# Artificial Intelligence-Machine Learning Techniques Promoting SDG's: An Exploratory Approach

Pratyush Prasad[1], Pranjal Prasad[2] and Asim Prasad[3]
[1]*Manipal University Jaipur, India*
[2]*Ajay Kumar Garg Engineering College, Ghaziabad, India*
[3]*Amity University, Noida, India*

Keywords: SDG, Artificial Intelligence, Machine Learning, Linear Models, Decision Trees, Random Forest, Naïve Bayes.

Abstract: This article provides an overview of the Machine Learning (ML) techniques, models, and ideas utilized to analyze datasets to achieve Sustainable Development Goals (SDG) targets. Furthermore, this study investigates the use of Artificial Intelligence (AI) in facilitating the attainment of SDGs. An exploratory approach and a concept-centric literature review were employed to address the study issues. The study reveals the fundamental principles of Supervised, Unsupervised, and Reinforced ML methodologies, as well as several algorithms like k-Nearest Neighbours, Linear Models, Naïve Bayes, Decision trees, Random forests, gradient boosted decision trees, Support vector machines, and Neural networks. The study implications pertain to the use of artificial intelligence and machine learning techniques to advance the aims of the SDGs for the betterment of society, the economy, and the environment.



## 1 INTRODUCTION

The seventeen Sustainable Development Goals (SDGs), agreed by the UN in 2015, call for collaborative action to end poverty, protect the environment, and promote peace and prosperity for all by 2030. However, complex issues related to these require the application of Artificial Intelligence(AI) and Machine Learning(ML) algorithms, models to support SDG objectives(International Telecommunication Union, 2021). Machine and system intelligence is called artificial intelligence (AI). They can perform duties independently and work with humans and nature due to their intelligence. AI software can perceive, decide, forecast, extract information, recognize patterns from data, communicate, and think logically(Sætra, 2021). ML as defined by Arthur Samuel is the "field of study that allows computers to learn without being explicitly programmed." The growing field of data science uses ML to extract knowledge from datasets. It combines computer science, statistics, and AI(Müller & Guido, 2016). ML uses computerized approaches to solve problems using past data and expertise without changing critical operations (Sandhu, 2018). Unlike AI, ML involves discovering patterns in datasets (data mining) and using them to classify or predict occurrences related to a problem (Alpaydın, 2004). ML enables intelligent machines to maintain their talents. Statistical methods train algorithms to classify or predict, providing data mining insights. These insights guide application and business decisions to improve growth indicators. ML has several applications that relate to real-world problems supporting automation (Khanum et al., 2015) in fields related to bioinformatics(Tan & Gilbert, 2003), Population Genetics (Schrider & Kern, 2018), autonomous vehicle (AV), healthcare, natural language processing (NLP), business applications, intelligent robots, climate modeling, gaming, voice processing, image processing(Rustam et al., 2020), cancer detection(Prasad, 2023). ML involves data storage, abstraction, generalization, and evaluation(H, 2023). Data Storage stores and retrieves large amounts of data, essential to ML. Cognitive abstraction involves obtaining useful information from a dataset. Developing broad concepts that include all data is required. Abstraction (knowledge generation) uses current and new models. Training establishes model parameters from a dataset. After training, the model abstracts the data to capture its key points. Generalizing stored data knowledge



Prasad, P., Prasad, P. and Prasad, A.
Artificial Intelligence-Machine Learning Techniques Promoting SDG's: An Exploratory Approach.
DOI: 10.5220/0013405700003882

In *Proceedings of the 2nd Pamir Transboundary Conference for Sustainable Societies (PAMIR-2 2023)*, pages 1717-1726
ISBN: 978-989-758-723-8

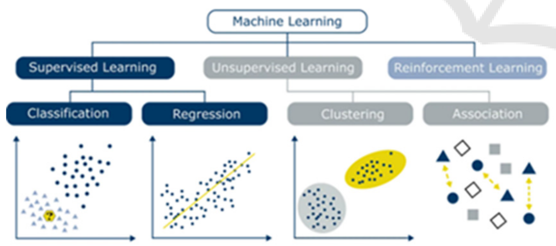
allows it to be used for future decision-making or action. These actions should be performed on similar tasks but not identical to earlier ones. The goal of generalization is to discover the data traits or qualities that will be most relevant to future activities. Evaluation involves systematic feedback to the user to measure the effectiveness or utility of acquired knowledge. Feedback is then used to improve learning. ML system knowledge acquisition involves decision process, error function, and model optimization. In light of these deliberations, considering the growing importance of ML, this article, through an exploratory approach, aims to provide answers to the following research questions:

*RQ1: What ML techniques, models, and concepts facilitate dataset analysis for SDG targets?*

*RQ2: Does the application of AI promote the achievement of SDGs?*

# 2 LITERATURE REVIEW

The researcher conducted a critical analysis to present the ML algorithm, models to understand what is known about the study topic, the related concepts, and the perspectives(Grant & Booth, 2009). The ML algorithms (H, 2023; Müller & Guido, 2016) are of three types: (1) Supervised ML, (2) Unsupervised ML, and (3) Reinforced ML, as detailed in Figure 1.

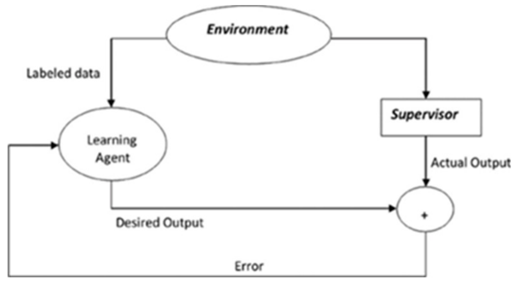



*Source:* (Polzer, 2021).

Figure 1: Machine Learning Types.

## 2.1 Supervised ML

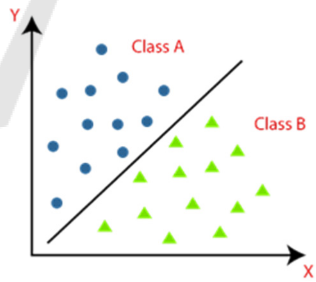
Supervised ML is where the user provides the algorithm with a series of input-output pairs. The input/output data pair teaches the ML algorithm. The program finds input-based techniques for output generation. Supervised ML train models to produce the desired output using a training set. The training dataset contains input data and target outputs to help the model learn iteratively. The approach uses a loss function to evaluate its performance and iteratively adjust its settings to minimize error until it reaches a desirable accuracy. Supervised ML techniques work in two steps. Analytical tasks begin with training data analysis. These algorithms then create dependent functions to map new attribute instances. ML approaches have found that a training subset of 66% of the data can achieve the desired result while minimizing processing needs. (Ng, 2005). The process diagram of supervised ML is in Figure 2. The Supervised ML problems are of two types:




*Source: https://ebrary.net/136995/computer_science/machine_learning*

Figure 2: Process diagram for Supervised Learning.

(a) Classification: Classification refers to the systematic procedure of utilizing a model to make predictions about values that are not yet known, specifically output variables, by leveraging a set of known values, namely input variables(Muhammad & Yan, 2015). It aims to predict a class label (Figure 3).




*Source: https://www.javatpoint.com/classification-algorithm-in-machine-learning*

Figure 3: Class Labelling.

It uses an algorithm to assign test data into specific categories accurately. It recognizes specific entities within the Dataset and attempts to draw some conclusions on how those entities should be labeled or defined. The classifier is the algorithm that is utilized to classify a given dataset. Classification problems are either binary classification or multiclass classification. A binary classifier has two possible outcomes: Yes or No, Male or Female, etc. The multiclass classifier has more than two outcomes, like classifying fruits, vegetables etc. Figure 4 shows a general classification architecture.

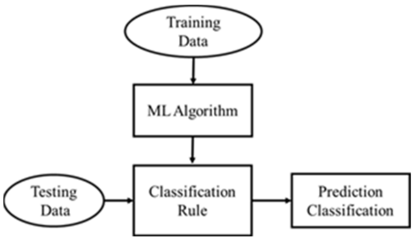
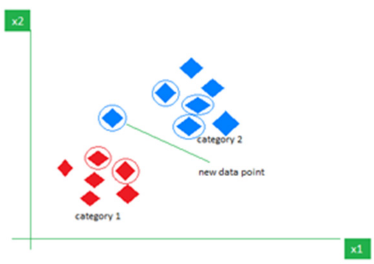



Figure 4: General Classification Architecture.

(b) Regression: This technique helps understand dependent and independent variables. Predicting a real or continuous number is the goal. Common regression methods include linear, logistic, and polynomial. If the outcome is continuous, it's regression; otherwise, classification. Different ML algorithms (Bhavsar & Ganatra, 2012) are k-Nearest Neighbors, Linear Models, Naïve Bayes, Decision trees, Random forests, Gradient boosted decision trees, Support vector machines, and Neural networks( Deep Learning). These are eleborrated herein.

(i) *k-Nearest Neighbors(KNN):* K-nearest neighbor (Lindholm et al., 2019) is an instance-based supervised ML learning method that does not rely on parameters and is one of the simplest to understand using small datasets. The idea is that "like" samples tend to cluster together. K-nearest neighbor classifiers are used to determine the most common class label given an unlabeled sample by searching the pattern space for the k-objects that are closest to it (Burges, 1998). If k=1, then the unknown sample is placed in the training sample class that most closely matches it in the pattern space. Figure 5 shows the KNN.




*Source: https://www.geeksforgeeks.org/k-nearest-neighbours/*

Figure 5: KNN Visualization.

(ii) *Linear models:* Linear models (Matloff, 2017) are another machine-learning technique class that explicitly learns from labeled datasets and maps the data points to the best-performing linear functions. This can be applied for prediction purposes on large multidimensional datasets.

(iii) *Naïve Bayes:* A category of supervised learning algorithms known as naive Bayes methods utilize Bayes' theorem with the "naive" assumption that each pair of features is conditionally independent given the value of the class variable(Maertens et al., 2017). It is used for Sentiment Analysis, Text Classification, Credit Scoring, Medical Data Classification, and Text Filtering for Spam. The naive Bayesian classifiers presume that, given the class variables, the value of one characteristic is independent of the value of any other characteristic. Accordingly, the following equation gives the posterior probability (Gianey & Choudhary, 2018).

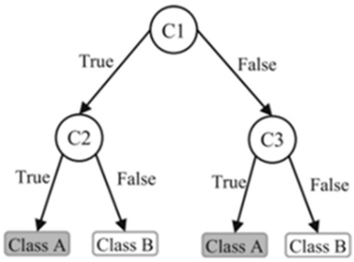
$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \quad (1)$$

Where,

P (A|B) - Posterior probability of the class when predictor is given (attribute),
P (A) - Prior probability of the class,
P (B|A) - Probability of the predictor when class is given,
P (B) - Prior probability of the predictor

(iv) *Decision trees:* A decision tree is a graphical representation used to facilitate decision-making or produce numerical forecasts by utilizing the information contained within a given dataset. It is a form of supervised learning methodology that is utilized to make predictions about response values, achieved by acquiring decision rules formed from the Dataset's features. The decision tree comprises three essential components: a root node, leaf nodes, and branches. Regardless of the precise form of the decision tree employed, the process invariably commences with a distinct decision. The choice is visually represented by a box serving as the root node. A tree structure's root and leaf nodes include inquiries or criteria that necessitate a response. Nodes are typically observed in the form of squares or circles. In this context, squares are utilized to symbolize decisions, whilst circles are employed to indicate ambiguous outcomes(Müller & Guido, 2016) . Decision Tree models can potentially be employed in both regression and classification scenarios.

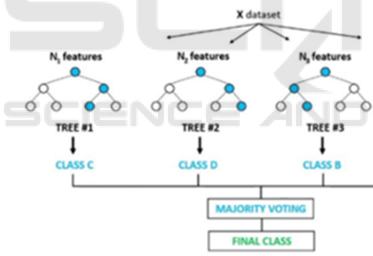
Hence, they are frequently described as Classification And Regression Trees (CART). Decision trees are utilized in the medical domain for diagnostic purposes and in risk management, personal management, corporate strategy, financial management, and project management requirements. Figure 6 shows a Decision Tree structure.




*Source:*(Uddin et al., 2019).

Figure 6: Decision Tree.

(v) *Random forests:* The Random Forest algorithm (Schrider & Kern, 2018) integrates the predictions of numerous decision trees in order to arrive at a consolidated outcome, as shown in Figure 7.

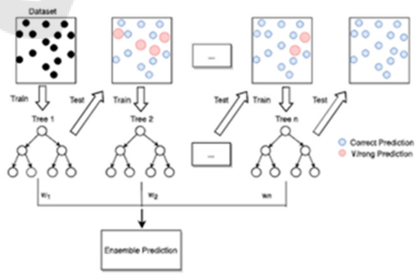



*Source:*(David, 2020).

Figure 7: Random Forest.

The high level of user-friendliness and adaptability of this tool has significantly contributed to its widespread adoption since it effectively addresses both classification and regression tasks. The Random Forest algorithm is extensively employed in domains such as E-commerce, banking, medicine, and the stock market. In the context of the Banking business, this technique can be employed to identify customers who are likely to fail on a loan. It is employed to forecast the factors that contribute to optimal functioning. It helps predict customer behavior and evaluate medical records.

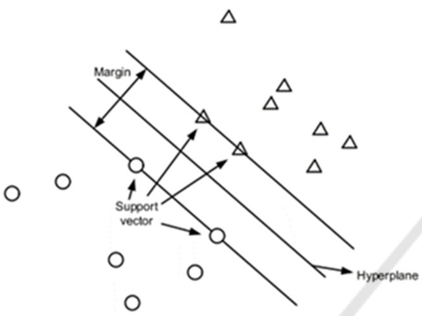
(vi) *Gradient-boosted decision trees:* Gradient-boosted decision trees (Natekin & Knoll, 2013), also referred to as Gradient boosting machine (GBM) or Gradient Boosted Regression Tree (GBRT) represent a machine learning methodology aimed at enhancing the prediction efficacy of a model by iteratively refining the learning process(Chen & Guestrin, 2016; Z. Zhang & Jung, 2021). The concept of Gradient refers to the rate of change of a function with respect to its independent Boosting is particularly advantageous in scenarios when the data has a lower number of dimensions, where a basic linear model exhibits poor performance, interpretability is of lesser importance, and there are no stringent constraints on latency. Boosting algorithms have demonstrated their suitability for artificial intelligence projects in several industries, including a wide spectrum of sectors. These algorithms have proven to be effective and efficient in enhancing the performance of AI systems. In healthcare, boosting techniques are employed to mitigate errors in the prediction of medical data, namely in areas like the estimation of cardiovascular risk factors and the prognosis of cancer patient survival rates. Gradient boosting is a commonly employed technique in the field of marketing to optimize the allocation of budget across various channels, with the ultimate goal of maximizing the return on investments. Figure 8 shows a GBM learning model.




*Source:* (T. Zhang et al., 2021).

Figure 8: GBM learning model.

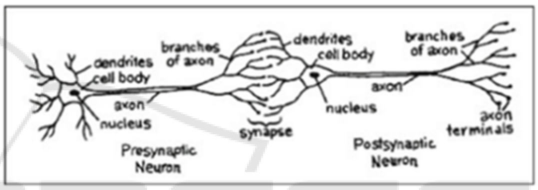
(vii) *Support vector machine(SVM):* The SVM (Vanneschi & Silva, 2023) is a highly effective ML technique that has demonstrated its versatility in numerous applications, encompassing text classification, picture classification, spam detection, handwriting identification, gene expression analysis, face detection, and anomaly detection. SVMs exhibit adaptability and efficiency across various applications because they can effectively handle high-dimensional data and capture nonlinear correlations. Its algorithms have demonstrated high efficacy in identifying the largest separation hyperplane across several classes within the target feature(Awad & Khanna, 2015; Jakkula, 2011). Figure 9 displays SVM for binary classification of data.




*Source: Source:*(Fan et al., 2021).

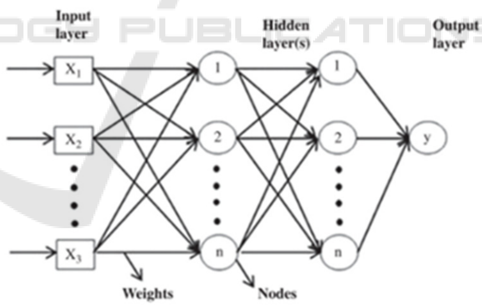
Figure 9: SVM for Binary Classification.

(viii) *Neural networks:* A neural network (Gurney, 1997) is a type of ML model that is specifically designed to replicate the functional and structural characteristics of the human brain. Neural networks, also known as artificial neural networks (ANNs) or deep neural networks have gained significant popularity as machine learning techniques that aim to replicate the learning mechanisms observed in biological organisms(Charu C. Aggarwal, 2018). This deep learning technology falls within the broader domain of AI.. Many people use ANN to learn computers in a way that is similar to how living things learn. The cells that make up the nervous system are called neurons. Axons and dendrites link the neurons to each other. The areas where axons and dendrites meet are called synapses. Synaptic connections often change how strong they are in reaction to things outside of the brain. Figure 10 displays the biological neural network (BNN) connections. The way living things learn changed because of this. Neural networks can build complex models for large datasets composed of interconnected neurons, which work together to address complex challenges. Neural networks are extensively employed throughout many domains, encompassing image identification, predictive modeling, and natural language processing (NLP). Since 2000, notable instances of commercial applications have demonstrated considerable significance(Mijwel et al., 2019). These include using handwriting recognition for cheque processing, transcribing speech into text, analyzing data for oil and gas exploration, predicting weather patterns, and implementing facial recognition technology. Neural networks are sensitive to parameter choice and data scaling. Figure 11 shows an ANN general structure.




*Source:* (Westbrook et al., 2010).

Figure 10: BNN.

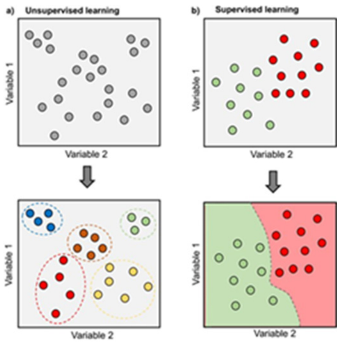



*Source:* (Sairamya et al., 2019).

Figure 11: ANN General Structure.

## 2.2 Unsupervised ML

An unsupervised ML algorithm has no known output and teacher[1]. Unsupervised ML approaches can find patterns and relationships in a dataset without a preset output variable, making them useful for description jobs. This type of ML classification is called unsupervised ML because there is no response variable to guide the study. Unsupervised ML seeks latent dimensions, components, clusters, and trajectories in data. Principle components analysis, factor analysis, and mixture modeling are unsupervised learning methods(Hastie et al., 2006).



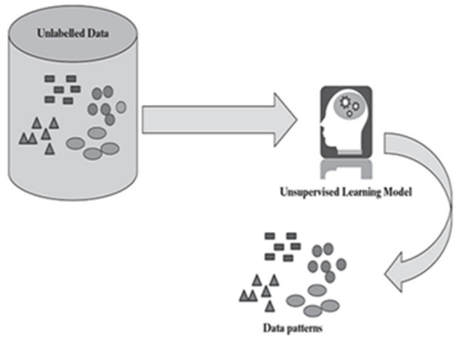

*Source:* (Morimoto & Ponton, 2021).

Figure 12: Supervised and Unsupervised Learning Model.

Figure 12 depicts a typical supervised and unsupervised learning model. The types of unsupervised ML algorithms are discussed herein.

(a) *Dataset Transformation*: Dataset Transformation is the process of transforming a dataset for ease of understanding. This involves reducing the dimension of the data set with high dimensions and many features with fewer features without compromising its essential characteristics.

(b) *Clustering:* Clustering is a data mining technique that facilitates the organization of unlabelled data by grouping them based on their commonalities or differences(Alloghani et al., 2020). Clustering refers to the procedure of grouping a Dataset based on the similarity of its components. Clustering algorithms (Khanum et al., 2015) generate distinct groups characterized by similar items within the various categories. Clustering techniques are utilized for the analysis of raw and unclassified data elements, aiming to arrange them into separate groups that exhibit inherent structures or patterns within the data. Figure 13 shows a clustering model. Clustering methods can be categorized into various classes, including exclusive, overlapping, hierarchical, and probabilistic.




*Source:* (Dutt et al., 2019).

Figure 13: Clustering Model.

(i) *Exclusive clustering*: Exclusive clustering is a type of clustering that enforces the constraint that each data point can belong to only one cluster. The K-means clustering algorithm exemplifies the concept of exclusive clustering. Pattern identification, image analysis, consumer analytics, market segmentation, social network analysis, and many more domains apply the clustering technique.

(ii) *Overlapping*: Overlapping clustering techniques permit data points to be attached to multiple clusters. Partitioning methods are more prevalent than overlapping clustering algorithms due to their simplicity and effectiveness on large datasets.

(iii) *Hierarchical clustering*: Hierarchical Clustering aims to identify inherent clusters by considering the Dataset's attributes. The primary objective of the hierarchical clustering algorithm is to identify and construct a hierarchical structure that reveals the presence of nested groups within the Dataset. The concept resembles the biological taxonomy in classifying organisms within the plant or animal kingdom. Hierarchical clusters are typically depicted through a hierarchical tree structure referred to as a dendrogram. Hierarchical clustering can be classified into two distinct approaches: agglomerative, also known as the bottom-up technique, and divisive, also referred to as the top-down approach.

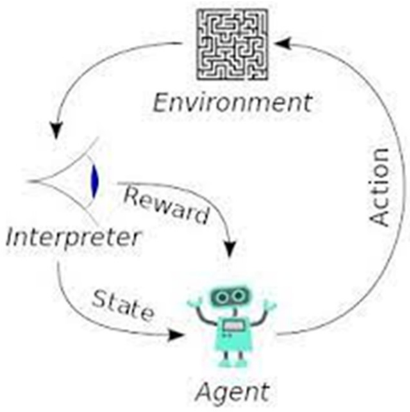
(iv) *Probabilistic clustering:* Probabilistic clustering is a technique that addresses density estimation or "soft" clustering challenges. It is utilized for the purpose of addressing density estimation or "soft" clustering difficulties. Probabilistic clustering is a technique wherein data points are grouped based on their probability of belonging to a specific distribution.

(c) Association: Association rule is a form of unsupervised learning methodology that examines the interdependence between different data elements and is designed to enhance cost-effectiveness. Market basket analysis is a commonly employed approach for examining the association between various items, enabling firms to enhance their comprehension of these relationships.

(d) Apriori algorithms: Apriori is an unsupervised learning methodology due to its frequent application in identifying and extracting remarkable patterns and associations. The Apriori algorithm can be adapted to perform classification tasks using labeled data. The popularity of Apriori algorithms has been primarily driven by their application in market basket research, resulting in the development of diverse recommendation engines for music platforms and online stores.

## 2.3 Reinforced ML

ML is a scientific study of decision-making, and reinforcement ML (Naeem et al., 2020; Sutton & Barto, 2018) is a subfield. A software agent interacts with an unknown environment. The agent's behaviors reveal the environment's dynamics. To maximize reward, obtain the best actions in a specific context. It involves using appropriate measures to maximize advantages in a given setting. This self-teaching system learns by trial and error. The agent optimizes rewards through trial-and-error behavior. As the reinforcement agent chooses how to complete the job, reinforcement learning has no predetermined answer. The machine may learn from its own experiences if there is no training dataset. This data is collected using trial-and-error ML techniques. Reinforcement learning algorithms learn from observed outcomes and select the best action. After each step, the algorithm receives feedback to determine whether its choice was correct, neutral, or erroneous. This technique is useful in automated systems that must make many incremental judgments without human interaction. Reinforced Learning has an agent, environment, policy, reward signal, and value function. Environment models may also be present. A common reinforcement learning model is in Figure 14. Reinforcement learning is used in robotics, autonomous control, healthcare, communication and networking, gaming, natural language processing, scheduling management, and self-organized systems(Naeem et al., 2020).




*Source:* (Mahesh Batta, 2020).

Figure 14: Reinforced Learning.

# 3 AI-ML AND SDGs

(Vinuesa et al., 2020) grouped SDGs into societal, economic, and environmental categories, arguing that the increasing influence of AI through technological improvement will likely enable 134 (79 %) targets across all SDGs. Sixty-seven societal targets (82%) benefit from AI that positively impact the provision of energy services, water, food, good health, and low carbon systems, promoting a circular economy. Forty-two economic group targets (70%) will benefit from AI-enabled technologies related to decent work, industry innovation, infrastructure, and inequality. Further, twenty five targets (93%) from the environmental group will be positively impacted. These relate to life below water, life on land, and climate action. As AI may inhibit some targets, it is necessary to overcome safety, transparency, and ethical standards and put regulatory standards in place to plug perceived gaps.(Sætra, 2021) supports these arguments, viewing AI as part of a sociotechnical system that includes bigger structures economic and political processes, not as a standalone tool. (Nasir et al., 2023) imply that while the advancement of AI technology is concentrated on enhancing present economic growth, significant societal and environmental challenges may be overlooked. Thus AI is poised to assume a more prominent position in the field of achieving SDGs. Its potential to provide support and facilitate coordination in this domain is expected to grow significantly in the future(Leal Filho et al., 2023).

# 4 FINDINGS AND CONCLUSION

The findings briefly present the answers to the research questions.

*RQ1: What ML techniques, models, and concepts facilitate dataset analysis for SDG targets?*

In a general sense, machine learning encompasses the use of diverse models to discern patterns inside data and subsequently generate precise predictions by leveraging the observed patterns. These subjects are interconnected with supervised learning, a technique that uses training data to teach the model. Generalization refers to the ability of a machine learning model to make accurate predictions about unseen data based on its training data. Overfitting occurs when a model exhibits excessive fidelity to the training data, diminishing the ability to generalize to unseen data. Underfitting occurs when the model fails to predict outcomes accurately using training and fresh, unseen data. Supervised learning involves partitioning data into three distinct categories: training, development, and testing datasets. The test dataset is employed post-model development to evaluate the model's performance on previously unseen data.

Additionally, the selection of pertinent fields within a dataset was deliberated upon. Subsequently, an analysis was conducted on ANN, which serve as the first model inside this sequence of blog entries. Neural networks typically consist of three layers: an input layer, a hidden layer, and an output layer. Neural networks emerged as pioneering machine learning models, with subsequent investigations delving into numerous versions of this paradigm. The utilization of several hidden layers in deep neural networks enhances their performance in certain tasks compared to simple neural networks, owing to their inherent complexity.

The research presented Supervised, Unsupervised, and Reinforced ML algorithms. Under Supervised ML, the classification and regression models were deliberated. The different ML algorithms presented are k-Nearest Neighbors, Linear Models, Naïve Bayes, Decision trees, Random forests, Gradient boosted decision trees, Support vector machines, and Neural networks. The types of unsupervised ML and reinforced ML with concepts were discussed.

*RQ2: Does the application of AI promote the achievement of SDGs?*

The findings reveal that AI-ML research supports and promotes the achievement of SDG targets. AI-ML helps to model worldwide complex challenges related to overcoming poverty, inequality, climate change, environmental degradation, peace, and justice(Leal Filho et al., 2023). AI can help solve humanity's biggest problems in almost all fields, like human health. agriculture and forest ecosystems that affect our planet, but large-scale AI adoption also poses unanticipated hazards(Holzinger et al., 2021). Thus, stakeholders, governments, policymakers, industry, and academia must ensure that AI is developed with these potential threats in mind. Also, it needs to be ensured that AI applications are safe, traceable, transparent, explainable, valid, and verifiable. This will be possible if stakeholders employ trustworthy and ethical AI and avoid misusing AI technologies. AI provides many opportunities to solve complex problems, manage climate change, and help nations achieve their stated targets for net zero carbon emissions in the long run. This response aims to outline the essential principles and insights that must be embraced to ensure a constructive transformation of AI advancements and implementations, ultimately facilitating the achievement of the SDGs by the year 2030.

# REFERENCES


Alloghani, M., Al-Jumeily, D., Mustafina, J., Hussain, A., & Aljaaf, A. J. (2020). *A Systematic Review on Supervised and Unsupervised Machine Learning Algorithms for Data Science*. https://doi.org/10.1007/978-3-030-22475-2_1

Alpaydın, E. (2004). *Introduction to Machine Learning* (2nd ed.). The MIT Press.

Awad, M., & Khanna, R. (2015). Efficient learning machines: Theories, concepts, and applications for engineers and system designers. In *Efficient Learning Machines: Theories, Concepts, and Applications for Engineers and System Designers* (Issue April 2015, pp. 1–248). https://doi.org/10.1007/978-1-4302-5990-9

Bhavsar, H., & Ganatra, A. (2012). A Comparative Study of Training Algorithms for Supervised Machine Learning. *International Journal of Soft Computing and Engineering*, *2*(4), 74–81.

Burges, C. J. C. (1998). A Tutorial on Support Vector Machines for Pattern Recognition. *Data Mining and Knowledge Discovery*, *2*(2), 121–167. https://doi.org/10.1023/A:1009715923555

Charu C. Aggarwal. (2018). Neural Networks and Deep Learning. In *Neural Networks and Deep Learning*. Springer. https://doi.org/110.1007/978-3-319-94463-0

Chen, T., & Guestrin, C. (2016). XGBoost: A Scalable Tree Boosting System. *KDD '16: Proceedings of the 22nd*

*ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*.

David, D. (2020). *Random Forest Classifier Tutorial: How to Use Tree-Based Algorithms for Machine Learning*. FreeCodeCamp. https://www.freecodecamp.org/news/how-to-use-the-tree-based-algorithm-for-machine-learning/

Dutt, S., Chandramouli, S., & Das, A. K. (2019). Machine Learning. In *Pearson*. Pearson India Educa?ion Services Pvt. Ltd.

Fan, J., Lee, J., & Lee, Y. (2021). A transfer learning architecture based on a support vector machine for histopathology image classification. *Applied Sciences (Switzerland)*, *11*(14). https://doi.org/10.3390/app11146380

Gianey, H. K., & Choudhary, R. (2018). Comprehensive Review On Supervised Machine Learning Algorithms. *Proceedings - 2017 International Conference on Machine Learning and Data Science, MLDS 2017*, *2018-Janua*(December 2017), 38–43. https://doi.org/10.1109/MLDS.2017.11

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, *26*(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Gurney, K. (1997). Introduction to neural networks. In *Routledge* (Vol. 317). UCL Press Limited. https://doi.org/10.1016/S0140-6736(95)91746-2

H, V. M. (2023). *What Is Machine Learning? Components And Applications*. VTUPulse. https://www.vtupulse.com/machine-learning/what-is-machine-learning-components-and-applications/

Hastie, T., Tibshirani, R., James, G., & Witten, D. (2006). An Introduction to Statistical Learning Second Edition. *Springer Texts*, *102*, 618.

Holzinger, A., Weippl, E., Tjoa, A. M., & Kieseberg, P. (2021). Digital Transformation for Sustainable Development Goals (SDGs) - A Security, Safety and Privacy Perspective on AI. *International Cross-Domain Conference for Machine Learning and Knowledge Extraction*, 1–20. https://doi.org/10.1007/978-3-030-84060-0

International Telecommunication Union. (2021). *United Nations Activities on Artificial Intelligence*.

Jakkula, V. (2011). Tutorial on Support Vector Machine (SVM). *School of EECS, Washington State University*, 1–13. http://www.ccs.neu.edu/course/cs5100f11/resources/jakkula.pdf

Khanum, M., Mahboob, T., Imtiaz, W., Abdul Ghafoor, H., & Sehar, R. (2015). A Survey on Unsupervised Machine Learning Algorithms for Automation, Classification and Maintenance. *International Journal of Computer Applications*, *119*(13), 34–39. https://doi.org/10.5120/21131-4058

Leal Filho, W., Yang, P., Eustachio, J. H. P. P., Azul, A. M., Gellers, J. C., Gielczyk, A., Dinis, M. A. P., & Kozlova, V. (2023). Deploying digitalisation and artificial intelligence in sustainable development research. In *Environment, Development and Sustainability* (Vol. 25, Issue 6). Springer Netherlands. https://doi.org/10.1007/s10668-022-02252-3

Lindholm, A., Wahlström, N., Lindsten, F., & Schön, T. B. (2019). *Supervised Machine Learning: Statistical Machine Learning course* (p. 112). http://www.it.uu.se/edu/course/homepage/sml/literature/lecture_notes.pdf

Maertens, R. M., Long, A. S., & White, P. A. (2017). Performance of the in vitro transgene mutation assay in MutaMouse FE1 cells: Evaluation of nine misleading ("False") positive chemicals. *Environmental and Molecular Mutagenesis*, *58*(8), 582–591. https://doi.org/10.1002/em.22125

Mahesh Batta. (2020). Machine Learning Algorithms - A Review. *International Journal of Science and Research (IJSR)*, *January 2019*. https://doi.org/10.21275/ART20203995

Matloff, N. (2017). Statistical Regression and Classification. *Statistical Regression and Classification*. https://doi.org/10.1201/9781315119588

Mijwel, M. M., Esen, A., & Shamil, A. (2019). Overview of Neural Networks. In *Neural Networks and Fuzzy Systems* (Issue April). https://doi.org/10.1007/978-1-4615-6253-5_1

Morimoto, J., & Ponton, F. (2021). Virtual reality in biology: could we become virtual naturalists? *Evolution: Education and Outreach*, *14*(1), 1–14. https://doi.org/10.1186/s12052-021-00147-x

Muhammad, I., & Yan, Z. (2015). Supervised Machine Learning Approaches: a Survey. *ICTACT Journal on Soft Computing*, *05*(03), 946–952. https://doi.org/10.21917/ijsc.2015.0133

Müller, A. C., & Guido, S. (2016). *Introduction to Machine Learning with Python* (D. Schanafelt (ed.); 3rd ed.). O'Reilly Media, Inc. https://www.oreilly.com/library/view/introduction-to-machine/9781449369880/

Naeem, M., Rizvi, S. T. H., & Coronato, A. (2020). A Gentle Introduction to Reinforcement Learning and its Application in Different Fields. *IEEE Access*, *8*, 209320–209344. https://doi.org/10.1109/ACCESS.2020.3038605

Nasir, O., Javed, R. T., Gupta, S., Vinuesa, R., & Qadir, J. (2023). Artificial intelligence and sustainable development goals nexus via four vantage points. *Technology in Society*, *72*(November 2022), 102171. https://doi.org/10.1016/j.techsoc.2022.102171

Natekin, A., & Knoll, A. (2013). Gradient boosting machines, a tutorial. *Frontiers in Neurorobotics*, *7*(DEC). https://doi.org/10.3389/fnbot.2013.00021

Ng, A. (2005). *Lecture notes Supervised Learning* (Issue 0).

Polzer, D. (2021). *7 of the Most Used Regression Algorithms and How to Choose the Right One*. Towards Data Science. https://towardsdatascience.com/7-of-the-most-commonly-used-regression-algorithms-and-how-to-choose-the-right-one-fc3c8890f9e3

Prasad, P. (2023). The Application of Machine Learning Techniques to the Diagnosis of Breast Cancer. *2023 3rd International Conference on Artificial Intelligence and*

*Signal Processing (AISP)*. https://doi.org/10.1109/AISP57993.2023.10134824

Rustam, F., Reshi, A. A., Mehmood, A., Ullah, S., On, B. W., Aslam, W., & Choi, G. S. (2020). COVID-19 Future Forecasting Using Supervised Machine Learning Models. *IEEE Access*, *8*, 101489–101499. https://doi.org/10.1109/ACCESS.2020.2997311

Sætra, H. S. (2021). Ai in context and the sustainable development goals: Factoring in the unsustainability of the sociotechnical system. *Sustainability (Switzerland)*, *13*(4), 1–19. https://doi.org/10.3390/su13041738

Sairamya, N. J., Susmitha, L., George, S. T., & Subathra, M. S. P. (2019). Hybrid Approach for Classification of Electroencephalographic Signals Using Time–Frequency Images With Wavelets and Texture Features - ScienceDirect. In *Intelligent Data Analysis for Biomedical Applications Challenges and Solutions* (pp. 253–273). Academic Press. https://doi.org/10.1016/B978-0-12-815553-0.00013-6

Sandhu, T. H. (2018). Machine learning and natural language processing - a review. *International Journal of Advanced Research in Computer Science*, *9*(2), 582–584.

Schrider, D. R., & Kern, A. D. (2018). Supervised Machine Learning for Population Genetics: A New Paradigm. *Trends in Genetics*, *34*(4), 301–312. https://doi.org/10.1016/j.tig.2017.12.005

Sutton, R. S., & Barto, A. G. (2018). *Reinforcement Learning- An Introduction* (2nd ed.). The MIT Press.

Tan, A. C., & Gilbert, D. (2003). *An Empirical Comparison of Supervised Machine Learning Techniques in Bioinformatics BT - First Asia-Pacific Bioinformatics Conference (APBC2003)*. *19*(Apbc), 219–222. http://www.cs.waikato.ac.nz/~ml/weka/%0Ahttp://crpit.com/confpapers/CRPITV19Tan.pdf

Uddin, S., Khan, A., Hossain, M. E., & Moni, M. A. (2019). Comparing different supervised machine learning algorithms for disease prediction. *BMC Medical Informatics and Decision Making*, *19*(1), 1–16. https://doi.org/10.1186/s12911-019-1004-8

Vanneschi, L., & Silva, S. (2023). Support Vector Machines. *Natural Computing Series*, 271–281. https://doi.org/10.1007/978-3-031-17922-8_10

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S. D., Tegmark, M., & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature Communications*, *11*(1), 1–10. https://doi.org/10.1038/s41467-019-14108-y

Westbrook, A. L., Hannigan, D. A., Developer, C., Dougherty, M., College, H., Friedman, D., & Carolina, N. (2010). *The Brain : Understanding Neurobiology Through the Study of Addiction*.

Zhang, T., Lin, W., Vogelmann, A. M., Zhang, M., Xie, S., Qin, Y., & Golaz, J. C. (2021). Improving Convection Trigger Functions in Deep Convective Parameterization Schemes Using Machine Learning. *Journal of Advances in Modeling Earth Systems*, *13*(5), 1–19. https://doi.org/10.1029/2020MS002365

Zhang, Z., & Jung, C. (2021). GBDT-MO: Gradient-Boosted Decision Trees for Multiple Outputs. *IEEE Transactions on Neural Networks and Learning Systems*, *32*(7), 3156–3167. https://doi.org/10.1109/TNNLS.2020.3009776