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Article

Assessing the future influence of tourism-related factors on economic growth in selected south Asian countries through a random forest approach

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Abstract: The study applies sophisticated machine learning techniques to measure the effect induced by important tourism indicators upon the GDP of six South Asian countries from 2001–2019. Among the models tested, the Random Forest model demonstrated the highest predictive accuracy, making it the most effective approach for analyzing GDP determinants in the region. It was determined from a World Development Indicators dataset analysis through the use of a Random Forest model what were the main determinants behind GDP growth for all countries in the area. Tourist arrivals and international tourism expenditure are good indicators of economic growth, while the unemployment rate and population growth have only minor effects. Other tourism-related factors contribute very significantly toward explaining any possible variation in GDP growth. Therefore, these results are important from the standpoint of the formulation of policies related to tourism toward maximizing its contribution to the economies of South Asia. For such policies to result in maximizing contributions from tourism, investments need to focus on the development of tourism infrastructure and international marketing to effect sustainable tourism development environments. Such policies are also very important with respect to unemployment and demographics. This work offers an evidence-based perspective to inform policymakers in developing investment in tourism infrastructure, international tourism promotion, and sustainable tourism practice. Such investment will greatly empower the South Asian economies to reconfigure tourism as a key driver of sustained economic growth and globally improved competitiveness.

Keywords: tourism; economic growth; unemployment rate; random forest model; South Asia

1. Introduction

Tourism is among the fastest-growing global industries and has importance given its contribution through eventual economic growth, employment generation, foreign exchange, and infrastructure development [1]. In those developing regions where economic diversification and growth must be even more relevant issues, tourism has shown that it can help meet specific access-related sustainable development goals. Within South Asia, the culture and biodiversity, as well as greenery and natural landscape, have combined to create immense tourism as an engine for economic growth [2]. This importance notwithstanding, the contribution of tourism to economic growth has still been a subject that has attracted low attention in South Asia, thus preventing evidence-based design interventions from policymakers [3]. The problem is that there is a scarcity of comprehensive research quantifying the contribution of tourism-related factors in influencing economic growth in this region, such as tourist arrivals and international tourism expenditure. The literature at the global level recognizes the impact of tourism in fostering GDP growth; however, these studies mostly focus on developed economies where the dynamics of tourism are very

different from the unique socio-economic and institutional characteristics of South Asian countries [4,5]. Moreover, research on South Asia is often confined to country-specific studies, omitting regional interlinkages and diversity. This lack of comprehension presents a significant limitation for policymakers and other stakeholders desiring to optimize the economic benefits of tourism in the region [6].

Empirical evidence from global studies suggests that tourism-related variables, such as tourist arrivals, positively impact GDP growth by boosting consumption and creating job opportunities. However, South Asian economies, characterized by high unemployment rates, growing populations, and diverse economic structures, may exhibit different relationships between tourism and economic growth [7]. For example, unemployment and population growth can either reinforce or water down the benefits accruing from tourism, depending on conditions in the labor market and demographic trends. Such interactions are poorly tackled in the literature, and hence there is a felt need for a multi-country, longitudinal, and detailed analysis of the role of tourism in the economic trajectory of South Asia [8]. This paper, therefore, tries to fill this research gap by analyzing what impact key tourism-related factors in tourist arrivals and international tourism expenditure as a share of all imports, unemployment rate, and population growth rate have on GDP growth of six South Asian countries—namely, Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka—across the period 2001–2019. This paper applies the Random Forest model, a special machine learning technique that would uncover complex nonlinear relationships perhaps missed by traditional econometric models. Given the less researched region and the adoption of advanced methodologies, such a study will not only add to the existing knowledge but also provide a sound framework for understanding the socio-economic implications of tourism [9]. This research has a twofold purpose: on one hand, to establish the relative importance of tourism-related factors and socio-economic aspects in explaining the variation of GDP growth in the South Asia region; and on the other hand, to present actionable insights and policy recommendations on how countries can make tourism a strategic driver of inclusive and sustainable economic development [10]. This is very important for policymakers, as it reinforces investment in tourism infrastructure and the promotion of international tourism, with socio-economic policies to enhance the contribution of tourism to economic growth. Based on this research, a regional strategy is developed that could place tourism as the cornerstone of South Asia's economic future [11]. South Asia stands out as a unique destination due to its rich cultural heritage, biodiversity, and natural landscapes. South Asia's unique cultural and natural assets make it particularly well-placed to meet these goals, as the tourism sector can draw on the rich traditions and biodiversity that other regions may not possess to the same extent. For instance, iconic cultural landmarks such as India's Taj Mahal, Sri Lanka's ancient cities, and Nepal's heritage sites offer unparalleled tourism opportunities that directly contribute to local economies [12].

1.1. Research objectives

1) To survey the commitments of the key tourism-related factors like traveler appearances and the global travel industry, use as a portion of all-out imports to Gross domestic product development in South Asia.

2) To look at financial factors, for example, the Joblessness Rate and Populace Development Rate, which would significantly affect Gross domestic product development in the locale.
3) To survey the differential significance of both the travel industry-related and financial factors in the clarification of varieties in Gross domestic product development utilizing an irregular woodland model.
4) To foster country-explicit points of view on the nexus among the travel industry and monetary development across Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka.
5) It might require strategy suggestions that would fit the portrayal of the travel industry being utilized as one of the essential drivers for manageable and comprehensive financial improvement in South Asia.

1.2. Research questions

1) How much is the travel industry connected with Gross domestic product development in South Asia not entirely set in stone through elements like traveler appearances and the global travel industry, use as a level of complete imports?
2) How do financial factors, for example, Joblessness Rate and Populace Development Rate influence the connection between the travel industry and monetary development?
3) What are the travel industry-related and financial elements that can be viewed as the main indicators of Gross domestic product development in South Asia as per the Arbitrary Woods model?
4) What is the variety of impacts of the travel industry-related factors and financial factors on Gross domestic product development across these South Asian nations chosen: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka?
5) What strategy-related systems can work with the lawmakers to amplify and bridle the monetary advantages from the travel industry while overseeing concerns like joblessness and population development in South Asia?

2. Literature review

It has, therefore, emerged as one of the critical drivers of economic growth globally, whose impacts are significant in gross domestic product, employment, and foreign exchange earnings [13]. The theoretical underpinning is presented by the Tourism-Led Growth Hypothesis, which posits that tourism economic growth is stimulated through an increase in aggregate demand, which increases infrastructural investment and, hence, ancillary industries [14]. However, this theory has been considerably substantiated in the literature, which has focused on the role that tourism plays in developed and developing economies. Though the sector is gaining importance, the exact modalities and determinants, with reference to GDP, remain understudied—especially in South Asia.

2.1. Global evidence on tourism's role in economic growth

Numerous studies globally highlight a strong positive correlation between tourism and economic growth. A study in the European Union [13] demonstrated that

international tourism stimulates economic growth by creating jobs, attracting foreign investment, and boosting domestic consumption. This kind of research is already being experienced in emerging economies like the Latin American countries, where [15] included the role of international tourism expenditure on the GDP growth. Still, such studies have been carried out in countries with better and well-functioning infrastructure and institutional stability, which are not the conditions similar to that of South Asia as such. Human beings engage in conversing with each other by being trained on October 2023.

In developing countries, tourism has proved to enhance foreign exchange earnings and alleviate poverty [16]. For instance, Ranjbar et al. [17] noted that tourism was especially important for low- and middle-income countries, as it is a means of diversifying these economies away from agriculture or a manufacturing-based economy. And yet, there are inequitable benefits from them. Most often, other structural issues such as bad infrastructure, poor governance, and socio-political instability limit the tourism potential for developing regions. Such findings suggest that the relationship between tourism and economic growth is context-specific, influenced by a range of mediating factors; thus, region-focused practice about the subject of study is called for [18].

2.2. Tourism in the South Asian context

Possessing immense cultural heritage, breathtaking natural landscapes, and high biodiversity within its geography, South Asia is a region holding a great future for tourism [19]. Although it ranks on a much lesser scale in the global tourism income index, it still means the underutilization of its potential tourism resources. While there have been country-wise studies on tourism and its economic growth in South Asia, such studies have not been viewed in a regional perspective. For instance, Lin [4] evaluated tourism's contribution to economic growth for India and discovered that tourism adds considerably to GDP. Bennike and Nielsen [20] presented the economic returns of tourism in Nepal with reference to rural areas. However, these find an absence of critical interstate cross-country differences and dynamics, bringing about a rather gaping hole in the understanding of regional dimensions of tourism GDP impact.

In addition, the features of South Asian countries, as parallel to other countries, actually provide a totally different view. Like many other countries, South Asia faces critical challenges such as high unemployment rates, rapid population growth, and inadequate tourism infrastructure, which hinder tourism's contribution to GDP growth [21]. While increased tourist arrivals are a key driver of growth, limited infrastructure and insufficiently served demands would reduce the impact of the tourists on GDP. High unemployment, on the other hand, may increase tourism's benefit as absorbed labor gets employment in the sector or could toll down tourism benefits as jobs may not be well extended to all [22]. These kinds of complex relationships between tourism and socio-economic variables are said to be underexplored in literature; hence, more region-specific, thorough analyses are warranted.

2.3. Role of key tourism indicators

Tourism performance indicators such as tourist arrivals and international tourism expenditure are considered major engines of economic growth [23]. This has been particularly true with reference to tourist arrivals, which indicate the tourism demand that has a positive correlation with economic activity in developed and developing countries. Identified by [24], international tourism expenditure as a portion of total imports signifies the export values of foreign earnings from tourism. Studies conducted in regions such as Latin America have shown that tourism expenditures raise the GDP with amounts received as foreign reserves from reduced trade deficits [25]. Nevertheless, as much as in South Asia, the role of international tourism expenditure is generally yet to be sufficiently explored, which hinders policymakers from fully understanding how to optimize tourism's economic contributions.

2.4. Socio-economic factors and their influence on tourism-growth dynamics

Unemployment rate and population growth are socio-economic variables that create a perfect environment for the conditions under which tourism acts on economic growth [22]. The higher unemployment rates and value offered to countries increased economic effects from tourism due to the provision of employment opportunities, especially in labor-intensive sectors such as hospitality and transportation. On the contrary, the growing dependence on tourism jobs, which are often low-paying, exacerbates income inequalities and increases vulnerability [6]. Population growth, too, will increase employment opportunities within the economic scope of tourism or stress its resources and infrastructure, thus limiting the contributions of the sector to GDP growth. However, global studies do not sufficiently provide evidence for the association of socio-economic variables with tourism in the region. Hence, there is no literature on their importance in terms of measuring tourism impacts on GDP in South Asia. Such as, the unemployment rates in Nepal and Sri Lanka are very high, and because of this, tourism jobs may create a different dimension in terms of distribution. Indian population growth, on the other hand, tends to be very fast, and the burden would be on infrastructure for tourism. All of these dynamics are very poorly researched, and hence much more specific regional studies on the same are necessary.

2.5. Methodological advances in tourism research

Regression analysis, a traditional econometric method, has historically dominated tourism research. However, while effective at identifying linear relationships, it struggles to capture complex, non-linear interactions among variables. Recently, machine-learning methodologies such as Random Forest models have found their decomposition by accumulation through their capability of modeling complicated relationships rather than just simple correlations [26,27]. Núñez et al. [28] used Random Forest models as applicable to tourism research, pointing out their effectiveness for analyzing large multi-variable data. Their application in the studies of South Asian tourism is, however, scarce, hence, leaving a methodological gap that this research intended to address.

2.6. Addressing the research gap

This study will occupy the identified gaps in research and methodology by providing a wide-ranging multi-country study on the impact of tourism on GDP growth in South Asia. Through the use of key tourism indicators such as tourist arrivals and international tourism expenditure, as well as socio-economic variables such as unemployment rate and population growth rate, this study provides a clear understanding of the processes through which economic growth will occur in the region; in addition, the use of a Random Forest model will allow for insight into non-linear relationships and the relative importance of each of the variables, insights impossible to achieve by traditional econometrics.

3. Methodology

3.1. Study design

This research investigation is about the tourism-related factors, socio-economic variables and GDP growth in six South Asian countries which are Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka based on the available data. This study has collected panel data from 2001 to 2019 and analyzed the data so as to evaluate the relationship of major variables with GDP growth utilizing Random Forest. The model is one of the machine learning techniques that have the capability to understand very complex, non-linear relations among decisive determinants [29,30].

3.2. Research hypothesis

Based on the research objectives and research questions, the hypotheses of this study are as follows:

H1: There exists a positive relationship between tourist arrivals and GDP growth in South Asian countries.

H2: Expenditure on foreign tourism as a percentage of total imports has a significant positive impact on GDP growth.

H3: Unemployment rate has a negative effect on GDP growth in South Asia.

H4: Population growth rate has a big effect on GDP growth, but the direction of such diversity may be different.

H5: There is a significant difference between tourism-related variables and GDP growth amongst countries of South Asia, as they reflect the differences in the economy and institutions of each of the countries.

3.3. Model formulation

The Random Forest model is a machine learning technique that creates multiple decision trees, each of which provides a result based on the data. The final result is made by averaging the results from all the individual decision trees. Unlike traditional econometric models, Random Forest does not have a direct equation or a specific functional form. However, its conceptual framework can be described as follows:

It predicts that GDP growth (GDP_i) is the average forecast from T individual decision trees:

$$GDP_i = \frac{1}{T}\sum_{t=1}^{T} ft(X_{it}),$$

where,

GDP_i predicts GDP growth rate for country i.

T represents the total number of decision trees in Random Forest.

$ft(X_{it})$ represents the prediction from t decision.

X_{it} represents the set of input features

3.4. Data collection and sources

This study's data was sourced from the World Development Indicators (WDI), which also serves as a worthy reference for one to get an all-inclusive and rich source of global economic data. The dataset consists of annual observations spread over the years, 19 in number, and six South Asian countries, therefore giving a balanced panel structure. The variables included in the analysis are shown in **Table 1**.

Table 1. Variable description.

Variable Type	Variable Name	Description	Data Source
Dependent Variable	GDP Growth Rate (%)	Measures annual economic growth in percentage terms, serving as the key indicator of economic performance.	WDI
Independent Variable	Tourist Arrivals (number)	Represents the number of international tourists visiting the country, capturing the demand for tourism.	WDI
Independent Variable	International Tourism Expenditure (% of total imports)	Reflects the share of tourism-related spending in the country's import structure, highlighting tourism's contribution to foreign exchange earnings.	WDI
Independent Variable	Unemployment Rate (%)	Serves as an indicator of labor market conditions and potential socio-economic challenges.	WDI
Independent Variable	Population Growth Rate (%)	Indicates demographic changes and their potential impact on resource utilization and economic growth.	WDI

Source: Author.

The study employs the Random Forest model, a machine learning algorithm that combines multiple decision trees to enhance predictive accuracy and interpretability. This model fits the study very well as it captures the non-linear relationship among variables, shows the relative importance of independent variables in predicting GDP growth, and reduces overfitting by averaging the results of multiple decision trees to improve generalization. The random forest model further applies MDA (Mean Decrease in Accuracy) and MDG (Mean Decrease in Gini) metrics for ranking the importance each independent variable contributes, thus providing a very strong framework for understanding the key determinants of GDP growth in the study.

4. Results and discussion

4.1. Descriptive statistics

Summary statistics for all variables were calculated to provide an overview of the dataset, including mean, median, standard deviation, and range. Here in **Table 2**, describe it.

Table 2. Descriptive analysis.

	GDP	PGR	UnemR	TouArr	TouEXP
Min	−11.200	0.200	1.800	5600	1.730
1st Qu.	4.500	0.900	4.100	247,500	3.815
Median	6.150	1.200	5.900	587,500	6.050
Mean	5.839	1.463	6.473	1,839,863	6.609
3rd Qu.	7.550	1.700	8.575	1,364,000	9.447
Max	23.600	4.400	11.700	17,914,000	14.880

Source: Author.

The descriptive statistics summarize the variables included in this study and indicate the variability and distribution across the six South Asian countries from 2001 to 2019. The dependent variable, which can be GDP growth rate, ranges between a minimum of −11.2% and a maximum of 23.6%, thus representing periods of severe economic squeeze and rapid expansion, respectively. The mean GDP growth rate stands at 5.839%, while the median is 6.15%. This depicts economic growth at a moderate level across the region. The range and quartiles indicate huge variability likely due to differences in countries' economic conditions, policy shifts, and external shocks.

Population growth rate (PGR) is fairly less in range, with a minimum of 0.2% and a maximum of 4.4%. The mean growth rate is 1.463%, while the median remains 1.2%, meaning that most of these countries have been experiencing moderate population growth during the period of the study. The PGR is generally distributed fairly uniformly but shows some incidences of rapid increase in some countries that could prove harmful to economic resources and growth at large. Meanwhile, the unemployment rate (UnemR) has a much broader range, ranging from 1.8% to 11.7%, with a mean of 6.473% and a median of 5.9%. This is, therefore, considered a region with moderate unemployment, although a high part of the distribution indicates huge employment challenges in some selected countries or in certain years. The interquartile range (4.1% to 8.575%) also provides an indication of significant differences between labor markets in different countries.

Tourist arrivals (TouArr) vary greatly, with a minimum and maximum of 5600 and 17,914,000 tourists, respectively. In fact, the mean is at 1,839,863 and the median has a skewness of 587,500, showing that very few countries account for the major inflow. Such a big difference emphasizes that tourism is not similarly developed in South Asia; there are some countries that are tourist destinations and those whose capacity is not fully realized. International tourism expenditure (TouExp) also ranged from 1.73% to 14.88% of total imports, with an average of 6.609% and a median of 6.05%. This suggests that on average, tourism has played a moderate part in these countries' foreign exchange earnings. There, though, is a great variation in tourism dependency, as some countries are heavily dependent on tourism to earn foreign exchange, while others show little contribution. As a whole, the descriptive statistics show considerable heterogeneity across the variables, which reflects diverse economic, demographic, and tourism-related dynamics across the region. All these variations further support the need for advanced analytical methods, such as the Random Forest

model, to capture the complex, non-linear relationships between tourism, socio-economic factors, and GDP growth all over South Asia.

4.2. Exploratory data analysis (EDA)

Visualization techniques such as scatter plots (**Figure 1**) are employed to examine the relationships among variables.

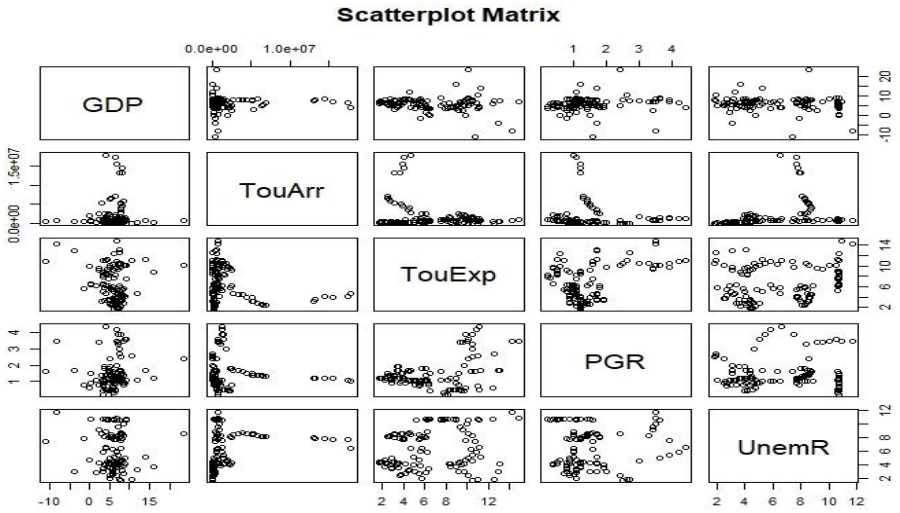

Figure 1. Scatterplot.

Source: Author.

The scatterplot matrix examines the relationships between GDP Growth (GDP), tourist arrivals (TouArr), international tourism expenditure (TouExp), population growth rate (PGR), and unemployment rate (UnemR). A slightly positive non-linear connection is seen between GDP and TouArr, indicating that more tourist arrivals may enhance economic growth in certain instances. For the same reason, however, the scatter plot between GDP and the other variables, TouExp, PGR, and UnemR, looked messy and indicated weak or complex patterns for these relationships. TouArr has a decent positive relation with TouExp, as expected. But there is an unclear-scattered association of TouArr with PGR and UnemR. Similar is the situation with TouExp; that is, it has not been very well showing patterns with PGR or UnemR. The significance of such relationships is that tourism doesn't act in a consistent manner when dealing with different socio-economic parameters. Thus, this matrix would depict that all these are non-linear and heterogeneous, giving reason enough to promote models, such as Random Forest, to reveal deeper patterns and highlight variables of importance to GDP growth.

4.3. Random forest analysis

The model was applied to the training data to predict GDP growth and identify the most significant variables (**Figure 2**).

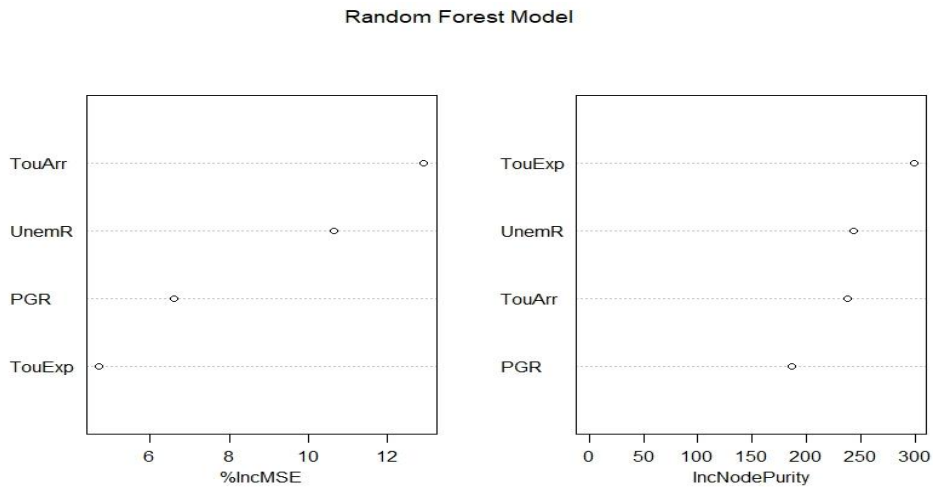

Figure 2. Random forest model.

Source: Author.

The Random Forest model was employed for predicting GDP growth and parameterizing the most significant components affecting it. Measures of variable importance include two metrics: % Increase in Mean Squared Error (%Inc MSE), measuring by how much the increase in prediction error would be for a specific variable exclusion, and Increase in Node Purity (IncNodePurity), representing the variable's contribution to error reduction in decision trees. According to %Inc MSE, through tourist arrivals (TouArr) solely cannot add significant predictive accuracy following metrics in the construction of the model. Next comes the unemployment rate (UnemR) and then the population growth rate (PGR) and Tourism Expenditure (TouExp), respectively, albeit less influential by this measure. Inc Node Purity, however, denoted Tourism Expenditure (TouExp) as the most significant variable; that is, a variable relatively high in its portion of explanatory power on some selected subsets of data. Unemployment rate and tourist arrivals also played sufficiently large roles in reducing model error, while population growth rate contributed the least, yet still had a considerable impact. These results show that tourism has a very complex relationship with particular socio-economic factors and growth in GDP. Among different sources of predictive accuracy, tourist arrivals were the main one, whereas Tourism Expenditure predominantly contributed to explaining GDP growth when certain conditions applied. Unemployment significantly affected both measures, thus reflecting its broad economic impacts. These results reiterate the influence of tourism in the economy of South Asia through some of its factors, namely, arrivals and expenditure. Therefore, proper attention should be given to enhancing infrastructure development and promotion of international leisure travel as well as investing in areas geared towards reduction of unemployment for all economic benefits accrued through tourism and considering the population growth as a demographic factor for sustainable development [31].

4.4. Interpretation of results

The findings were interpreted in the context of the South Asian region, highlighting the influence of tourism-related and socio-economic factors on GDP growth (**Figure 3**).

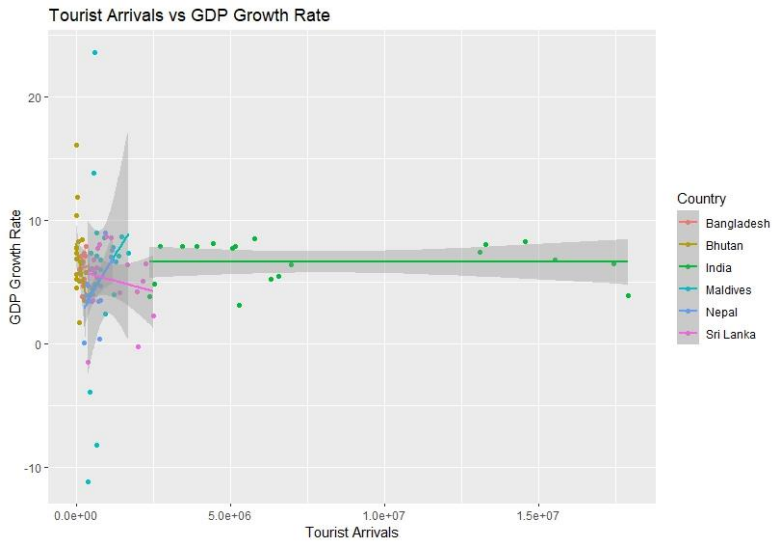

Figure 3. Tourism and GDP G. rate.

Source: Author.

The scatter plot image shows the relation of tourist arrivals and GDP Growth Rate for the six countries in South Asia: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. The data points represent tourist arrivals as well as GDP growth Rate (%) for every observation on this plot. The GDP growth rates hence cluster together around moderate positive values. Thereafter, this increases till under 5 million tourist arrivals, where that variability gets significant. The more tourists arrive in the country, say beyond 5 million, the more stabilized GDP growth rates will be, leading to less variability. The regression line shows a weak positive relationship between tourist arrivals and GDP growth, but the slope is pretty flat, indicating that, in general, higher tourist arrivals are associated with higher GDP growth. At the lower end of tourist arrivals, the confidence interval is wider; this shows that there is a lot of uncertainty about the relationship in countries or years where tourism is low. Therefore, one needs to factor in other socio-economic determinants when analyzing the GDP growth dynamics in South Asia.

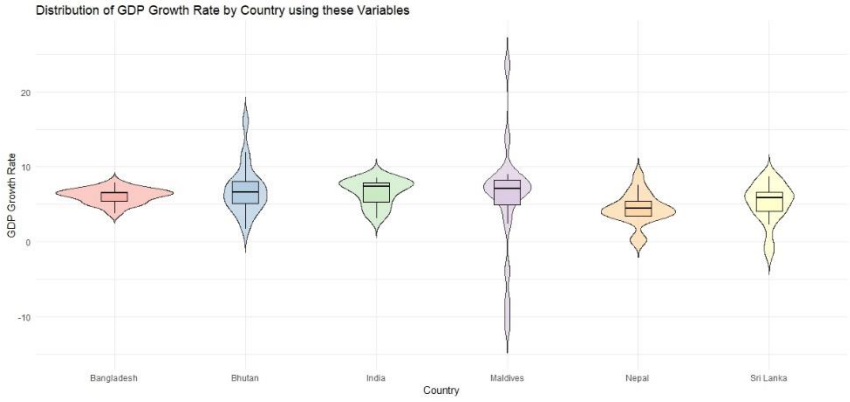

Figure 4. GDP growth rate.

Source: Author.

The violin plot depicts GDP growth rates' distribution for the six countries studied—Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lankan states—during

the study period. Each country has its unique distribution pattern as an effect of its internal economy and external influences. Thus, the GDP growth rates of Bangladesh have a distribution that is quite tight, with clusters around the median, which demonstrates the steadiness and consistency of Bangladesh across time. Similar to that, India has also shown that considerable distribution is relatively less tight, signifying a healthy and consistent growth like that of Bangladesh with low variation. Furthermore, GDP growth rates in Sri Lanka are similarly distributed but centered at a very close median with only occasional deviations (**Figure 4**). On the contrary, Bhutan displays a significant degree of variability borne out of a wider distribution reflecting more definite swings over GDP growth rates. The presence of a longer tail below indicates occurrences of very low growth at intervals. Nepal so has a narrower distribution yet somewhat asymmetric, signifying low variability of growth rate, indicating some deviations from a consistent trend occasionally. Maldives, however, has the most extensive distribution, implying the most volatility of GDP growth rates. The extreme high and extremely low reflect periods of very fast and contrasted movements into and out of the economy, respectively, owing much to the tourism dependence of the country and susceptibility to external shocks. In general, this plot indicates the heterogeneity of the GDP growth patterns across the region. While countries such as Bangladesh, India, and Sri Lanka show stable patterns, those like Bhutan and Nepal reflect moderate variability while the Maldives shows an extreme degree of economic volatility. These differences emphasize the need to consider country-specific factors when analyzing GDP growth determinants in South Asia.

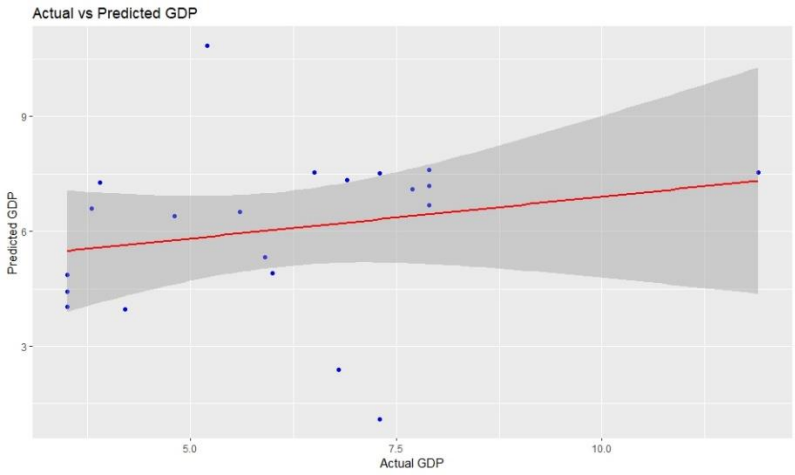

Figure 5. Actual vs predicted GDP.

Source: Author.

Simply put, the comparison of the transformed actual GDP growth rates on the *x*-axis and predicted GDP growth rates on the *y*-axis from the Random Forest model is really a scatter plot (**Figure 5**). Red line means regression, gray shadings mean confidence interval, and blue point means a certain observation. It shows an upward slope but no definite trend since the predicted values are so packed together, considering about 3 to about 9, even though the actual GDP values are very much scattered. This means that even though the model is making predictions of trends rather successfully, it underestimates some higher GDP growth rates and

overestimates some lower ones, which is substantiated by the gravity of points appearing from the regression line. Outliers show those points very wide from the regression line, which indicated that there were instances when this model would not be able to give the right predicted growth of GDP due to unmeasured variabilities or the linear relationship not being much followed. Interaction difficulty will be indicated by wider confidence intervals as the GDP increases in order to show uncertainty of predictions in that observation. Therefore, the whole plot draws the inference that general tendency patterns in GDP are captured by the random forest model in most cases but not in abnormally high or low values, in which case further refinements may have to be carried out or additional explanatory variables introduced to ensure effective predictions.

5. Key findings

This therefore proves that tourist arrivals are the most accurate predictors of GDP growth, while international tourism expenditure also plays a major role in explaining it, underlining the importance of tourism as a key driver of economic growth in South Asia. However, for tourism to have its full economic effect, governments need to address the fundamental challenges of unemployment and infrastructure deficiencies to ensure a strong and sustainable tourism sector. It also points out that country-specific solutions, and not a standard regional strategy, are required; while Bangladesh and India are going through steady economic growth, the Maldives has to bear with economic turbulence. This study therefore constitutes an important methodological enrichment through the implementation of the Random Forest model for the ranking of the importance of factors related to tourism, turning out to perform better than those proposed by standard econometric approaches. The Random Forest model successfully captures complicated nonlinear interactions of economic variables. In all, the results have shown how vital tourism is in the economic growth of South Asia and that optimization in policies concerning international marketing, sustainable tourist practices, and tourism infrastructure is required for long-term financial gains.

5.1. Future implications of the study

Thus, this study is very useful for policymakers, economists, tourism authorities, development agencies, and researchers, as it provides ideas on how tourism could actually be used to capitalize on the economic growth of South Asia.

5.2. Policy formulation and implementation

The evidence-based insights and their contributions to various tourism-related parameters in GDP growth are confirmed by travel arrivals and international tourism expenditures. Such data can assist policymakers in prioritizing infrastructural investment towards tourism, incentives for international tourists, and synergetic policy goals in faster-growing tourism as part of policy [32]. Furthermore, attention needs to be given to dealing with socio-economic issues, especially unemployment, as part of all the other policies linking tourism development, job creation, and labor market reforms [33]. This study shows the varied perspectives on GDP growth dynamics across South Asian countries. Regional organizations like this could then use such

studies for formulating particular measures that would enhance the development of cooperation among and between various countries in this regard, especially those focusing on tourism initiatives that could benefit the whole member country [34,35].

5.3. Tourism industry development

This research is a wake-up call for all aspects related to spreading awareness about sustainable tourism practices, investment in tourism-related advertisement and infrastructure. This would also benefit the tourism boards of Maldives, Nepal and Bhutan by providing such places with tools to manage economic volatility and make the tourism sector resilient through diversification of offerings in tourism as well as reducing dependency on given markets. The research also forms an agenda for private stakeholders for the tourism industry, such as hotel chains, airlines and tour operators, to understand the economic impact of tourism and where to invest in highly potential markets within the South Asia region [36,37].

5.4. Economic development agencies

In developing programs for tourism as an engine for sustainable economic growth, institutions like the World Bank, IMF, and UNDP would find this study useful. Findings already point out the areas where financial and technical assistance can be directed towards infrastructure building, improved governance, and inclusive growth through tourism. Such expenditure on international tourism accentuates the call for reinvestment of such tourism revenues in sustainable development initiatives that will benefit not just the economy but also the environment [38].

5.5. Academic and research contributions

This study enhances academic knowledge regarding the function of tourism towards economic development by bridging some existing voids within literature, especially in South Asia. Further research can build off this study to investigate other facets such as infrastructure, quality of governance, environmental sustainability, or methods on some combinations with time-series econometrics to capture dynamic effects. This shows how machine learning models like Random Forests can prove useful in analyzing non-linear relationships and ranking variable importance, thereby prompting further methodological innovation within tourism and economy research [39].

5.6. Global and regional policy frameworks

Such findings can be made a part of international and region-specific reports by pertinent institutions like the United Nations World Tourism Organization (UNWTO) so that monitoring can be improved on understanding the role of tourism within the economy of developing regions like South Asia. Insights from this research can further tune strategies in line with achieving the Sustainable Development Goals (SDGs), especially those linked to economic growth (SDG 8) and tourism that is sustainable (SDG 12) [40].

5.7. Limitations of the study

The Random Forest model tries to probe into how the tourist and socioeconomic variables influence GDP growth in six South Asian nations. While having much to offer in terms of capturing intricate nonlinear interactions, this method has a number of disadvantages compared to traditional econometric models from previous studies. One major disadvantage of the Random Forest model is that it is not interpretable. While Random Forest does provide a ranking on the relevance of variables, unlike conventional regression-based models, it does not indicate the strength and direction of correlations due to the very clear coefficient values. Due to this fact, policymakers may find it difficult to deduce precisely how increasing tourism-related factors affect GDP. While this work focuses more on the machine learning technique in terms of prediction accuracy, previous studies conducted using the linear regression or SEM methods have been able to give far clearer insights into the causality of the relationships.

Besides, completeness and quality of data are two major determining factors for the accuracy of the Random Forest model. While the dataset used here represents a sound panel of the six countries in this study, operational issues—a number of the observations have either missing values or measurement errors—across successive time periods still remain very pertinent. Several recent studies using traditional econometric methods have approached similar issues with the use of either imputation techniques or tighter variable selections, among other approaches. For this reason, future studies will be required to establish the possible impact of the fluctuations in the international tourist receipts and other socio-economic indicators across countries on the reliability of the results. The second major limitation is linked to the few variables considered in the analysis. The other determinants that have not been considered in the present study include infrastructure development, quality of governance, and external shocks—examples include natural disasters, geopolitical instability, or financial crises—emphasizing tourist arrivals, international tourism expenditure, unemployment rate, and population growth rate. Indeed, previous studies have given a deeper understanding of the subject matter of the contribution of tourism to economic growth through the inclusion of indices of macroeconomic stability and institutional quality. Future studies can add much robustness to these findings by extending the model to include these factors.

This study also makes use of country-level, aggregated data that could mask regional economic variations. The economic systems in India and Nepal are very dissimilar, with the effects of tourism quite possibly differing greatly across areas within a single nation. Such subnational economic patterns, in other studies, have picked up localized differences using subnational or case study methods and proved more relevant to policies. In this way, future research could provide some more specific policy suggestions based on the use of data at a lower level of aggregation. For example, the estimation of long-run dynamic changes remains out of capture by the model. While Random Forest provides some static snapshot, it does not consider how a changeable relationship varies over time. Long-run trends, lagged effects, and causation have been considered more successfully on previous occasions, using time series econometric modeling such as VAR or panel cointegration analysis. Future

research on these issues, using dynamic modeling approaches, may provide further insight into how tourism influences economic growth over time. These facts notwithstanding, the present study has filled a critical gap in the literature through its investigation of the contribution of tourism to economic growth in South Asia, using a state-of-the-art machine learning approach. Further studies may seek to transcend these limitations by including more explanatory variables, sub-national level analyses, and dynamic econometric methodologies that can lead to further refinement of the understanding of the relationship between tourism and growth.

6. Conclusion

Tourism has retained its status as one of the major avenues through which economic growth is driven in virtually every region of the world, especially in developing areas such as South Asia, where it contributes significantly to GDP, earnings from foreign exchange, and employment generation [41]. This paper fills an important research gap by analyzing how tourism and socio-economic factors jointly influence GDP growth in six South Asian countries: Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka for the period 2001 to 2019. This research unveils novel insights into the complex non-linear relationships between GDP growth and some of its major factors, namely tourist arrivals, international tourism expenditure, unemployment rate, and population growth rate, using a Random Forest model. Results reveal that the tourism-related variables, especially tourist arrivals and international tourism expenditure, affect GDP growth in the region significantly. The evidence indicates that tourist arrivals are the most powerful predictor of GDP growth, while international tourism expenditure is proven to be very explanatory in some contexts. Among the socioeconomic variables, the unemployment rate had a moderate but constant effect on tourism and employment market dynamics [42]. Population growth rate had a less significant effect on other variables, and therefore it requires further attention. From these results, therefore, tourism is found to be very important for the entire region of South Asia as a growth engine but creates a very critical need for effective policies to address unemployment and infrastructure deficiencies. The study suggests that policymakers in South Asia should prioritize investments in tourism infrastructure and promote sustainable practices to maximize the sector's economic benefits [43,44]. They can even plug into this resource, leveraging cultural and natural asset offerings and having more tourists visit the region and leaving aside some of the labor market inefficiencies that have enabled some growth that is not entirely inclusive. Differences between countries are also seen, such as continuous growth in Bangladesh and India vis-à-vis volatility in economies like the Maldives; these are further arguments for country directions rather than strategies. The major contribution of this study to research is that it uses the Random Forest technique that can reflect complex interactions and rank the importance of different variables that affect the growth of GDP. Such a methodological innovation goes beyond most econometric models and does give a finer interpretation of the role tourism plays in economic development. Furthermore, this study looks across countries at South Asia, thus dealing with a gap in most regional analyses reported in the literature, and provides tangible insights into policies that could benefit the entire region. It does

indeed seem that the present research, as much as it contributes, has some inherent limitations situated in them; avenues and opportunities for avenues and future research. In less interpretative but much more non-linear, the Random Forest Model has an interpretative appeal as compared to traditional regression. Other possible avenues for research in the future may be taking up these results with some time-series econometric models to consider the dynamic effects and lags attached to these results over time. It would also augment such an understanding if other influencing factors such as infrastructure, governance, or even environmental sustainability were explored. Finally, analyses for the sub-nation could unveil more localized patterns, which would allow even more specificity in policy recommendations. This study emphasizes the critical role of tourism in growth economics in South Asia and has built a strong case to empower policymakers to actualize the potential. It successfully bridges some of the major identified gaps in research and methodology for future work into the dynamic and multidimensional relationship between tourism and economic development in the region.

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