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Disposition of Youth in Predicting Sustainable Development Goals Using the Neuro-fuzzy and Random Forest Algorithms

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Abstract

This paper evaluates the inclination of Asian youth regarding the achievement of Sustainable Development Goals (SDGs). As the young population of a country holds the key to its future development, the authors of this study aim to provide evidence of the successful application of machine learning techniques to highlight their opinions about a sustainable future. This study's timing is critical due to rapid developments in technology which are highlighting gaps between policy and the actual aspirations of citizens. Several studies indicate the superior predictive capabilities of neuro-fuzzy techniques. At the same time, Random Forest is gaining popularity as an advanced prediction and classification tool. This study aims to build on the previous research and compare the predictive accuracy of the adaptive neuro-fuzzy inference system (ANFIS) and Random Forest models for three categories of SGDs. The study also aims to explore possible differences of opinion regarding the importance of these categories among Asian and Serbian youth. The data used in this study were collected from 425 youth respondents in India. The results of data analysis show that ANFIS is better at predicting SDGs than the Random Forest model. The SDG preference among Asian and Serbian youth was found to be highest for the environmental pillar, followed by the social and economic pillars. This paper makes both a theoretical and a practical contribution to deepening understanding of the predictive power of the two models and to devising policies for attaining the SDGs by 2030.

Keywords

Random Forest, ANFIS, SDGs, Asian Youth

1. Introduction

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The global agenda of sustainable development (SD) is attracting ever more attention [1]. The international community proposed the Sustainable Development Goals (SGDs) in the wake of the relative successive of the Millennium Development Goals [2] in protecting the planet, reducing poverty, and ensuring peace and security. Earlier decades witnessed great progress by humans in different fields. However, these developments have come at a price in terms of climate change, income inequality and wealth, and social division across classes [3–5].

The United Nations (UN) Sustainable Development Goals include seventeen objectives related to universal peace and security that were agreed upon and adopted by all UN member states with the aim of achieving them by 2030[6]. The main goals of the SDGs include protecting the planet, reducing poverty, and ensuring peace and safety [2]. Public institutions, businesses, organizations, and individuals are all called upon to contribute to this challenge [7]. The SD 2030 agenda, paragraph 53, highlighted the importance of the younger generation in relation to development. This has attracted increasing attention from academics, practitioners, and policymakers [8–10]. As such, it has now become imperative to meet the present needs without compromising our common future [11].

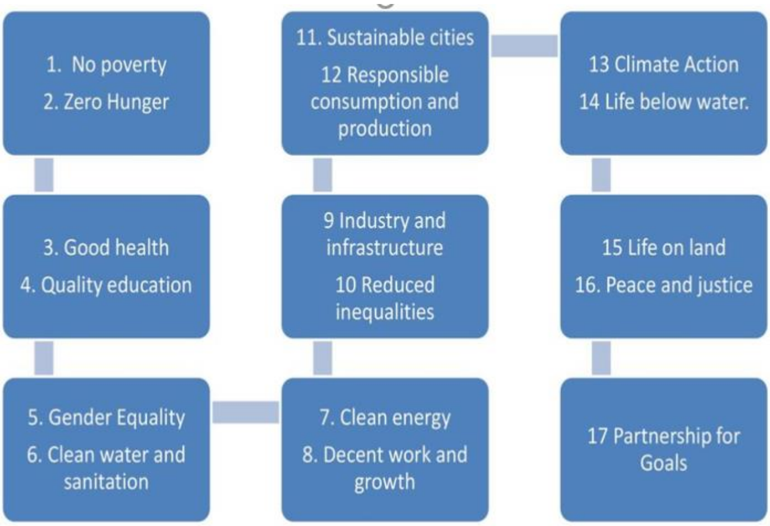


Fig. 1. Seventeen United Nations Sustainable Development Goals [6].

Youth act as a catalyst in the decision-making process concerning development and growth [6, 12]. According to India's census data for 2011, nearly half of the country's population is under 25 years of age. With proper education, political support, adequate resources, appropriate skills, and motivation, these youth can become positive participants in achieving the SD [12–14]. Through youths' active participation and contribution, a country can improve and advance politically, economically, socially, and culturally. Participation of youths is key to fully attaining the SDGs presented in Agenda 21 [15].

This study aims to build on the studies of Petkovic et al. [16], Le Blanc [17], and Cutter et al. [18], to compare the predictive accuracy of the adaptive neuro-fuzzy inference system (ANFIS) and Random Forest models for three categories of SGDs, and to explore the importance of these categories for youth in Asia [19,20]. A dataset of 498 results was generated through an online survey, and subsequent data screening left 425 responses for use in the analysis. The survey instrument contained 24 questions. The two most popular state-of-the-art machine learning algorithms were used to compare the prediction accuracy, i.e., the ANFIS and Random Forest methods [21,22]. The rationale of using ANFIS is that it incorporates the benefits of artificial neural networks and fuzzy systems into a single model [23], thus giving it the ability to capture the nonlinear structure of a process [24–26]. The Random Forest model has recently emerged as an accurate classification model; its ability to handle multidimensional features with its fast computation capability has usually been the main reason for choosing it [27].

The remaining sections of this paper are organized as follows: Section 2 discusses the relevant literature on SDGs and the theoretical foundation of this study; Section 3 presents a discussion on the inclination of youth concerning the achievement of SDGs; Section 4 describes the methodology applied to conduct this study; Section 5 explains the results of the analysis; Section 6 discusses the results in comparison to previous studies and, highlights the implications of this study; Section 7 outlines the limitations of this study and provides directions for future research; and, finally, Section 8 concludes the paper by detailing the fundamental propositions of the study.

2. Related Work

This section presents the literature review of the SDGs, youth participation in SDGs, and the implementation of SDGs in Asia [6]. This review of the literature establishes the current frontiers of knowledge of the study topic.

In the past few decades, SD has been the focus of much research [28–30]. However, few studies have looked at youths’ role in attaining SD [31–33]. The study by [34] explored the design and application of policies and strategies for promoting youth empowerment, innovation, and the eradication of poverty in the context of developing countries. The paper by [35] examines the well-being of youth within the sustainable development framework. It highlights the SDGs and the 2030 global framework for policy-making and reviews the progress towards achieving the SDGs. Youth plays a vital role in the making of any social structure. It is essential to assess youth's progress to understand the condition of a given society's development [35]. Identifying opportunities for youth and recognizing their capabilities should be a priority of all government policies.

The development of plans without the inclusion of youth will not deliver the desired results [36]. A nation’s youth can contribute to economic, cultural, and social development through their empowerment. The global picture of a sustainable future is under threat. This includes climate, which is a mirror of modern citizens' habits [37–40]. To change the global dynamics, it is critical that youth have all the necessary social, moral, and intellectual skills to attain the SD. The agreement between all member states to adopt national strategies for achieving the SD at the earliest possible time was the outcome of the World Summit on SD held in Johannesburg in August 2002. At that time, new dimensions of SD, namely economic and social goals, were included along with environmental protection in the definition of SD. The United Nations’ agencies and other local national governments unanimously agreed that Agenda 21 could not be overlooked.

The three essential pillars of SD are attracting ever greater appreciation [41,42]:

- Economic: A sustainable economic system should be properly equipped to produce goods and services in continuity and maintain a controllable level of government and external debt.
- Environmental: A balanced resource base is an essential aspect of an environmentally sustainable system. Renewable resources should not be depleted.
- Social: A socially sustainable system should follow an unbiased approach and adequately provide all social services, including health and education services, according to the principle of gender equality.

In the present era, the focus should be on well-nourished SD. The New Global Sustainable Development Agenda covers all areas, including the end of poverty, focus on prosperity, advocacy of everyone’s welfare, balanced consumption and production, along with ecology conservation efforts, until 2030. The United Nations General Assembly brought up a resolution in September 2015 for a New Sustainable Development Agenda spanning the period 2015–2030 [43]. Seventeen SD goals formed the blueprint of a sustainable and better future, and there were calls for all nations to unite in its implementation. This interconnected plan covers everyone and does not leave anyone behind. It covers all the global challenges currently facing humanity. Human Rights also constitute part of the SDGs.

2.1 Asian Youth and Sustainable Development Goals

The SDG 4 quality education goal works in a new and integrated way with the aim of bridging the gap between cultural and natural environments [44]. Keeping this plan in mind, the United Nations declared the period 2005–2014 as the "Decade of Education for Sustainable Development" (DESD) in a drive to promote the agenda of transformative education all around the world [45]. On the one hand, it did not have a significant impact on Asians [46]; on the other hand, it recognized that interconnectedness between the natural environment and humans is deeply rooted in Asian culture. Long before the current environmental crisis became evident worldwide, Mahatma Gandhi emphasized the importance of conserving the natural environment and using natural resources wisely [47]. Earlier, the economic, social, and environmental aspects were missing in the five years of development plans.

Consequently, the government and the education system have also attracted criticism for not paying attention to these problems [48]. Now, however, the trend is changing, and the Indian government is working rapidly to involve youth in decision-making and recognize their potential and importance to achieving the SDGs. In different fields, youth can play different roles that facilitate growth and development. Thus, education is an instrument for solving many problems in Asia. Asian youth can contribute significantly to both the growth achievements of the SDGs and national growth [49,50].

2.2 NITI Aayog and the Implementation of Sustainable Development in Asia

Agenda 21 is a roadmap that gives the directions for the SD. This United Nations run program is associated with SD. It is a road map for global action by UN organizations inclusive of governments and other significant groups, wherein there is a direct human, or manmade, impact on the environment [51].

The National Institution for Transforming India (NITI Aayog), chaired by India's Prime Minister, has the official capacity to oversee the implementation of SDGs in India. The Indian government has authorized NITI Aayog to act on its behalf and collaborate with the United Nations in India to successfully implement the United Nations Sustainable Development Framework (UNSDF) in the years 2018–2022, which will result in accomplishing the global SDGs. This framework of cooperation is focused on achieving the national priorities. The government has demonstrated its firm devotion to the globally accepted SDGs. As per India's first National Review, NITI Aayog, State Governments, and India's parliament have taken meaningful actions to localize the SDGs [52]. The UNSDF motto is "Leaving no one behind!"

2.3 Theoretical Concept and Contribution: Youth Participation in Sustainable Development

Youth is defined as "the transitional period in which individuals evolve as active and responsible members of society." The UN General Assembly defines youths as individuals aged between 15 and 24 years [53], whereas the Commonwealth of Nations regards youths as individuals aged between 15 to 29 years.

Only when youth realize their ability to cope with socio-economic matters can the assurance of empowerment be possible. Youth empowerment revolves around the economic environment and covers all the dimensions of social, cultural, political, technological, and educational roles [54].Significant importance is assigned to youth empowerment and SD, as future prosperity lies in the hands of youth [55].

This study contributes to highlighting the importance of youth participation in policy-making regarding SD in Asia. India currently has the youngest population globally, with more than 62% of its population falling within the working-age group (15–59 years) and more than 54% of its total population below the age of 25 [56]. The country can only fulfill its vision of a sustainable economy by raising awareness among different sections of youth in rural and urban India. This study highlights the importance, and provides evidence, of the use of machine learning algorithms to achieve the above-stated vision [57–59]. It also encourages the practical implementation of data collection and analysis tools to interpret the sustainability areas that have the maximum impact on youth. The aim was to examine the predictive capability of ANFIS [60–62] and Random Forest using demographic data [63–65] in the assessment of youth's opinions regarding/the main pillars of SD [67]. This assessment of the goals could provide a better picture for evaluating the present position of the SDG agenda and for analyzing the intensity of the changes required. Furthermore, the degree of accuracy offered by the respective machine learning algorithms are required to be compared and analyzed[68,69].

3. Research Methodology

This section of the paper outlines the methodology adopted by this study. The flowchart of the research methodology adopted is also explained in Fig. 2. This methodology is similar to that used by Petković et al. [16], wherein an assistive questionnaire survey comprising 24 questions was conducted via an online platform on a sample of 425 Asian youths aged 14 to 30. The survey's first four questions (on gender, age, residency, and education) were included to ascertain the respondents' demographic profile. Questions #5 to #7 were included to ascertain the respondents' knowledge of SD, what it stands for, their understanding of the SDGs, and the importance of youth participation. Questions #8 to #15 required the respondents to rate each of the 17 SDGs. A 5-point Likert scale ranging from 1 "not important" to 5 "most important" was used. The respondents' profiles are presented in Table 1. Subsequently, a descriptive analysis of the SDGs' responses and ranking according to their actual mean values was conducted. The supervised forecasting techniques of ANFIS [70] and Random Forest were then applied by training the models with labeled data and then testing them to predict the pillars based on the youth profile. Various studies have confirmed that an online survey is the most appropriate method of collecting data on young respondents below the age of 18 [71]. The pitfalls, potentials, and ethics of the online survey research were as follows: LGBTQ and other marginalized and hard-to-access youth. Participation in this study was voluntary, and the verbal consent of those subjects who agreed to participate was obtained.

4. Data Analysis

Table 2 presents the results obtained from SPSS software that ranks the 17 SDGs according to the arithmetic mean. The values were calculated using Exploratory Data Analysis in SPSS to rank each SD pillar (Fig. 3). The results show that the "Environment"pillar had the highest mean, followed by the "Economic" and "Social"pillars.

4.1 Forecasting Techniques and Models

The objective of this study is to compare the accuracy of the predictive capabilities of the proposed models using an ANFIS [63] and Random Forest on MATLAB and R software, respectively. The input data in ANFIS (particularly gender, age, residence, and education level) were obtained from the survey. The values were first converted into categorical data given as input, as shown in the presented models (Figs. 4, 5); and the output variable was derived from the scores of each of the three SD pillars.

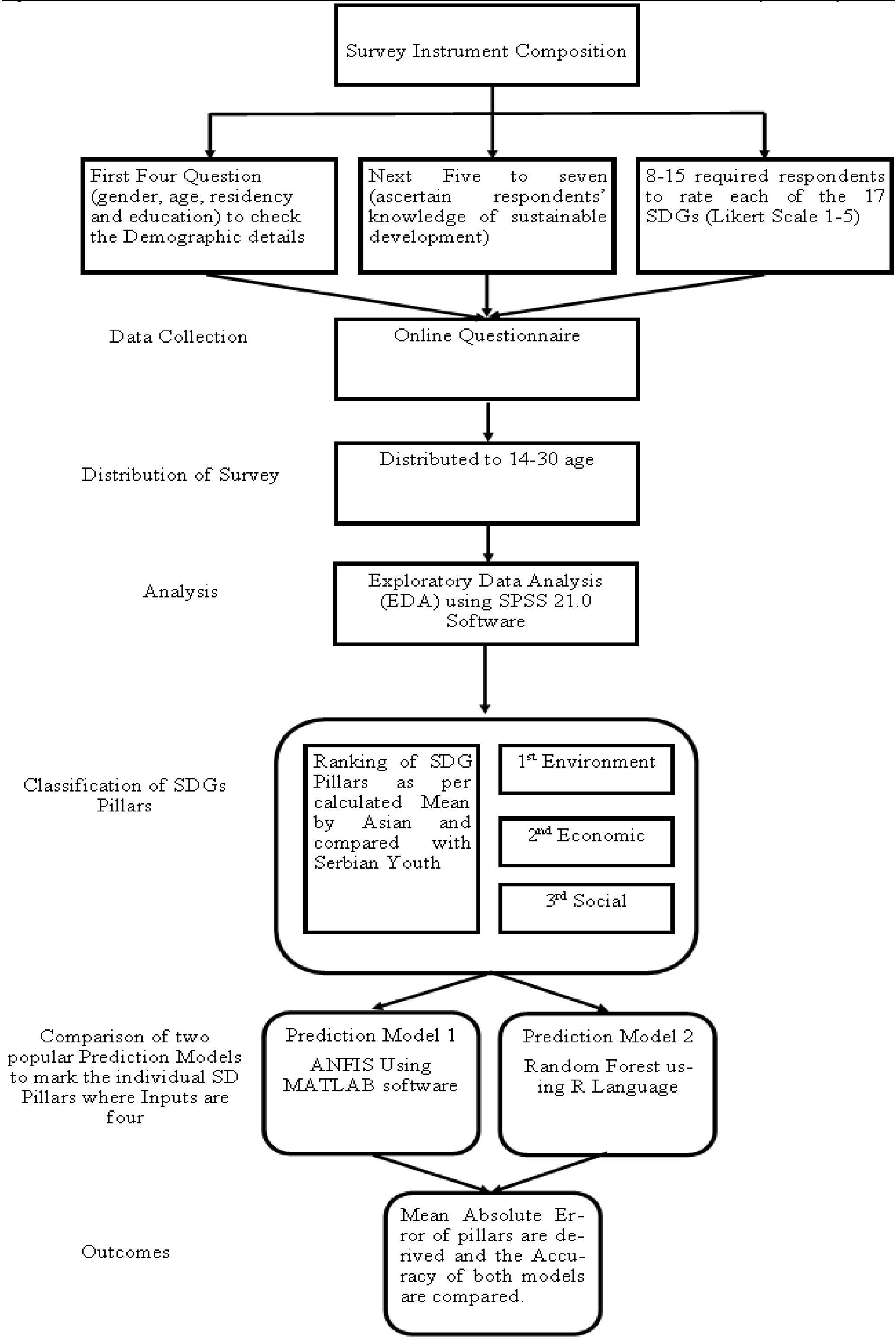


Fig. 2. Flowchart of research methodology adopted.

Table 1. Profile of respondents

Category	Subcategory	N (%)
Gender	Man	172 (40.47)
	Women	253 (59.52)
Age (yr)	14–20	89 (20.94)
	21–25	185 (43.52)
	26–30	150 (35.29)
Education	Senior secondary	21 (4.90)
	Bachelors' education	154 (36.23)
	Masters' education	239 (56.23)
	Doctor of philosophy	11 (2.58)
Residence	Urban	313 (73.64)
	Rural	112 (26.35)

Table 2. Ranked SDGs by the arithmetic mean

Rank	Development domains	Average
1	Water and sanitation	4.9032
2	Health and well-being	4.6367
3	Hunger eradication	4.6084
4	Ensure sustainable consumption and production patterns	4.5566
5	Combat climate change	4.5542
6	Sustainable management of forests	4.4339
7	Conservation of seas and marine resources	4.2523
8	Achieve gender equality	4.2474
9	Access sustainable and modern energy	3.8372
10	Bring an end to poverty	3.6394
11	Sustainable economic growth	3.6179
12	Inclusive and safe cities	3.5188
13	Quality education for all	3.5094
14	Promotion of inclusive societies	3.4411
15	Sustainable industrialization and innovation.	3.3726
16	Against inequality	2.8702
17	Revamp global partnership	2.8325

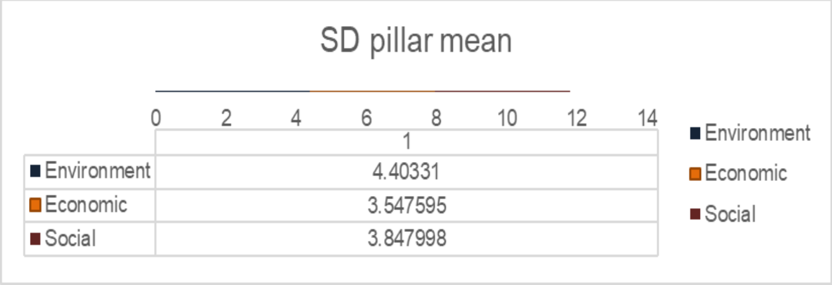


Fig. 3. Calculated mean values of SD pillars.

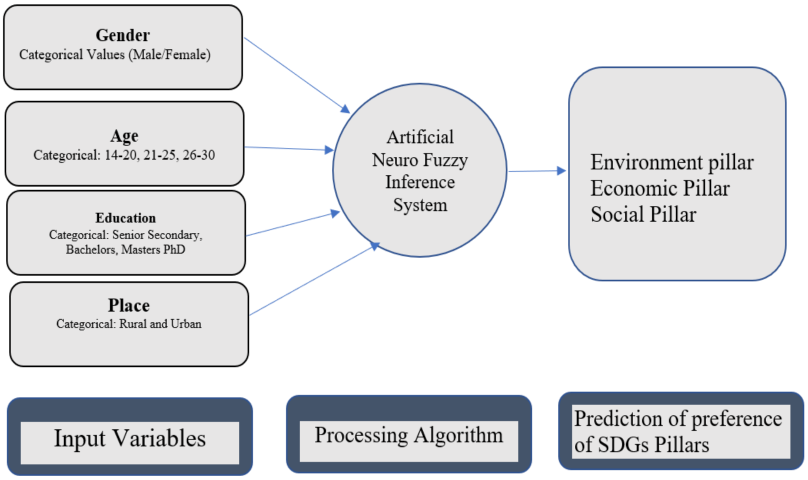


Fig. 4. Pillar prediction via adaptive neuro-fuzzy interface model using MATLAB software.

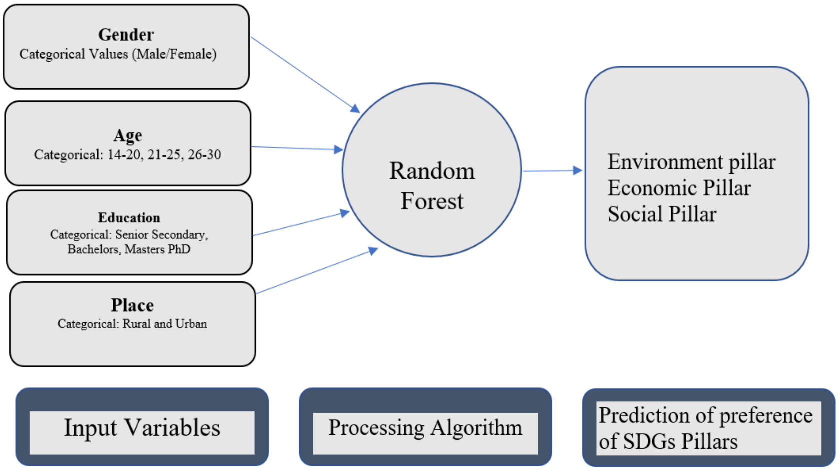


Fig. 5. Random Forest model for pillar prediction using R software.

4.2 Adaptive Neuro-Fuzzy Inference System (ANFIS): Algorithm

1. The value of each node is calculated.
2. Every node *i* in this layer is adaptive with a node function.

$$\mu_{A_i}(x) = \frac{1}{1 + \left[\left(\frac{x - c_i}{a_i}\right)^2\right]^{b_i}}$$

3. Every node here is a fixed node which calculates the firing strength w_i of a rule.

$$w_i = \mu_{A_i}(x) \times \mu_{B_i}(x), i = 1,2 \ldots$$

4. Calculation in this layer leads to a normalized equation of the *i*-th rule.

$$\overline{w_i} = \frac{w_i}{w_1 + w_2}, i = 1,2 \ldots$$

5. Every node in this layer is an adaptive node with a node function given by:

$$O_i^4 = \overline{\omega}_i f = \omega_i(p_i x_1 + qi x_2 + r_i), i = 1,2 \ldots$$

Here, ω_i is the output from step 3, while p_i, q_i, and r_i are the set of parameters that refer to the conclusion. The values of x_1 and x_2 are the initial input values.

MATLAB 9.5 software was used for the application of ANFIS. The training and testing data ratio is 3.47:1. The software generated 81 rules automatically due to use of four input variables (Fig. 6). The most common function is the bell-shaped function in ANFIS.

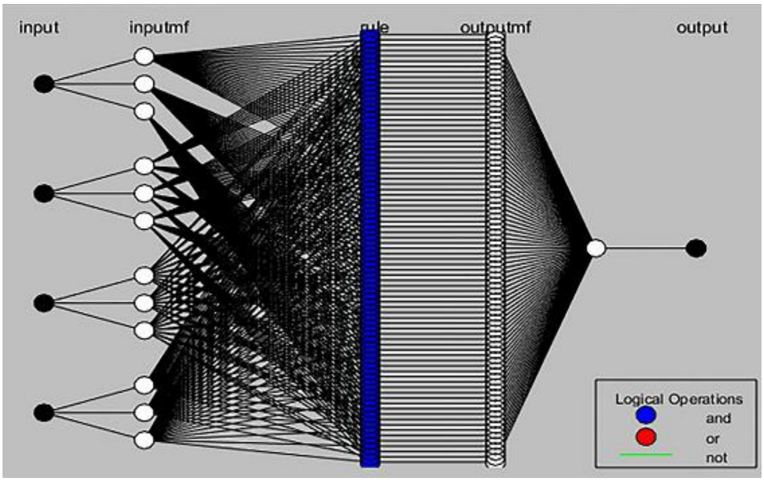


Fig. 6. Nodal structure of the model.

The method of training was via backpropagation. Training error was ranged from 3.14 to 4.05, with 50 epochs considered for training. Figs. 7–9 show a decrease in training error.

The models were first trained individually for the three SD pillars, and then tested later to measure the accuracy of the model. The model predicted the values using actual values. The true set mean for the Social pillar was 3.778, and the predicted value was 3.779. The relative error was 0.02%, which was below 5% and therefore accepted.

The true set mean for the Environment pillar was 3.436, and the predicted value was 3.450. The relative error was computed as 0.40%.

The true set mean for the Economic pillar was 4.365, and the predicted value was 4.352. The relative error was computed as 0.29%. The outcomes of the ANFIS are shown in Tables 3 and 4.

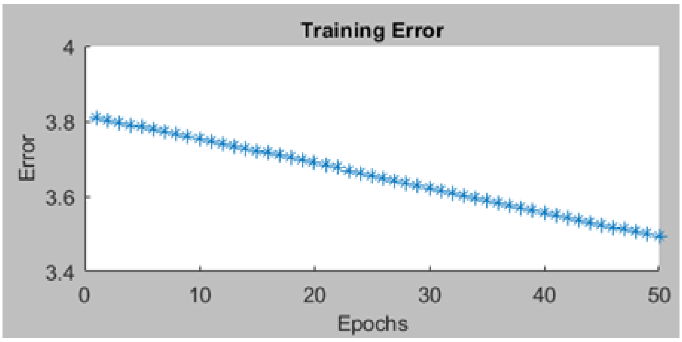


Fig. 7. Training error for Social pillar.

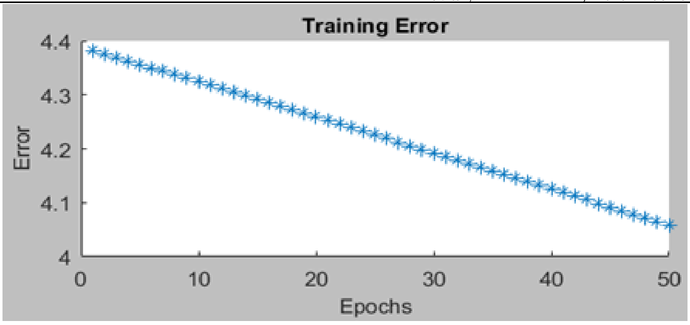


Fig. 8. Training error for Environmental pillar.

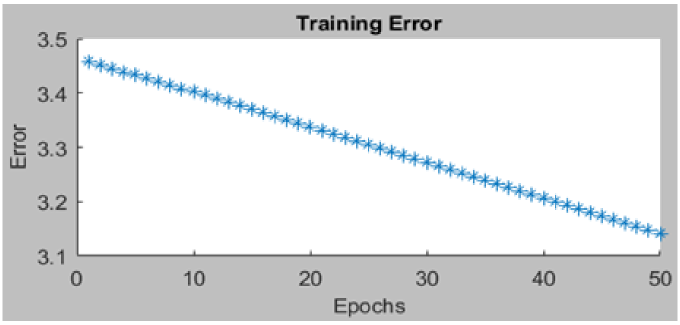


Fig. 9. Training error for Economic pillar.

Table 3. Results of ANFIS model application in the forecasting of SD pillars

	Social	**Economic**	**Environmental**
True set	3.778	3.436	4.365
Predicted set ANFIS	3.779	3.450	4.352
Relative error (%)	0.02	0.40	0.29
Average absolute error	0.184	0.210	0.200

Table 4. The relative error of the ANFIS model for SD pillars forecasting

	Social	**Economic**	**Environmental**
Relative error (%)	0.02	0.40	0.29
Relative error <5%	×	×	×
Relative error >5%	NIL	NIL	NIL

4.3 Random Forest: Algorithm

The Random Forest is an innovation based on bagged decision trees, which allows split-variable randomization [27]. The algorithm is popularly used for classification and regression.

1. For b = 1 to B:
   (a) A small sample of training data.
   (b) Random-Forest tree T_b is grown.
   (c) Repetition of steps.
2. Collection of trees $\{T_b\}_1^B$
   To predict a new point x:

Regression: $\hat{f}_{rf}^{B}(x) = \frac{1}{B}\sum_{b=1}^{B} T_b(x)$

Classification: Let $\hat{C}_b(x)$be the class prediction of the *b*-th Random Forest

$$\hat{C}_{rf}^{B} = majority\ vote\ \{\hat{C}_b(x)\}_1^B.$$

4.4 Forecasting SD Pillars using Random Forest

Random Forests were applied to the dataset of 425 respondents using the "randomForest" package version 4.6-14 in R. The dataset was split into 70:30 for training and testing, respectively. The training input variables used included "gender,""age,""place of birth," and "education."

On defining the input variables and the target variable, i.e., the pillar values, the Random Forest package was used to classify the training dataset into different sets of trees.In the proposed model, 500 classifier trees were used.

Training of data Random Forest only uses a small portion of the data to predict the error for that bag; therefore, it is called out of bag error (OOBE). Fig. 10 depicts the OOBE as a function of *mtry*, i.e., the number of variables available for splitting at each tree node. The above plot shows that the *mtry* of 4 (four) gives the least OOBE error.

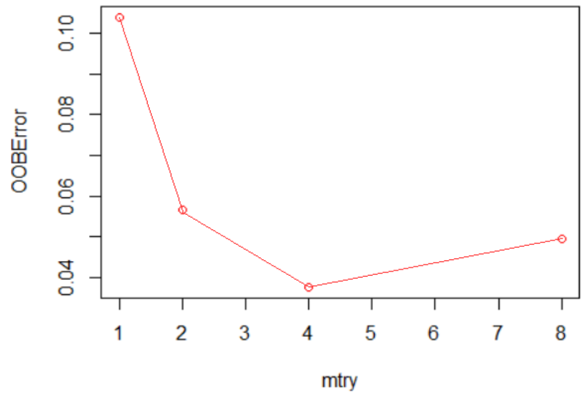


Fig. 10. Optimum number of variables sampled at each split for the least OOB error.

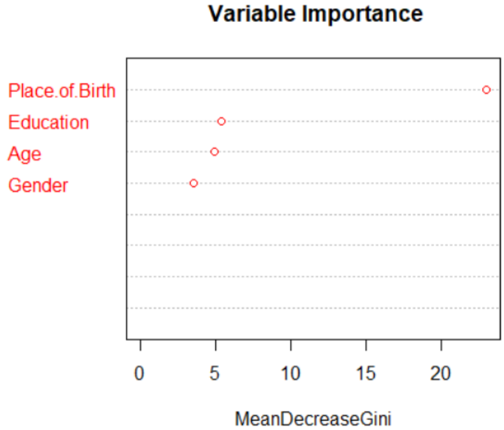


Fig. 11. Variable importance plot.

The variable importance plot (Fig. 11) depicts the importance of the variables in classifying the data. Fig. 11 shows the variables on the y-axis and their significance on the x-axis (mean decrease Gini). The mean decrease in the Gini coefficient is a measure of how each variable contributes to the homogeneity of the nodes and leaves in the resulting Random Forest. The changes in Gini are summed for each variable and normalized at the end of the calculation. The variables that result in nodes with higher purity have a higher decrease in the Gini coefficient.

The results show the variables in top-to-bottom order, from the most necessary down to the least necessary. Hence, Place of Birth is the most critical variable, followed by Education, Age, and Gender in that order (Fig. 11).

5. Results and Discussion

This section outlines the results derived from the analysis of the data and discusses the findings. Tables 3 and 4 present the results of ANFIS in the forecasting of SD pillars. The results are comparable as the values predicted by ANFIS are very close to the actual value. For instance, the Social pillar's actual value is 3.778, while ANFIS has predicted it as 3.779, giving a relative error of just 0.02%.

The Economic pillar's actual value is 3.436, and ANFIS has predicted it as 3.450, with a relative error of 0.40%. The Environmental pillar's actual value is 4.365, and ANFIS has predicted it as 4.352, giving an error of 0.29%. The average absolute error is 0.184, 0.21, and 0.20 for the Social, Economic, and Environmental pillars, respectively.

The relative error is calculated and tabulated in Table 4. The relative error for the Social, Economic, and Environmental pillars is 0.02%, 0.40%, and 0.29%, respectively, which is less than the 5% threshold.

Fig. 12 shows a comparison of the actual test values to the values predicted by the Random Forest algorithm. It also depicts the tally of respondents considered for testing against their choice of SD pillars (both actual and predicted). Fig. 13 shows a comparison in terms of the actual values of the individual pillars and the mean values predicted by the ANFIS algorithm.

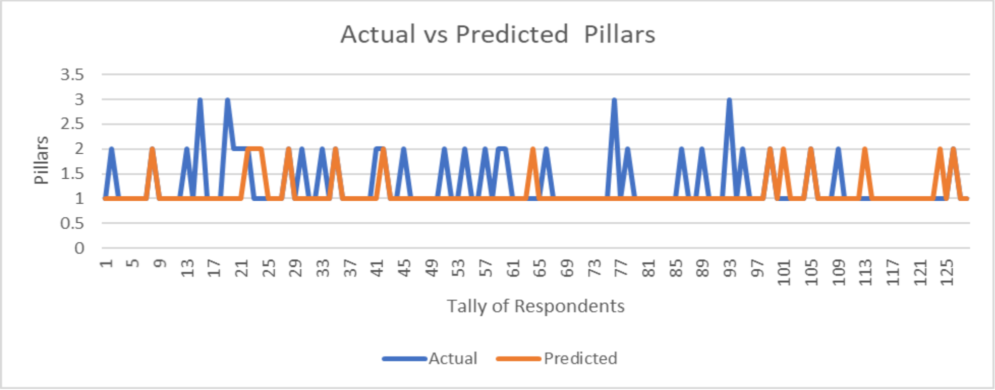
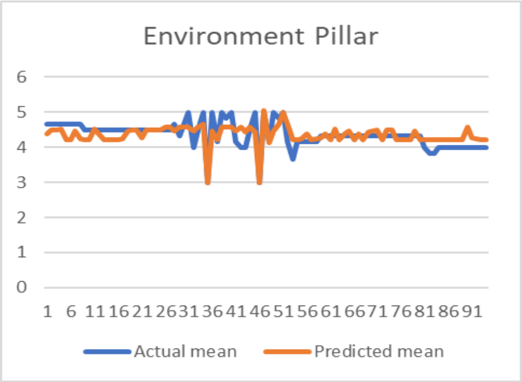


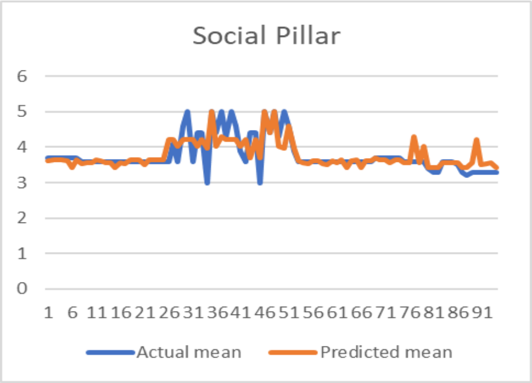
Fig. 12. Actual versus predicted pillars for Random Forest.

Here, the three SD pillars are categorized and coded, with "1" representing the Environmental pillar, "2" the Social pillar, and "3" the Economic pillar. The data show that the Random Forest model has performed well in predicting the SDGs for the testing data. The number of variables sampled at each split is four, as calculated by the *mtry* parameter. The OOBE comes out at 4.72% (Fig. 10). The computed value of mean absolute error (MAE) using the "randomForest" package is 0.26, with accuracy of 96.88%.

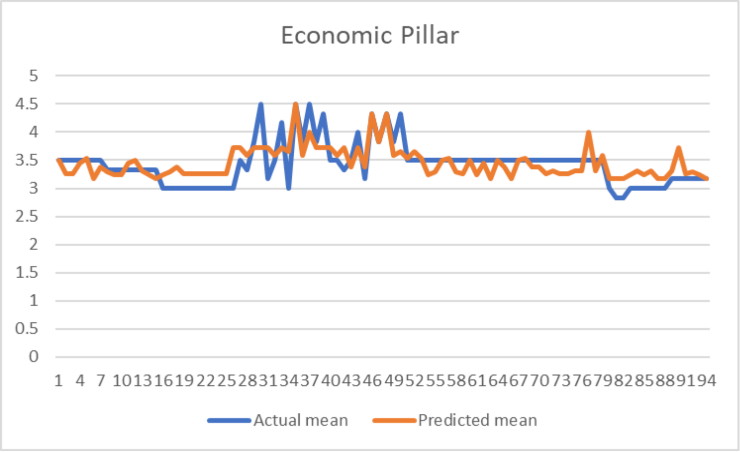
When comparing the resultant values of ANFIS and Random Forest in terms of accuracy, the results indicate that ANFIS can predict SDG preferences with greater accuracy than Random Forest. The MAEof the pillars derived from ANFIS was 0.21, 0.20, and 0.184 for the Economic, Environmental, and Social pillars, respectively. This is less than the mean drawn from Random Forest, which calculates it as 0.26 by comparing the actual and predicted test values. Thus, ANFIS has a better predictive capability than Random Forest for the given data.



(a)



(b)



(c)

Fig. 13. Actual versus predicted means for three pillars in ANFIS: (a) Environmental pillar, (b) Social pillar, and (c) Economic pillar.

Table 5. Ranked SD pillar comparison (Asian vs. Serbian)

(Predicted by arithmetic mean value)	Ranked SD pillar

	Asian Youth	Serbian Youth[a)]
1st	Environmental (4.30)	Environmental (4.20)
2nd	Social (3.779)	Social (4.121)
3rd	Economic (3.456)	Economic (3.94)

[a)]From the study of Petković et al. [16].

Table 5 shows the comparative mean results obtained for Asian youth and Serbian youth. The results clearly show that youth perceive environmental sustainability as the topmost priority, followed by social and economic sustainability.

5.1 Implications

The main aim of this study was to furnish evidence on the successful application of machine learning techniques to highlight youth's opinions about a sustainable future. This was achieved by collecting online data and analyzing it using SPSS and prediction by two models, namely Random Forest and ANFIS, which were applied through R and MATLAB respectively. The practical contribution of this study’s findings is that they provide much-needed evidence of the suitability of machine learning techniques in helping governments to identify gaps in policy and connect with the young population. This could be expanded globally and the outcomes used to present a case at the United Nations. Secondly, this study’s findings prove that the two proposed models are suitable for use in similar domains, and countries which follow this could invest in machine learning technologies for research purposes.

6. Conclusion

The 2030 Agenda, paragraph 53 [43], clearly highlights that the future belongs to youth, and with them lies the fate of our planet. Youth are the instruments of change, and their opinion is valuable for achieving sustainability. However, progress is uneven due to such issues as limited awareness and political inclusion, high levels of poverty, and discrimination. This study was conducted with Asian youth to identify their preferences among the three SD pillars. The mean results show the same preferences among youth from Serbia and Asia, and particularly India. In other words, the Environment pillar is the uppermost object of attention among Asian and Serbian youth, followed by the Social and Economic goals. These predictions, however, cannot replace discussions with youth, but they could propel discussion in the direction that holds most importance in the minds of young people. This study’s findings should induce Asia’s policy-makers to intensify their focus on youth as a resource for SD and to practically plan ahead and engage their opinions by encouraging research and entrepreneurship opportunities. The two famous predictive models of machine learning, ANFIS and Random Forest, validate the results. Thus, our study provides substantial evidence of the predictive accuracy of the ANFIS and Random Forest models for the three categories of SD.

7. Future Scope and Limitations

This study offers the following directions for future research. First, future studies could be conducted with a larger sample of global respondents to increase the findings’ generalizability. Second, future studies could apply different machine learning models to predict youth preferences for the betterment of national policies and SD strategies. Third, future studies could explore a mixed methodological approach to data collection involving the use of secondary sources of information and interviews to generate better insights. In addition, different tools other than the one employed in this study could be used to run the models based on a machine learning algorithm. This is because the machine learningalgorithms used in this study came with a set of limitations, as ANFIS models tend to overfit, while the Random Forest algorithm is known while the Random Forest algorithm is known to consume huge memory with the increase of dataset as well as it increases difficulty in interpretability. The methodology used in this study was based on the results of a survey questionnaire based on a 5-point Likert scale. Future studies may derive additional and more detailed insights by using text responses analyzed through text mining models.

Author's Contributions

Conceptualization, LG, UB,NP. Funding acquisition, NZJ, SV, MFI, WK. Investigation and methodology, LG, UB, NP, GS, SS, NZJ. Project administration, LG, NZJ, GS, SV, K. Resources, LG, UB, NZJ, GS, WK. Supervision, LG, NZJ, SV, AS. Writing of the original draft, LG, UB. Writing of the review and editing, GS, SS, NZJ, NP. Software, LG, AS, UB. Validation LG, UB, GS, NZJ. Formal Analysis LG, UB, NP, FI, WK. Data Curation LG, UB, GS, NZJ. Visualization LG, UB, GS, NZJ. All the authors have proofread the final version.

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Competing Interests

The authors declare that they have no competing interests.

References

[1] P. Solis, B, McCusker, N. Menkiti, N. Cowan, and C. Blevins, "Engaging global youth in participatory spatial data creation for the UN sustainable development goals: the case of open mapping for malaria prevention," *Applied Geography*, vol. 98, pp. 143-155, 2018.

[2] J. Weststrate, G. Dijkstra, J. Eshuis, A. Gianoli, and M. Rusca, "The sustainable development goal on water and sanitation: learning from the millennium development goals," *Social Indicators Research*, vol. 143, no. 2, pp. 795-810, 2019.

[3] M. Shahbaz, M. A. Nasir, and D. Roubaud, "Environmental degradation in France: the effects of FDI, financial development, and energy innovations," *Energy Economics*, vol. 74, pp. 843-857, 2018.

[4] T. MacNeill and D. Wozniak, "The economic, social, and environmental impacts of cruise tourism," *Tourism Management*, vol. 66, pp. 387-404, 2018.

[5] M. Azam and S. A. Raza, "Financial sector development and income inequality in ASEAN-5 countries: does financial Kuznets curve exists?," *Global Business and Economics Review*, vol. 20, no. 1, pp. 88-114, 2018.

[6] Young Leaders, "SDG Young Leaders," 2018 [Online]. Available: https://www.sdgyoungleaders.org/personal-growth/sdg-young-leaders/.

[7] European Youth Ideas (2018) Future of Europe: What's the role for young people?https://www.europeanyouthideas.eu/future-europe-what%E2%80%99s-role-young-people. Accessed 30 March 2020.

[8] J. Kim, "Voices of youth in reconceptualising and repositioning the role of mobile learning for sustainable development," *Information Technology for Development*, vol. 26, no. 4, pp. 711-727, 2020.

[9] A. Nasr-Allah, A. Gasparatos, A. Karanja, E. B. Dompreh, S. Murphy, C. M. Rossignoli, M. Phillips, and H. Charo-Karisa, "Employment generation in the Egyptian aquaculture value chain: implications for meeting the sustainable development goals (SDGs)," *Aquaculture*, vol. 520, article no. 734940, 2020. https://doi.org/10.1016/j.aquaculture.2020.734940

[10] I. Batra, S. Verma, A. Malik, Kavita, U. Ghosh, J. J. Rodrigues, G. N. Nguyen, A. S. M. Sanwar Hosen, and V. Mariappan, "Hybrid logical security framework for privacy preservation in the green internet of things," *Sustainability*, vol. 12, no. 14, article no. 5542, 2020. https://doi.org/10.3390/su12145542

[11]G. Philippidis, L. Shutes, R. M'Barek, T. Ronzon, A. Tabeau, and H. Van Meijl, "Snakes and ladders: world development pathways' synergies and trade-offs through the lens of the Sustainable Development Goals," *Journal of Cleaner Production*, vol. 267, article no. 122147, 2020. https://doi.org/10.1016/j.jclepro.2020.122147

[12] J. Picatoste, L. Perez-Ortiz, and S. M. Ruesga-Benito, "A new educational pattern in response to new technologies and sustainable development: enlightening ICT skills for youth employability in the European Union," *Telematics and Informatics*, vol. 35, no. 4, pp. 1031-1038, 2018.

[13] S. Verma and A. C. Petersen, "Developmental science and pathways to sustainable development for children and youth," in *Developmental Science and Sustainable Development Goals for Children and Youth*. Cham, Switzerland: Springer, 2018, pp. 1-35.

[14] F. Zamora-Polo, J. Sanchez-Martín, M. Corrales-Serrano, and L. Espejo-Antunez, "What do university students know about sustainable development goals? A realistic approach to the reception of this UN program amongst the youth population," *Sustainability*, vol. 11, no. 13, article no. 3533, 2019. https://doi.org/10.3390/su11133533

[15] A. Rexhepi, S. Filiposka, and V. Trajkovik, "Youth e-participation as a pillar of sustainable societies," *Journal of Cleaner Production*, vol. 174, pp. 114-122, 2018.

[16] J. Petkovic, N. Petrovic, I. Dragovic, K. Stanojevic, J. A. Radakovic, T. Borojevic, and M. Kljajic Borstnar, "Youth and forecasting of sustainable development pillars: an adaptive neuro-fuzzy inference system approach," *PloS One*, vol. 14, no. 6, article no. e0218855, 2019.https://doi.org/10.1371/journal.pone.0218855

[17] A. Cutter, D. Osborn, J. Romano, and F. Ullah, "Sustainable development goals and integration: achieving a better balance between the economic, social and environmental dimensions," 2015 [Online]. Available: https://sf.stakeholderforum.org/index.php/news/617-sustainable-development-goals-sdgs-and-integration-achieving-a-better-balance-between-the-economic-social-and-environmental-dimensions.

[18] D. Le Blanc, "Towards integration at last? The sustainable development goals as a network of targets," *Sustainable Development*, vol. 23, no. 3, pp. 176-187, 2015.

[19] B. Vijayalakshmi, K. Ramar, N. Z. Jhanjhi, S. Verma, M. Kaliappan, K. Vijayalakshmi, S. Virmal, Kavita, and U. Ghosh, "An attention-based deep learning model for traffic flow prediction using spatiotemporal features towards sustainable smart city," *International Journal of Communication Systems*, vol. 34, no. 3, article no. e4609, 2021.https://doi.org/10.1002/dac.4609

[20] G. Yang, M. A. Jan, A. U. Rehman, M. Babar, M. M. Aimal, and S. Verma, "Interoperability and data storage in internet of multimedia things: investigating current trends, research challenges and future directions," *IEEE Access*, vol. 8, pp. 124382-124401, 2020.

[21] A. P. Singh, N. R. Pradhan, S. Agnihotri, N. Jhanjhi, S. Verma, U. Ghosh, and D. Roy, "A novel patient-centric architectural framework for blockchain-enabled healthcare applications," *IEEE Transactions on Industrial Informatics*, vol. 17, no. 8, pp. 5779-5789, 2021.

[22]M. Nilashi, F. Cavallaro, A. Mardani, E. K. Zavadskas, S. Samad, and O. Ibrahim, "Measuring country sustainability performance using ensembles of neuro-fuzzy technique," *Sustainability*, vol. 10, no. 8, article no. 2707, 2018. https://doi.org/10.3390/su10082707

[23]I. Batra, S. Verma, and M. Alazab, "A lightweight IoT-based security framework for inventory automation using wireless sensor network," *International Journal of Communication Systems*, vol. 33, no. 4, article no. e4228, 2020.https://doi.org/10.1002/dac.4228

[24] M. K. Tiwari, S. Bajpai, and U. K. Dewangan, "Prediction of industrial solid waste with ANFIS model and its comparison with ANN model: a case study of Durg-Bhilai twin city India," *International Journal of Engineering and Innovative Technology (IJEIT)*, vol. 6, no. 2, pp. 192-201, 2012.

[25] D. K. Sharma, L. Gaur, and D. Okunbor, "Image compression and feature extraction using Kohonen's self-organizing map neural network," *Journal of Strategic E-Commerce*, vol. 5, no. 1-2, pp. 25-38, 2007.

[26] K. Anshu and L. Gaur, "E-satisfaction estimation: a comparative analysis using AHP and intuitionistic fuzzy TOPSIS," *Journal of Cases on Information Technology (JCIT)*, vol. 21, no. 2, pp. 65-87, 2019.

[27] L. Breiman, "Random forests," *Machine Learning*, vol. 45, no. 1, pp. 5-32, 2001.
[28] J. Bebbington and J. Unerman, "Achieving the United Nations sustainable development goals," *Accounting, Auditing & Accountability Journal*, vol. 31, no. 1, pp. 2-24, 2018.
[29] A. L. Salvia, W. Leal Filho, L. L. Brandli, and J. S. Griebeler, "Assessing research trends related to Sustainable Development Goals: local and global issues," *Journal of Cleaner Production*, vol. 208, pp. 841-849, 2019.
[30] W. Leal Filho, U. Azeiteiro, F. Alves, P. Pace, M. Mifsud, L. Brandli, S. S. Caeiro, and A. Disterheft, "Reinvigorating the sustainable development research agenda: the role of the sustainable development goals (SDG)," *International Journal of Sustainable Development & World Ecology*, vol. 25, no. 2, pp. 131-142, 2018.
[31] P. Rani, S. Verma, and G. N. Nguyen, "Mitigation of black hole and gray hole attack using swarm inspired algorithm with artificial neural network," *IEEE Access*, vol. 8, pp. 121755-121764, 2020.
[32] L. Zu, "Fostering social innovation and youth entrepreneurship for the achievement of the UN 2030 agenda: the Chinese way," in *The Future of the UN Sustainable Development Goals*. Cham, Switzerland: Springer, 2020, pp. 341-365.
[33] I. K. Ogamba, "Millennials empowerment: youth entrepreneurship for sustainable development," *World Journal of Entrepreneurship, Management and Sustainable Development*, vol. 15, no. 3, pp. 267-278, 2019.
[34] G. J. Jones, M. B. Edwards, J. N. Bocarro, P. G. Svensson, and K. Misener, "A community capacity building approach to sport-based youth development," *Sport Management Review*, vol. 23, no. 4, pp. 563-575, 2020.
[35] S. A. Rye and S. Vold, "International development aid and young people's participation in societal development of the global south," *Children's Geographies*, vol. 17, no. 3, pp. 321-333, 2019.
[36] S. A. Gill, R. Aftab, S. U. Rehman, and S. Javaid, "Youth empowerment and sustainable development: an evidence from Pakistan's Prime Minister's Youth Program," *Journal of Economic and Administrative Sciences*, vol. 35, no. 3, pp. 202-219, 2019.
[37] W. Ripple, C. Wolf, T. Newsome, P. Barnard, W. Moomaw, and P. Grandcolas, "World scientists' warning of a climate emergency," *BioScience*, vol. 70, no. 1, pp. 8-12, 2020. https://doi.org/10.1093/biosci/biz088
[38] T. M. Lenton, J. Rockstrom, O. Gaffney, S. Rahmstorf, K. Richardson, W. Steffen, and H. J. Schellnhuber, "Climate tipping points: too risky to bet against," *Nature*, vol. 575, no. 7784, pp. 592-595, 2019.
[39] D. Tong, Q. Zhang, Y. Zheng, K. Caldeira, C. Shearer, C. Hong, Y. Qin, and S. J. Davis, "Committed emissions from existing energy infrastructure jeopardize 1.5 C climate target," *Nature*, vol. 572, no. 7769, pp. 373-377, 2019.
[40] A. Hussain, S. Nazir, F. Khan, L. Nkenyereye, A. Ullah, S. Khan, and S. Verma, "A resource efficient hybrid proxy mobile IPv6 extension for next generation IoT networks," *IEEE Internet of Things Journal*, 2021. https://doi.org/10.1109/JIOT.2021.3058982
[41] A. Ait Sidhoum and T. Serra, "Corporate sustainable development: revisiting the relationship between corporate social responsibility dimensions," *Sustainable Development*, vol. 26, no. 4, pp. 365-378, 2018.
[42] S. Spierling, E. Knupffer, H. Behnsen, M. Mudersbach, H. Krieg, S. Springer, S. Albrecht, C. Herrmann, and H. J. Endres, "Bio-based plastics: a review of environmental, social and economic impact assessments,"*Journal of Cleaner Production*, vol. 185, pp. 476-491, 2018.
[43] United Nations, "Transforming our world: the 2030 Agenda for Sustainable Development," 2015 [Online]. Available: https://sdgs.un.org/2030agenda.
[44] UNESCO, "Qian Tang (2010-2018), Former UNESCO Assistant Director-General for Education," 2019 [Online]. Available: https://en.unesco.org/themes/education/about-us/assistant-director-general-for-education/list.
[45] A. Takala and K. Korhonen-Yrjanheikki, "A decade of Finnish engineering education for sustainable development," *International Journal of Sustainability in Higher Education*, vol. 20, no. 1, pp. 170-186, 2019.
[46] M. Ozturk, "Response of educational research in Turkey to the UN Decade of Education for Sustainable Development," *Asia Pacific Education Review*, vol. 19, no. 4, pp. 573-586, 2018.
[47] A. Agarwal, "Gandhi, ecology and the last person," in 13th Gandhi Peace Foundation Lecture.

1987.https://www.cseindia.org/page/major-lectures.

[48] S. Chaudhuri, "What is to be done? Economies of knowledge," *Thesis Eleven*, vol. 105, no. 1, pp. 7-22, 2011.

[49] V. Singhal, S. S. Jain, D. Anand, A. Singh, S. Verma, S., Rodrigues, et al., "Artificial intelligence enabled road vehicle-train collision risk assessment framework for unmanned railway level crossings," *IEEE Access*, vol. 8, pp. 113790-113806, 2020.

[50] H. Kopnina, "Education for the future? Critical evaluation of education for sustainable development goals," *The Journal of Environmental Education*, vol. 51, no. 4, pp. 280-291, 2020.

[51] L. Y. Xavier, P. R. Jacobi, and A. Turra, "Local Agenda 21: planning for the future, changing today," *Environmental Science & Policy*, vol. 101, pp. 7-15, 2019.

[52]United Nations, "2017 Voluntary National Reviews (VNRs) at the High Level Political Forum on Sustainable Development," 2017 [Online]. Available:https://sustainabledevelopment.un.org/content/documents/16665Compilation_of_Executive_Summaries_2017_VNRs.pdf.

[53] United Nations, "Report of the Secretary-General: International youth year: participation, development, peace (A/36/215)," 1981 [Online]. Available: https://undocs.org/en/A/36/215.

[54] A. McKay, C. Mussida, and L. Veruete, "The challenge of youth employment in Asia: lessons from four fast-growing economies," *The World Economy*, vol. 41, no. 4, pp. 1045-1067, 2018.

[55] I. M. Krishna, V. Manickam, A. Shah, and N. Davergave, *Environmental Management: Science and Engineering for Industry*. Cambridge, MA: Butterworth-Heinemann, 2017.

[56] Government of India, "India is one of the youngest countries in the world," 2019 [Online]. Available: https://www.mygov.in/newindia/wp-content/uploads/2017/09/newindia301634_1504694260.pdf.

[57] S. H. Kok, A. Abdullah, N. Z. Jhanjhi, and M. Supramaniam, "A review of intrusion detection system using machine learning approach," *International Journal of Engineering Research and Technology*, vol. 12, no. 1, pp. 8-15, 2019.

[58] M. Ahmad, N. Zaman, and M. Al-Amin, "An experimental research in health informatics for enhancing ovarian cancer identification in ovarian imaging analysis using fuzzy histogram equalization," *Journal of Medical Imaging and Health Informatics*, vol. 7, no. 6, pp. 1385-1390, 2017.

[59] M. Malkawi and O. Murad, "Artificial neuro fuzzy logic system for detecting human emotions," *Human-centric Computing and Information Sciences*, vol. 3, article no. 3, 2013. https://doi.org/10.1186/2192-1962-3-3

[60] F. R. Lima-Junior and L. C. R. Carpinetti, "An adaptive network-based fuzzy inference system to supply chain performance evaluation based on SCOR metrics," *Computers & Industrial Engineering*, vol. 139, article no. 106191, 2020. https://doi.org/10.1016/j.cie.2019.106191

[61] Y. Li, W. Dong, Q. Yang, S. Jiang, X. Ni, and J. Liu, "Automatic impedance matching method with adaptive network based fuzzy inference system for WPT," *IEEE Transactions on Industrial Informatics*, vol. 16, no. 2, pp. 1076-1085, 2019.

[62] A. Singh, P. Nath, V. Singhal, D. Anand, S. Verma, and T. P. Hong, "A new clinical spectrum for the assessment of nonalcoholic fatty liver disease using intelligent methods," *IEEE Access*, vol. 8, pp. 138470-138480, 2020.

[63] O. O. Akinade and L. O. Oyedele, "Integrating construction supply chains within a circular economy: an ANFIS-based waste analytics system (A-WAS)," *Journal of Cleaner Production*, vol. 229, pp. 863-873, 2019.

[64] V. D. Kouloumpis, V. S. Kouikoglou, and Y. A. Phillis, "Sustainability assessment of nations and related decision making using fuzzy logic," *IEEE Systems Journal*, vol. 2, no. 2, pp. 224-236, 2018.

[65]Y. Tan, C. Shuai, L. Jiao, and L. Shen, "Adaptive neuro-fuzzy inference system approach for urban sustainability assessment: a China case study," *Sustainable Development*, vol. 26, no. 6, pp. 749-764, 2018.

[66] J. S. Jang, "ANFIS: adaptive-network-based fuzzy inference system," *IEEE Transactions on Systems, Man, and Cybernetics*, vol. 23, no. 3, pp. 665-685, 1993.

[67] K. Anshu, L. Gaur, and D. Khazanchi, "Evaluating satisfaction level of grocery E-retailers using intuitionistic fuzzy TOPSIS and ECCSI model," in *Proceedings of 2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions)(ICTUS)*, Dubai, UAE,

2017, pp. 276-284.

[68] J. Vanus, M. Smolon, R. Martinek, J. Koziorek, J. Zidek, and P. Bilik, "Testing of the voice communication in smart home care," *Human-centric Computing and Information Sciences*, vol. 5, article no. 15, 2015. https://doi.org/10.1186/s13673-015-0035-0

[69] M. Treude, D. Schostok, O. Reutter, and M. Fischedick, "The future of North Rhine-Westphalia-participation of the youth as part of a social transformation towards sustainable development," *Sustainability*, vol. 9, no. 6, article no.1055, 2017. https://doi.org/10.3390/su9061055

[70] M. Sood, S. Verma, and V. K. Panchal, "Optimal path planning using swarm intelligence based hybrid techniques," *Journal of Computational and Theoretical Nanoscience*, vol. 16, no. 9, pp. 3717-3727, 2019.

[71] G. Yang, M. A. Jan, A. U. Rehman, M. Babar, M. M. Aimal, and S. Verma, "Interoperability and data storage in internet of multimedia things: investigating current trends, research challenges and future directions," *IEEE Access*, vol. 8, pp. 124382-124401, 2020.