarro, J. Buele, S. Gimeno Jarque, and A. Bronchal Garcia, "Cognitive Decline Detection for Alzheimer's Disease Patients Through an Activity of Daily Living (ADL)," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 30, pp. 2225–2232, 2022, doi: 10.1109/TNSRE.2022.3196435.
- [4]. Razavi, F., Tarokh, M.J. & Alborzi, M. An intelligent Alzheimer's disease diagnosis method using unsupervised feature learning. *J Big Data* 6, 32 (2019). <https://doi.org/10.1186/s40537-019-0190-7>.
- [5]. R. Sivakani and G. A. Ansari, "Machine Learning Framework for Implementing Alzheimer's Disease," *2020 International Conference on Communication and Signal Processing (ICCSP)*, Chennai, India, 2020, pp. 0588-0592, doi: 10.1109/ICCSP48568.2020.9182220.
- [6]. S. Al-Shoukry, T. H. Rassem and N. M. Makbol, "Alzheimer's Diseases Detection by Using Deep Learning Algorithms: A Mini-Review," in *IEEE Access*, vol. 8, pp. 77131-77141, 2020, doi: 10.1109/ACCESS.2020.2989396.
- [7]. S. Kim, S. Noh and H. S. Ryoo, "Identifying Combinatorial Significance for Classification of Alzheimer's Disease Proteomics Expression with Logical Analysis of Data," *2021 IEEE International Conference on Bioinformatics and Biomedicine (BIBM)*, Houston, TX, USA, 2021, pp. 1661-1663, doi:10.1109/BIBM52615.2021.9669835.
- [8]. Basher, Abol & Kim, Byeong & Lee, Kun Ho & Jung, Ho Yub. (2021). Volumetric Feature-Based Alzheimer's Disease Diagnosis From sMRI Data Using a Convolutional Neural Network and a Deep Neural Network. *IEEE Access*. PP. 1-1. 10.1109/ACCESS.2021.3059658.
- [9]. Logan R, Williams BG, Ferreira da Silva M, Indani A, Scholnicov N, Ganguly A, Miller SJ. Deep Convolutional Neural Networks With Ensemble Learning and Generative Adversarial Networks for Alzheimer's Disease Image Data Classification. *Front Aging Neurosci.* 2021 Aug 17;13:720226. doi: 10.3389/fnagi.2021.720226. PMID: 34483890; PMCID: PMC8416107
- [10]. Xusheng Fang, Zhenbing Liu, Mingchang Xu et al. "Ensemble of deep convolutional neural networks based multi-modality images for Alzheimer's disease diagnosis." *IET Image Process.* 14 (2020): 318-326. <https://doi.org/10.1049/iet-ipr.2019.0617>
- [11]. Martinez-Murcia FJ, Ortiz A, Gorriz JM, Ramirez J, Castillo-Barnes D. Studying the manifold structure of Alzheimer's disease: a deep learning approach using convolutional autoencoders. *IEEE J Biomed Health Inform.* (2020) 24:17–26. doi: [10.1109/JBHI.2019.2914970](https://doi.org/10.1109/JBHI.2019.2914970)
- [12]. Helaly HA, Badawy M, Haikal AY. Deep learning approach for early detection of Alzheimer's disease. *Cogn Computing.* (2021) 21:1–17. doi: [10.1007/s12559-021-09946-2](https://doi.org/10.1007/s12559-021-09946-2)
- [13]. Venugopalan J, Tong L, Hassanzadeh HR, Wang MD. Multimodal deep learning models for early detection of Alzheimer's disease stage. *Sci Rep.* 2021 Feb 5;11(1):3254. doi: 10.1038/s41598-020-74399-w. PMID: 33547343; PMCID: PMC7864942.
- [14]. Khan P, Kader MF, Islam SR, Rahman AB, Kamal MS, Toha MU, et al. Machine learning and deep learning approaches for brain disease diagnosis: principles and recent advances. *IEEE Access.* (2021) 9:37622– 55. doi: [10.1109/ACCESS.2021.3062484](https://doi.org/10.1109/ACCESS.2021.3062484)
- [15]. Saratzaga CL, Moya I, Picón A, Acosta M, Moreno-Fernandez-de-Leceta A, Garrote E, et al. MRIDeep learning-based solution for Alzheimer's Disease Prediction. *J.Pers. Med.* (2021) 11:902. doi: 10.3390/jpm11090902.
- [16]. Prajapati R, Khatri U, Kwon GR. "An efficient deep neural network binary classifier for alzheimer's disease classification," In: *International Conference on Artificial Intelligence in Information and Communication (ICAIIIC)*. (2021), p. 231–234.
- [17]. Sudharsan M, Thailambal G. *Alzheimer's disease prediction using machine learning techniques and principal component analysis (PCA)*, *Materials Today: Proceedings* (2021).
- [18]. Uddin, K.M.M., Alam, M.J., Jannat-E-Anawar et al. A Novel Approach Utilizing Machine Learning for the Early Diagnosis of Alzheimer's Disease. *Biomedical Materials & Devices* 1, 882–898 (2023). <https://doi.org/10.1007/s44174-023-00078-9>

- [19]. Robert Logan, Brian G. Williams¹, Maria Ferreira da Silva¹, Akash Indani¹, Nicolas Schcolnicov¹, Anjali Ganguly¹ and Sean J. Miller¹. "Deep Convolutional Neural Networks With Ensemble Learning and Generative Adversarial Networks for Alzheimer's Disease Image Data Classification." Volume 13 - 2021 | <https://doi.org/10.3389/fnagi.2021.720226>
- [20]. Lama, Ramesh Kumar, Ji-In Kim, and Goo-Rak Kwon. 2022. "Classification of Alzheimer's Disease Based on Core-Large Scale Brain N diagnosing AD that separates longitudinal brain MRI data into two categories—demented and non-demented—using supervised learning. diagnosing AD that separates longitudinal brain MRI data into two categories—demented and non-demented—using supervised learning. network Using Multilayer Extreme Learning Machine" *Mathematics* 10, no. 12: 1967. <https://doi.org/10.3390/math10121967>
- [21]. P. Singh and S. K. Mishra, "Alzheimer's Detection And Categorization using a Deep-Learning Approach," *2022 Third International Conference on Intelligent Computing Instrumentation and Control Technologies (ICICICT)*, Kannur, India, 2022, pp. 727-734, doi: 10.1109/ICICICT54557.2022.9917774.
- [22]. H. Saxena, D. Joshi, H. Singh and R. Anand, "Comparison of Classification Algorithms for Alzheimer's Disease Prediction," *2022 Seventh International Conference on Parallel, Distributed and Grid Computing (PDGC)*, Solan, Himachal Pradesh, India, 2022, pp. 687-692, doi: 10.1109/PDGC56933.2022.10053163.
- [23]. Khan, A., & Zubair, S. (2020). An Improved Multi-Modal based Machine Learning Approach for the Prognosis of Alzheimer's disease. *J. King Saud Univ. Comput. Inf. Sci.*, 34, 2688-2706. <https://doi.org/10.1016/j.jksuci.2020.04.004>
- [24]. Kavitha C, Mani V, Srividhya SR, Khalaf OI and Tavera Romero CA (2022) Early-Stage Alzheimer's Disease Prediction Using Machine Learning Models. *Front. Public Health* 10:853294. doi: 10.3389/fpubh.2022.853294
- [25]. Nishanth chuhan and Byung-Jae Choi, Open Access Article Classification of Alzheimer's Disease Using Maximal Information Coefficient-Based Functional Connectivity with an Extreme Learning Machine. doi: 10.3390/brainsci13071046
- [26]. Sudarsan, K., Abhishiek, B., Jeeva, D., & Nisha Devi, K. (2023). Early Stage of Alzheimer's Disease Prediction. *International Journal of Scientific Research in Engineering and Management (IJSREM)*, 7(10). DOI: 10.55041/IJSREM26101