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SOVEREIGN GREEN BOND ISSUANCES AS A SILVER-BULLET TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS IN THE EAST AND SOUTH ASIAN NATIONS

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Abstract

Access to voluminous amount of funds is a pre-requisite for the successful achievement of the Sustainable Development Goals (SDGs) by the year 2030. In this regard, Green Bonds have the prospective to narrow down a sovereign's fiscal deficits at comparable lower yields. This paper attempts to draw a linkage between the proceeds from green bond issuances and the SDGs, viz. Clean water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Industry, Innovation and Infrastructure (SDG 9), Sustainable Cities and Communities (SDG 11), Climate Action (SDG 13) and Life on Land (SDG 15). Subsequently, we argue that the global green bond issuances can be a viable financial instrument for tapping the domestic and foreign capital in order to achieve the six SDGs. This article has the potential to forward the green bond literature in the East and South Asian geographical domain by developing an econometric relationship between green bonds and SDGs. For this study, the authors have collected data from Bloomberg, Thomson Reuters, government websites and think-tank reports for the period 2015-22. Further, this is a pioneering work to investigate the established cause-effect relationship using machine learning algorithms, namely Random Forest and Support Vector Machine in the Python programming platform. The outcome of this work offers novel and constructive evidence for the East and South Asian countries, viz. India, China, Thailand, Malaysia and Singapore, because the study endorses the debt markets as an alternative to the equity products for accumulating assets pertaining to achievement of their respective Nationally Determined Contributions (NDCs). This, in turn supports the view that more number of nations are planning their own sovereign climate bond issuances as part of the Paris Climate Agreement and other commitments related to global warming.

Keywords: Green Bonds, Sustainable Development Goals, Paris Agreement, Public Finance

1. INTRODUCTION

As per the United Nations Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report- The Physical Science Basis released in August 2021- "Recent changes in the climate are widespread, rapid and intensifying and unprecedented in thousands of years." No region of the planet Earth has been left untouched by the vagaries of this crisis. To limit and restrain the global warming phenomena, drastic and rapid reductions in the greenhouse gas emissions like CO_2, CH_4, etc. are necessitated to arrest the global surface temperatures below 1.5^oC and 2^oC.

Accordingly, two landmark developments by the United Nations in the year 2015 viz. Agenda 2030- 17 Sustainable Development Goals (SDGs) and Paris Agreement on climate change showed the global universe that we all together have the potential to perform more affluent, justifiable and balanced activities for our future generations. Subsequently, the Addis Ababa Action Agenda (AAAA) provided a wide-ranging policy actions to be adopted by 196 member countries for financing the measures required to achieve the SDGs. However, just on the threshold of the Decade of Action (2020-30), the entire world had been grappled with the menace of COVID-19 which brought with it not only health related shocks but also economic and commercial downturns namely declining manufacturing production, shutdown in various sectors due to lockdown measures, cynicism in the concept of globalization and mounting liability distress along with more unembellished climate related tremors.

Considering the global macroeconomic environment and focus areas to succeed the Millennium Development Goals, the United Nations General Assembly in the year 2015 formulated the SDGs with a vision for a prosperous and sustainable future for all generations to come. Also known as Global Goals, these are compilation of 17 interconnected goals to be achieved between the years 2020 and 2030. A closer look at the 17 SDGs point out to the fact that the goals are not mutually exclusive of each other, for e.g. (SDG2, Target 2.1) safe, nutritious and sufficient food for all can only be achieved by taking proper preservation of water including conservation of floral and faunal species- a combination of (SDGs 6,14 and 15). The most critical goal seems to be Climate Action (SDG 13)- any worsening of climate related parameters has the potential to effect food production (SDG 2), health related effects (SDG 3), drinkable water and hygienic conditions (SDG 6), renewable energy (SDG 7), habitable neighbourhoods (SDG 11) and life at various ecosystems (SDG 14 and 15). Hence, climate mitigation and adaptation techniques has been the emphasis of various global think-tanks which in turn can positively impact all the countries to successfully achieve the SDGs.

India has a unique place in the global scenario- being the seventh largest, most populous, largest democracy, home to 1300+ languages and most importantly a sovereign state with a burgeoning youth population. This embodiment of Unity in Diversity makes India a prime-example wherein the developmental initiatives intersects with the focus areas of the SDG framework. In order to achieve the SDGs, the country has made a determined shift towards 'whole-of-society' model by including not only the Central Ministries, 28 States and 9 Union Territories; but also building an inclusive approach with thousands of civil society organizations, supranational institutions, business communities, including the private sector. Believing in our vision of taking everyone together, India is also at the forefront in assisting other developing countries through the $150 million India-UN Development Partnership Fund. Having crossed 33% of the time to achieve the SDGs as started in the year 2015, all the 196 affiliate countries are evaluating the progress made under the SDG framework. Innovative strategies and solutions are being comprehended in this Decade of Action to hasten the process of success and remove any impediments for its execution. India too is also not far behind. National Institution for Transforming India (NITI) Aayog, the nodal institution for implementing and monitoring the SDGs has played a leading role in its overall design and framework. As per the Constitutional mandate, India is a federal state wherein the powers have been segregated between the Union and the States/ UTs. But for the proper fulfilment of the SDG action agenda, continuous feedback and review at national level and sub-national levels of our governance structure is the need of the hour.

As per China's progress report on the implementation of the SDGs, three pillars form the basis for the SDG achievements: reducing poverty, forming a sustainable civilization and improving governance structures. The Chinese government is focussing on renewable energy initiatives and carbon-less infrastructure along with increasing overall forest cover. Achieving the SDGs have a great significance in the Chinese Five-Year plans, which helps in inter-departmental coordination and proper division of labour. Radical solutions from the local Chinese communities are also given due importance in making this effort an all-inclusive endeavour which is home to the world's largest population.

The SDGs include targets to be accomplished for all macroeconomic indicators in a country, viz. health, unemployment, education, environment, sanitation and energy. The challenges to achieve the SDGs are both complex and enormous in magnitude. Hence, all the sectors and actors in the economy is bound to work in tandem to achieve an inclusive and sustainable development. The collaborative effort among governments, Non-Government Organizations (NGOs)/ Civil Society Organizations (CSOs), the United Nations, etc. become more significant

as the entire global community is struggling to recover from the COVID-19 pandemic. Though all the individual countries under analysis has made significant strides in attaining time-bound targets, this study examines the pace of their progress in an evidence - based manner.

Though all the individual countries have taken various initiatives to combat the COVID-19 pandemic, specific announcement of policies and their impact on various SDGs has been studied for India. The COVID-19 pandemic has affected livelihoods, more specifically, the health infrastructure of the country. Various initiatives that have been taken by GoI has been categorized into the achievement of SDG goals (see Figure 1) to address the shocks brought about by this natural phenomenon. These steps, along with the measures introduced by the respective state governments, have gone a long way in addressing the impact of this pandemic and kept India on its course to become a $ 5 trillion economy (Suman and Rasleen, 2020).

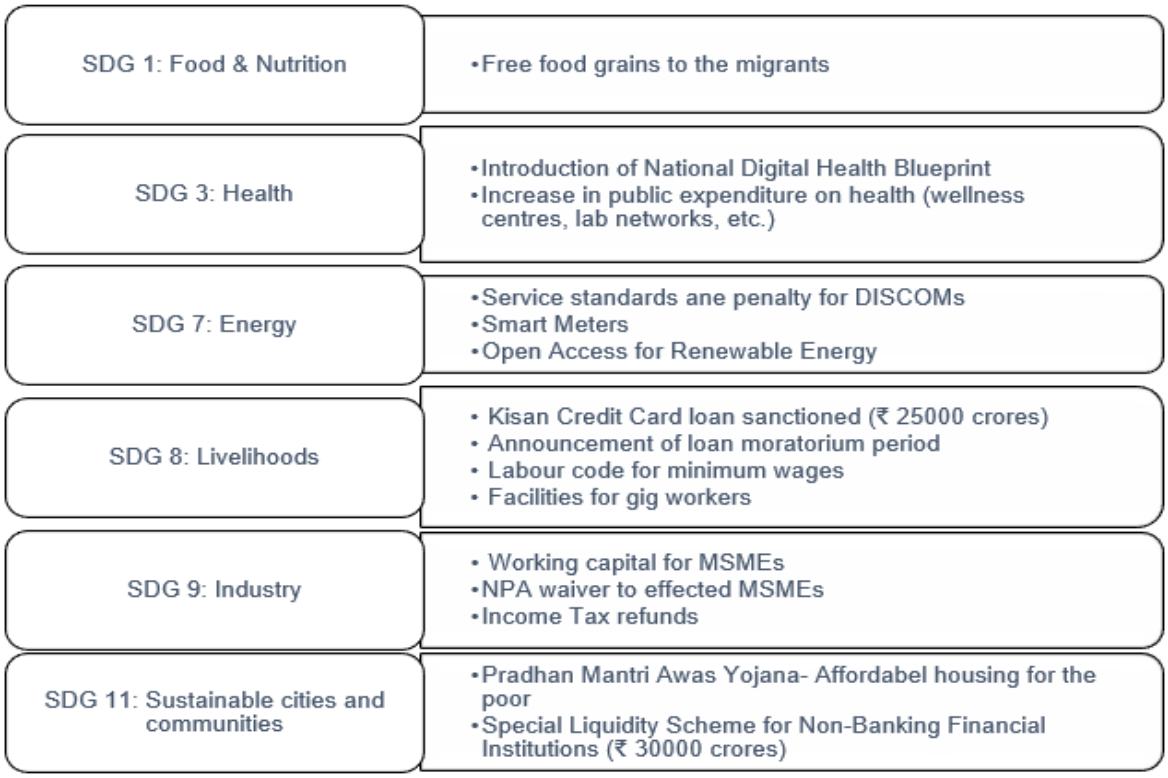


Figure 1: Actions taken by GoI to counter Covid related stress

Source: Compilation of Government of India Press Releases

Table 1: SDG Achievements for the East & South Asian countries considered for study

Countries	SDG Index Score (out of 100)	SDG Index Rank (out of 163 countries)
India	60.3	121
China	72.4	56
Malaysia	70.4	72
Thailand	74.1	44
Singapore	71.7	60

Source: United Nations Sustainable Development Report 2022

Section 2 in this research paper deals with the basics of Green Bonds, its principles, taxonomies along with the mapping between Green Bonds issuances and the related SDGs. Section 3 focuses on the academic views on green bonds pertaining to the aspects of greenium, the impact

of green bonds issuances on stock prices and the different methodologies used in various literatures to study these phenomena. Section 4 & 5 describes the data used in this study and the machine learning algorithms utilized to develop the relationship between SDGs and green bond markets.

1.1 Green Bonds

As per International Capital Market Association (ICMA) Green Bond Principles 2021 (as updated from time to time), these are debt instruments wherein the eligible green projects pertaining to renewable energy, energy efficiency, pollution prevention and control, environmentally sustainable management of living natural resources and land use, terrestrial and aquatic biodiversity, clean transportation, sustainable water and wastewater management, climate change adaptation, circular economy adapted products, production technologies, processes and green buildings can be financed/ re-financed with the proceeds obtained from the issuance of green bonds.

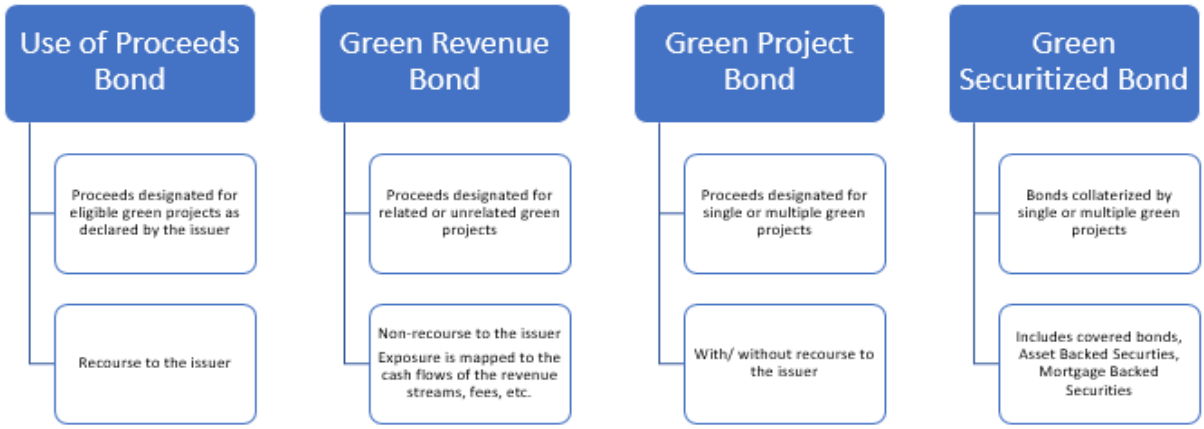


Figure 2: Taxonomy associated with the Green Bond Principles

Source: (ICMA GBP 2021), (Ntsama et al, 2021)

Clarity, Accountability and Veracity are the underlying pillars to the stakeholders involved in understanding the characteristics of issuance of Green Bonds. Such a clear roadmap pertaining to Green Bonds are provided by the ICMA released Green Bonds Principles (GBPs) which enumerates four essential components as follows:

Table 2: Components and its corresponding guidelines for Green Bonds

Components	Guidelines
Use of Proceeds	Utilization of proceeds to be clearly mentioned in the legal documentation of the debt instrument Proper evaluation and quantification of the environmental benefits to be provided for the eligible green projects
Process for Project Evaluation and Selection	Issuer to provide the environmental sustainability objectives and the processes to achieve those along with additional complimentary information on the risk involved for the eligible green projects
Management of Proceeds	Net proceeds to be credited to a separate account and regularly checked by an external auditor to ensure the proper intended allocation of funds Proceeds can be managed on an individual basis or portfolio approach
Reporting	Annual statements to be made on the amounts allocated and the tentative impact assessment of the green projects. Harmonized Framework for Impact Reporting to be followed for the use of qualitative and quantitative performance indicators

Source: Extracts from ICMA, GBP 2021 and Authors' Edition

1.2 Novelties of the present work

This study is a ground-breaking work to comprehend the plotting of SDGs with the volume growth of green bonds in an econometric set-up. Mapping of green bonds with the achievable SDGs and the subsequent, use of machine-learning algorithms in the domain of green bonds and SDGs is an original effort, especially in the context of East and South Asian nations.

2. LITERATURE REVIEW

The focal point of recent empirical literature has been the assessment in the pricing structure of green bonds and existence of green bond premium. Greenium refers to the fact that green bonds can be issued at lower yields in comparison to the yields of conventional bonds. Though it appears to be a win-win situation for both the issuers and investors, there is no unanimity in the academic domain on existence of such a premium. Considering a sample size of 110 green bonds, Zerbib (2019) concluded a premium of about 0.02% owing to the investing community's willingness to accept lower risk-adjusted returns for contributing to projects that are environment friendly. Gianfrate and Peri (2019) also confirmed the greenium evidence using propensity score matching on a sample size of 121 green bonds in the market based on European Union. Various studies using the regression model techniques has also contributed to the pricing of green bonds being tighter than traditional bonds [Karpf and Mandel (2018), Nanayakkara and Colombage (2019), Zerbib (2019), Patridge and Medda (2020), Immel et.al (2021)]. On the contrary, evidence of conventional bonds being cheaper than green bonds was found by Febi et. al (2018), Hachenberg and Schiereck (2018), Bachelet et. al (2019).

The development of a particular product in the capital markets depends on its interconnectedness with other financial products. Some studies on the price spillovers of green bonds vis-à-vis other financial instruments based on the regression model framework and their findings is presented below (see Table 3):

Table 3: Methodologies and Findings in the papers on Green Bonds

Author (s) Year	Methodology	Brief Findings
Daszynska-Zygadlo et. al (2018)	Multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH)	Significant correlation with conventional bonds
Draksaite et. al. (2018)	Covariation and Regression	
Reboredo and Ugolini (2020)	Structural Vector Autoregressive (VAR)	Correlation with USD foreign exchange markets
Park et. al. (2020)	Dynamic Conditional Correlation-GARCH	Positive relationship with stock markets
Reboredo et. al. (2020)	Structural VAR	Strong correlation with sovereign bonds
Saeed et. al (2021)	Quantile VAR	Green bonds have diversification benefits

Source: Authors Compilation

Though considerable amount of work has focussed on the impact of green bond issuances on the company's stock prices [Baulkaran (2019), Jakubik and Uguz (2021), Tang and Zhang (2020)]; very few studies have analysed the drivers of green bond issuances. One of the pioneer works in this area by Chiesa and Barua (2019) focussed on the company characteristics on the issue size of green bonds. Using a time period 2010-17 on 771 bonds, the study highlighted that green bonds issuances are directly proportional to the credit ratings and inversely proportional to coupon, Return on Assets and Leverage ratio of the issuer. Focussing on the green bonds issued in the Chinese markets, third party certifications/ verifications have been found to lower the financing of green bond issuers [Kai et. al (2020), Deng et. al (2020)]. Dou

and Qi (2019) using the Logit model in the Chinese policy framework environment concluded that the issuance of green bonds have a direct positive correlation with the amount of funds to be invested in green projects.

2.1 Rationale of the Study

Thus, it can be seen that, though various strands of work have been done to understand the connectedness of green bonds with other domains of finance; no significant work has been conducted to understand the achievement of SDGs and its consequent relationship with the drives of green bonds issuances, especially for East and South Asian nations. This paper makes an attempt to map the achievable SDGs with the surging amount of green bond issuances, and then tries to understand the linkage among both these parameters with machine learning algorithms.

3. MATERIALS AND METHODS

Six Sustainable Development Goals where green finance, especially green bonds has the potential to provide explicit advantages has been mapped in this study to develop the econometric relationship (see Figure 3):

Sustainable Development Goals	Objectives to be achieved
SDG 6: Clean Water and Sanitation	To provide potable drinking water for all, sustainable waste water management with low carbon footprint has to be the focal point. SDG 6 accounts for around 11% of green bonds issuance as on June 2018.
SDG 7: Affordable and Clean Energy	Renewable energy has the highest share of 40 % in the green bond market. Financing energy efficient techniques has twofold utility of achieving SDG and country NDCs.
SDG 9: Industry, Innovation and Infrastructure	Focus areas are green buildings and climate resilient transportation. Both included have the 2nd and 3rd highest shares of 24 % and 15 % of green bond market respectively.
SDG 11: Sustainable Cities and Communities	Municipalities and agencies associated with city linked initiatives can be the issuer of green bonds. This SDG can be fulfilled by achieving the targets at other SDGs.
SDG 13: Climate Action	Majority of the green bond issuance has been pertaining to climate mitigation and adaptation techniques.
SDG 15: Life on Land	Major target areas of this SDG are: forestry and biodiversity. Countries having abundance of such ecosystem can issue sector specific green bonds

Figure 3. Achievable SDGs with the proceeds of Green Bonds Issuances

Source: Climate Bonds Initiative & Authors' Compilation

Data for the present study has been considered for the period 2015-22 as the mandated SDG targets to be achieved begin from 2015 onwards. The period also assumes significance considering the increase in green bonds issuances of the East & South Asian countries considered viz. India, China, Thailand, Malaysia and Singapore. Rest of the countries in the geographical region have been excluded as the intensity of green bonds issuances haven't started or picked up to draw any meaningful conclusion related to the cause-effect relationship proposed to be studied. The relevant facts and figures for 2015-22 have been downloaded from the Bloomberg terminal and Thomson Reuters database. Parameters of the countries have been extracted from the respective government websites and policy reports published by their think-tanks for the period under study. Advanced machine learning algorithms- Support Vector Machine and Random Forest has been utilized to construct the linkage between the dependent and independent variables.

In order to achieve the Paris Agreement targets and effective implementation of the SDG objectives, huge amount of funds is required. To understand the determinants of green bond issue, this study makes an effort to construct a cause-effect econometric relationship to understand the association between green bonds issued and subsequent achievement of the related SDGs as given below:

$$Amount\_of\_Green\_Bonds\_issued_t = \alpha + \beta_1 SDG_{6,t} + \beta_2 SDG_{7,t} + \beta_3 SDG_{9,t} + \beta_4 SDG_{11,t} + \beta_5 SDG_{13,t} + \beta_6 SDG_{15,t} + \varepsilon_t \quad \ldots\ldots\ldots(1)$$

where,
α *is the constant*, β_i *are the estimated regression coefficients*,
$SDG_{i,t}$ *are the SDG variables of interest in a particular year* t, ϵ_t *is the error term*

Table 4. Relevant SDGs considered as the Independent variables

Relevant SDGs	Description
SDG- 6	*Clean Water and Sanitation*
SDG- 7	*Affordable and Clean Energy*
SDG- 9	*Industry, Innovation and Infrastructure*
SDG- 11	*Sustainable Cities and Communities*
SDG- 13	*Climate Action*
SDG- 15	*Life on Land*

Source: Authors Compilation

As evident in Equation (1), the variable to be predicted in this study is the amount of green bonds issued in the five countries belonging to the East & South Asian region. These five countries have been selected based on the highest amount of issuances of green bonds and the homogeneity of the time-series data under consideration. On the other hand, the six predictor variables are the mapped SDG index values collected from the United Nations Sustainable Development Reports for the period 2015-22, namely (i) Clean water and Sanitation (SDG 6), (ii) Affordable and Clean Energy (SDG 7), (iii) Industry, Innovation and Infrastructure (SDG 9), (iv) Sustainable Cities and Communities (SDG 11), (v) Climate Action (SDG 13) and (vi) Life on Land (SDG 15).

The choice of the appropriate algorithm depends on the complexity of the data-set and the accurateness of the expected outcomes. Though Neural Network (NN) technique is parametric in nature, it is entirely dependent on the rate of learning and the number of layers in the network. In comparison, the Random Forest (RF) algorithm requires number of trees and forest depth at every level to optimize the complexity of the data, and the Support Vector Machine (SVM) methods has only two parameters. Fewer input data are the requirements of RF and SVM, whereas more data is necessary for better approximation of the results in NN. This in turn, leads to saving of time as there is lesser requirement of categorizing, converting and scaling of data in RF and SVM. Therefore, the methodology adopted in this study are the RF and SVM algorithms and a comparative analysis of both with reference to the data-set used in our study.

The Random Forest (RF) is a type of ensemble learning method in which several basic models are grouped together to obtain the most optimal predictive model. Any model which provides different results with the changes in the training data is considered to have high variance. Bagging or Bootstrap Aggregation or Random Forest is a machine learning technique to reduce

such variances without any hindrance to the biasness in the model (Adnan, 2022). The RF technique is utilized to predict the amount of green bond issuances based on the SDG achievements of the respective East and South Asian countries for the period 2015-22. As the input data is fewer in number, RF algorithm has been implemented as it reduces the model variance without compromising biasness. Given a training set of $X = (x_1, \ldots, x_n)$ with responses $Y = (y_1, \ldots, y_n)$ defined as a set of micro-arrays as: $P = \{(x_1, y_1), \ldots\ldots, (x_n, y_n)\}$ drawn random from an unknown probability distribution $(x_i, y_i) \sim (X, Y)$. The objective is to build a model in which 'x' is predicted from 'y' based on the observations in 'P'. An ensemble of classifiers can be measured as : $Z = \{z_1(x), \ldots\ldots z_n(x)\}$. This ensemble is considered as a random forest if each of these $z_n(x)$ is a decision tree. The classifier $z_n(x)$ in a decision tree may be parametrized as : $\delta_n = (\delta_{n1}, \delta_{n2} \ldots\ldots \ldots \delta_{np})$, which can be written as $z_n(x) = z(x \mid \delta_n)$. Thus, a RF algorithm is defined as a classifier which is founded on a family of classifiers $z(x \mid \delta_1)$, $z(x \mid \delta_2), \ldots\ldots\ldots z(x \mid \delta_n)$ based on a classification tree with variables δ_n randomly chosen from a model random vector δ. RF machine learning technique is preferred for both classification and regression with the construction of multiple decision trees at training time. Being a non-parametric model, it has no formal assumptions to be followed. The average prediction of an individual tree is considered for performing the regression procedure. The efforts of the entire algorithm are pulled together by the creation of random forests (Tan, et al, 2019). Deeply grown tress has the potential to learn highly irregular patterns by overfitting the training data having low bias but considerably low variance. By averaging multiple decision trees, random forests assist in the reduction of this variance by training on numerous fragments of the same training set. This comes at the expense of a slight increment in the bias and loss of interpretability, but significantly enhances the performance in the final model.

Support Vector Machine (SVM) supervised learning algorithm that is used for classification as well as regression problems is based on statistical learning theory. The basic idea of support vector machines is to find the optimal hyperplane that can segregate n-dimensional space. Two separate classes are created by classifying the data points for calculating the distance between the data point groups and increasing the distance among them. There are multiple lines that segregate the classes, but the task is to find the best line that helps to classify the data points. This best line/boundary is known as hyperplane. Dimension of hyperplane depends on the features. The data points or vectors that are the closest to the hyperplane, which affect the position of the hyperplane are termed as Support Vector (Liu and Duan, 2018). Since these vectors support the hyperplane, hence they are called Support vector. Hyperplane is characterised by the following equation:

$$z = \theta^T x + p \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where, θ is vector of constants used to denote the slopes of the plane.

For support vector regression, the main objective is to basically consider the points that are within the decision boundary. The best line is the hyperplane that has a maximum number of points. Suppose, the lines are at a unit distance from the hyperplane. So, these lines are drawn at distance '+1' and '-1' from hyperplane. Then the equation of decision boundary becomes:

$\theta^T x + p = +1$ and $\theta^T x + p = -1$. Thus, any hyperplane that satisfies the support vectors should satisfy: $-1 < z - \theta^T x - p < +1$. The model finally computes the values of p and θ which maximizes the following function:

$$(\theta^*, p^*) max \frac{2}{||\theta^T||} z_i * (\theta^T x_i + p_i) \geq 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

4. RESULTS AND DISCUSSIONS

According to the UNDP SDG scores released for the year 2021, India has the lowest index score on Clean Water and Sanitation (SDG 6); whereas the lowest score on Life on Land (SDG 16) goes to Singapore. All the considered countries have done fairly good on Climate Action (SDG 13) with the lowest score observed for Singapore. As regards Affordable and Clean Energy (SDG 7), China has the lowest SDG index score for the year 2021. It gives an indication that much work still needs to be done in the Decade of Action (2020-30) and for which huge amount of dedicated financial resources are required.

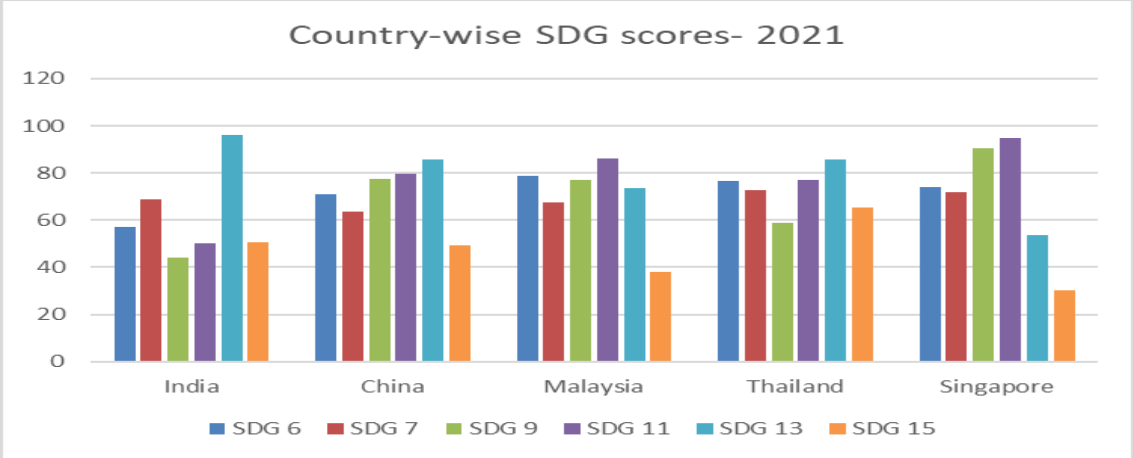


Figure 4: Overall SDG scores of the countries for the year 2021

Source: UN Database and Authors' Compilation

Though all the SDGs are relevant with respect to the issue on climate mitigation and adaptation, the SDGs having a cascading effect on climate change theme may include SDG6- Clean Water & Sanitation, SDG7- Affordable & Clean Energy, SDG9- Industry Innovation & Infrastructure, SDG11- Sustainable Cities and SDG15- Life on Land.

To understand the linkages between green bonds and SDG index scores, RF and SVM codes have been implemented in the Python programming platform. As both these machine learning algorithms provide meaningful information on the patterns in the data considered, Mean Squared Error (MSE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and R-square (R^2) are compared with respect to both these techniques.

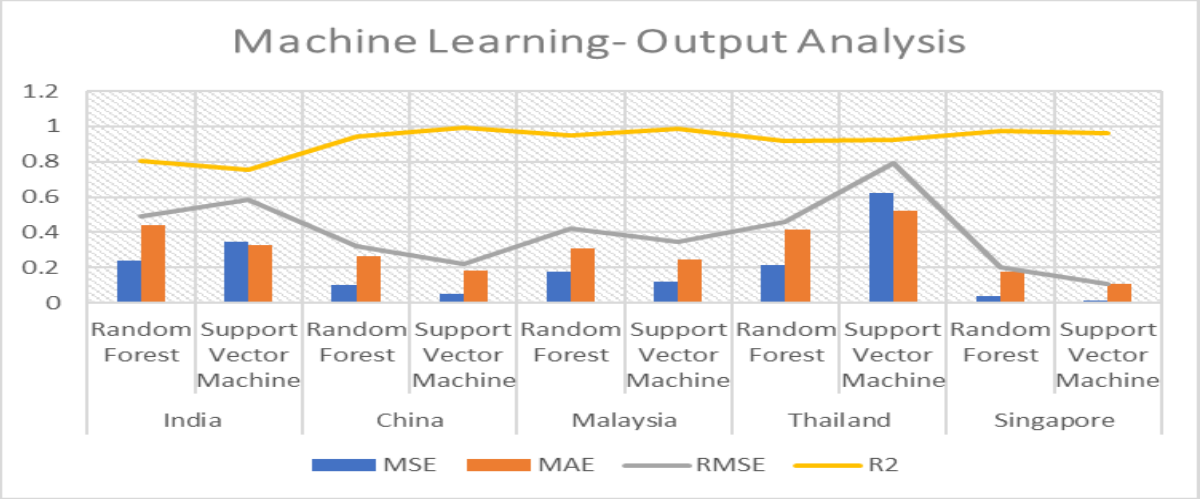
Table 5: Comparison of MSE, MAE, RMSE and R^2

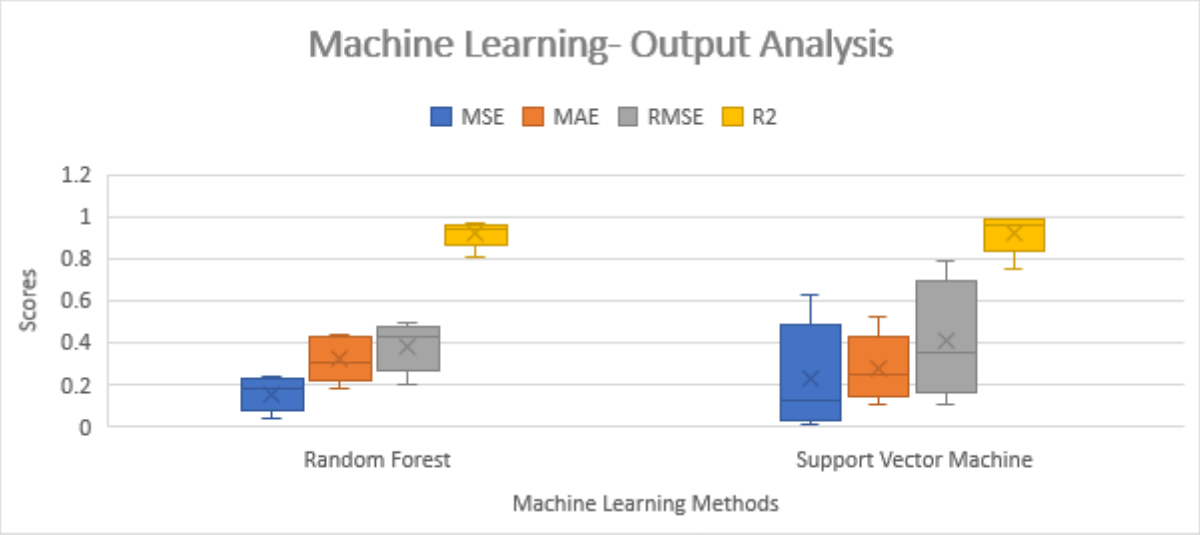
Techniques	MSE (Lowest)	MAE (Lowest)	RMSE (Lowest)	R^2 (Highest)
Random Forest	0.103388	0.175931	0.202097	0.971834
Support Vector Machine	0.011541	0.106784	0.107429	0.991517

Source: Authors Findings

MSE points out the average of the squared values of the difference between forecasted and actual predicted values. This is widely used as a model evaluation measurement technique in supervised learning algorithms. The smaller its value leads to better model evaluation. For both the RF and SVM algorithms, the lowest MSE values of 0.041 and 0.011 respectively was scored by Singapore. The corresponding RMSE values for Singapore are 0.202 and 0.107 respectively. The highest MSE score of 0.238 for the RF technique was scored by India; whereas the highest MSE score related to the SVM algorithm was obtained for Thailand. Sum of the absolute differences between forecasted and actual values is defined as Mean Absolute

Error (MAE). MAE is not sensitive to outliers and it treats smaller and larger errors equally. The lowest MAE values of 0.176 and 0.107 pertaining to the RF and SVM algorithms respectively has been obtained for Singapore. India has obtained the highest value of MAE = 0.437 with respect to the RF method. In reference to the SVM technique, Thailand has scored the highest MAE value of 0.521.





among the countries considered. The lowest value of R^2 = 0.75 was obtained for India; whereas for the other countries the value obtained is more than 0.81. The graph plotted above indicates that RF happens to be a better algorithm in our data analysis as compared to SVM method. In this paper, the random forest technique has been executed on the SDG index scores of the respective East and South Asian countries and corresponding total amount of green bonds issued for the period 2015-22. The prediction success rate was found to be 0.9718. The R^2 value of the SVM algorithm was found to be 0.9915 which shows that the established model had good predictive performance.

5. CONCLUSION AND MANAGERIAL IMPLICATIONS

This study assumes importance with the fact that more number of countries are cashing on the benefit of green bonds by coming up with their individual sovereign green bonds. To achieve the respective SDGs, climate bonds can be a new armour in the kitty of the nation's financial resources. In India, Securities and Exchange Board of India (SEBI)- the capital markets regulator have enumerated eight categories to be considered eligible for utilizing the proceeds

from the issuance of Green Debt Securities. As per Climate Bonds Initiative (CBI) India Report in 2018, India is among the top 10 labelled green bond issuers globally with cumulative issuance of USD 3.2 billion. Among the country specific green bond issuances, Poland is the pioneer nation in issuing the first green bonds in the year 2017. Sovereign green bonds with increased monitoring can augment the clarity on policy gaps. The development of an appropriate framework will help in green-tagging expenditures (Chile) or assigning green coefficients (France) to individual budget items suitable for inclusion in the green bond structure. Similar to the conventional government securities (G-secs) markets, sovereign green bonds can assist in providing benchmark pricing, liquidity and demonstration effects catalyzing the development of local green bond markets. Sovereign Green, Social and Sustainable bonds can contribute to support resilience expenditures in emerging economies like rehabilitation post Tropical Cyclone Winston in Fiji (launched in COP 23, 2017) and Netherland's flood risk management.

The background of this paper has been to initially identify the Sustainable Development Goals (SDGs) which has the potential to be fulfilled with the increase in amount of green bonds issued pertaining to the East and South Asian countries. The association between green bonds issued with the SDG scores has been tested using advanced machine learning algorithms, viz. Random Forest and Support Vector Machine. Moreover, this analysis can be a building block for India's recently released sovereign bond framework which was announced in the Union Budget 2022-23. A sovereign green bond provides nations with a gateway to launch a countrywide leadership in the green sponsoring framework while attracting a new investor niche and establishing its commitment to comply with Paris Climate Agreement. As per the latest Government of India borrowing calendar, sovereign green bond issuances to the tune of Rs. 16000 crores have already been issued for the financial year 2022-23. The two tranches of 5 and 10 year tenors was priced below the yield curve, which indicates green premium i.e. lower financing costs for the government. As per the framework, the proceeds from these green bond issuances would be utilized for capital expenditures in the areas of solar power, afforestation techniques, green hydrogen, etc. The sovereign greenium observed in India's local currency indicates a vibrant demand from the domestic investing community. The private sector may have the option to leverage the sustainable finance market as an alternative funding source for a smoother transition towards a net zero emissions policy.

The limitation of this study premises on the fact that the green bonds issuances in the East and South Asian countries are still at a nascent stage and hence, the data could be considered for only 5 countries. With the gaining of momentum and more awareness at this front, this study has the potential to become a building block for tapping the debt markets in the emerging economies. Though this study has made a sincere effort to advance the literature on green bonds, considerable amount of work can be done related to this still promising segment of the bond market. As the phenomenon of sovereign green bonds is relatively new, the existence of green premium, i.e. greenium in the issuance of green bonds would be a significant phenomenon to be observed as it indicates the increase or decrease in borrowing costs of the respective governments. The volatility aspects in this sector of the bond market along with the presence of greenwashing require further investigation for a comprehensive study of both the primary and secondary markets. A well-robust, transparent and proper risk management of the green bond market could go a long way in not only reducing the budget deficit of the countries; but also open a new avenue for the huge amount of funding required to achieve the individual targets in the Sustainable Development Goals and the respective Nationally Determined Contributions.

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