


# Fostering sustainable tourism through digital innovation and green tourism initiatives in Bangladesh

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## ABSTRACT

Tourism, a vital global industry, has faced significant setbacks due to health crises like COVID-19 and monkeypox, reshaping global travel perceptions around the world, including in Bangladesh. As a vital industry interconnected with the country's economy, it is crucial to understand the pandemic's impact on Bangladesh's tourism industry and identify ways to recover from its adverse effects. To that end, we employ a Computable General Equilibrium (CGE) modeling framework to analyze the impact of COVID-19 on Bangladesh's tourism industry and highlight the role of digital innovation in recovery. We simulate multiple policy experiments and find that expediting digital innovation can help the tourism industry recover from the adverse effects of the COVID-19 pandemic without any negative macroeconomic consequences. Moreover, we develop a conceptual framework that shows the interplay of stakeholders for augmenting digitization in the tourism industry, leading to green tourism development. To achieve sustainable tourism through digitization, we propose policies to ensure effective industry planning, diffusion, and decision-making among the stakeholders in the tourism industry.

## 1. Introduction

The blissful breeze on the face as one basks in the serenity of nature, the playful colors and beauty of the valleys and oceans, the adrenaline-inducing adventures, the mouth-watering delicacies of international cuisines, and the hospitality of hotels are the initial thoughts that come across our minds when we think of the word "tourism". The need for people to integrate with the rest of the world, to experience diversity and nature, and to explore remote places in this increasingly globalized world has led to tourism becoming a booming industry. This industry is an amalgamation of several major industries worldwide, including transportation, accommodation, and the restaurant and food sector, making it one of the most significant economic drivers [1].

The increasing shift in consumer culture toward exploration and recreation has led to a surge in tourism worldwide, resulting in significant positive impacts on the global economy. The tourism industry (TI from here onwards) is considered the third largest and constantly

growing industry in the world, contributing to almost 10.4% of the world GDP as of 2018, with an approximate projection of 11.5% by 2029, generating around 1.7 trillion USD in revenue and employing a diverse workforce containing 54% women [2,3]. Hence, this industry has a non-refutable economic potential for job creation, income generation and foreign exchange earnings, elevation of living standards, enhancement of private-public partnership and competition, and the reduction of poverty around the globe [4,5]. Prior to the COVID-19 pandemic, the tourism industry was one of the primary drivers of global economic growth. The industry expanded at a rate of 3.5% in 2019, surpassing the global economy's 2.5% growth rate. (World Travel and Tourism Council-[6]).

When the novel coronavirus, now known as COVID-19, emerged, our daily lives were disrupted. On March 11, 2020, the World Health Organization (WHO) announced the beginning of the pandemic, which was soon followed by a 100% travel restriction in all destinations worldwide and the complete shutdown of international tourism for 27% of

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destinations, decreasing tourist arrivals by 73.9% globally [2]. Since the nature of travel and tourism is analogous to carrying diseases and vectors [7], the imposition of strict Non-Pharmaceutical Interventions (NPIs), such as quarantine, border control, and lockdowns [8], has severely impacted the industry as the pandemic broke and spread globally. The COVID-19 pandemic has hindered the growth of the tourism industry, resulting in a loss of approximately USD 1.3 trillion in international tourist receipts in 2021. Nevertheless, the industry is returning to its pre-2022 trajectory from 2022 onwards, although for most developing countries, the recovery rate is not commendable.

Bangladesh, located in the Northeastern region of South Asia, is a developing country with a substantial tourism industry. The country offers a variety of tourist sites, including historical mosques, memorials, beautiful tea gardens, unique tribal cultural architectures, the world's largest mangrove forest, and the world's longest sea beach. The revamped National Tourism Policy introduced in 2010 is credited with Bangladesh's improved average tourism receipts from the beginning of 2013 [9]. The average contribution of the tourism and hospitality industry from 2007 to 2018 was Bangladeshi Taka (BDT) 377.46 billion, as shown in Fig. 1. The share of GDP remained steady at around 3% from 2007 to 2018 and ended at 4.4% in 2019. The country's fast-paced growth can thus be partially attributed to the growth of this industry.

On March 8, 2020, the first case of COVID-19 was confirmed in Bangladesh; shortly after, the number of cases sharply rose. Up till April 2023, about 2 million infected cases and 29,446 fatalities have been reported from Bangladesh since 2020. Like many other countries, the TI of Bangladesh has been hurt relatively more than its other industries because of stringent government restrictions and quarantine laws.

The TI was one of the most rammed industries in Bangladesh. In 2020, the sector lost USD 3.1 billion. In addition, during the same time period, more than 4 lakh individuals working in tourism-related activities lost their jobs [10]. Furthermore, the GDP share of the tourism industry was 2.3% in 2023 and is projected to remain unchanged in 2024 [11]. According to the Bangladesh Institute of Development Studies [12], the recovery process was sluggish and subpar compared to other industries, as there was limited stimulus support or financial aid. To restore this industry's contribution to Bangladesh's economic growth, it is imperative that recovery paths be established.

Apart from the government stimulus packages, among others, digitization as a potential recovery strategy has been highlighted by recent tourism literature [13–20]. This is primarily due to the increase in productivity that occurs when digital innovations are adopted by various stakeholders within the industry. Not only recovery but also

digitization is linked to the long-term sustainability of the TI by promoting a green ecosystem that preserves the destination's natural essence and environment [2,21]. Given the lack of literature from Bangladesh's perspective, we contribute to this area of discussion by evaluating the feasibility of digitization as a post-pandemic recovery strategy for sustainable tourism in Bangladesh. Digitization refers to the conversion of data into a computer-readable or digital format. In this context, we argue that the digitization of tourism data and services creates a digital transformation that encourages tourists to adopt domestic and green tourism, which has the potential to revive Bangladesh's tourism industry.

The novelty of the paper is thus threefold. First, we utilize a fit-for-purpose 86 activity and 86 commodity-equipped Computable General Equilibrium (CGE) model to analyze the impact of COVID-19 on Bangladesh, as well as the effects of digitization on the TI, through numerous policy simulations. Second, we outline the various innovations that can be implemented in the TI and provide a conceptual framework for facilitating digitization to ensure sustainable green tourism development after the pandemic. Third, we offer several policy suggestions based on the overall discussion. It is worth noting that the results and policy implications will be highly effective for countries like Bangladesh in advancing their journey towards sustainable tourism.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the existing literature. Section 3 discusses the CGE modeling framework along with policy simulation results. Section 4 presents the digitization of TI in Bangladesh. Section 5 concludes the paper with a few policy implications.

## 2. Literature review

### 2.1. Literature on CGE and tourism

In previous pieces of literature, many researchers have employed analyses of the COVID-19 impact using the CGE models. The CGE model is an effective approach for calculating the overall economic impact of tourism, contrary to general equilibrium and partial equilibrium approaches, due to the existence of prominent gaps in research in the fields of poverty, gender inequality, and the impact of environment and climate changes on tourism [22].

General equilibrium models typically characterize the tourists' expenditure patterns within the macroeconomy, utilizing activity linkages and multipliers [23]. The cash flows are interlinked by numerous circular loops involving direct net effects on industries and services for

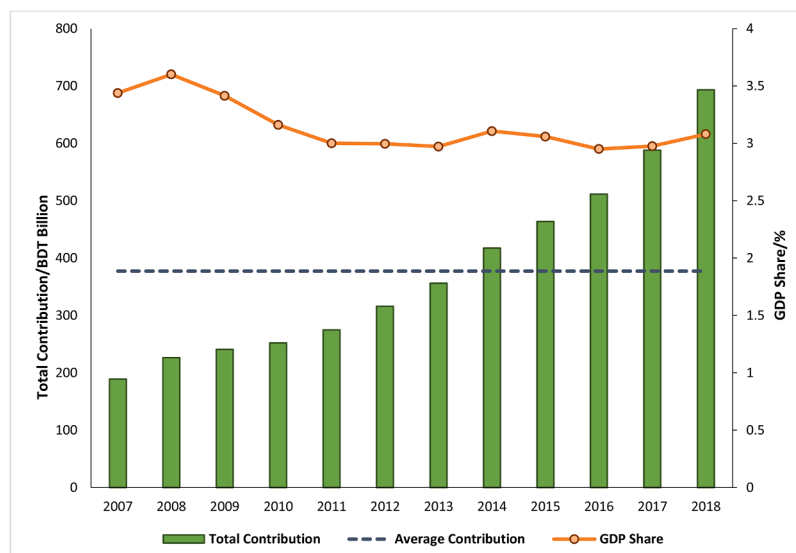


Fig. 1. Total contribution and GDP share of tourism in the economy of Bangladesh.

tourists, indirect effects from consequent spending on backward-linked activities, and higher household income and spending, which induce further multiplier effects. Hence, a basic CGE framework provides a mechanism to track monetary flows across industries, establishing intermediate linkages besides deriving derivative multipliers for various economic indicators [24].

Gössling et al. [25] analyzed the post-pandemic effects in their studies, drawing on the World Input-Output Database (WIOD). The authors highlighted the differential regional impacts and implications of COVID-19 on global tourism from its inception in March 2020, assessing the disruptions caused by travel restrictions and worldwide lockdown policies that negatively affected the tourism industry (TI), particularly the sub-industries linked to tourism, cruising, and accommodation. For instance, guest numbers have declined more than 50% in the accommodation industry in countries such as Italy and Greece, with a rising trend in COVID-19 cases.

Ramos et al. [26] divided the WIOD data into essential and non-essential industries and hypothesized that a symmetric shock would occur in all listed countries using an Input-Output model. Their findings concluded that the demand for the non-essential industry declined by half and that China and other Asian countries were most affected. The authors revealed how changes in consumption patterns affect productive leakages and the final demand composition of individual economic structures within countries.

Porsse et al. [27] assessed Brazil's economy using a dynamic inter-regional CGE model. The results indicated that, despite a reduction in GDP due to adverse labor supply shocks, the projected decline in GDP resulting from the COVID-19 outbreak was partially mitigated by government fiscal stimulus, as considered in their study. De Morel et al. [28] used a regional CGE model to evaluate the potential adverse effects of COVID-19 on the New Zealand economy, focusing on the restrictions applied to the entry and exit of people within the country, as well as the temporary idleness of labor and capital due to the adapted isolation and social distancing measures.

Wittwer [29] examined the impacts of the Australian economic crisis caused by the bushfires and COVID-19 from the perspective of the grape and wine industries, utilizing a multi-regional DCGE model. Interestingly, a similar study in Australia by Pham et al. [30] showed that the pandemic's effects reached industries and occupations beyond the TI. Thus, administering new policies as a measure to revive the TI can deliver spillover benefits to other industries and across the whole range of occupations in the labor market.

## 2.2. Literature on digital innovation and tourism

Technology, digitalization, and innovation—three essential components of productivity—have recently been major drivers behind the growth of the TI. However, it remains unclear how technology can support visitors' long-term, sustainable well-being [31]. Evidence from the UK, presented by Blake et al. [32], demonstrates how productivity drivers, such as technological innovation, have a beneficial impact on efficiency, welfare, and the development of human capital and creativity. According to a recent study by Pan et al. [33], regional innovation and carbon emissions from the tourism industry have an interdependent relationship. The technical advancement of renewable and clean energy sources significantly improves energy efficiency, thereby reducing carbon emissions associated with tourism.

Recent literature highlights the various ways in which countries can recover from the structural harms of the TI. Khazai et al. [34] establish that tourism recovery requires proper attention to the safety of tourists, recovery of businesses, and physical recovery. Yeh [35] suggests that effective Tourism Crisis and Disaster Management (TCDM) with proper prioritization and government support can help struggling businesses achieve a sustainable recovery of the tourism industry. Tiong et al. [36] further postulate that the adoption of better hygiene and cleaner environments in hotels can help overcome the deterrence of people from

traveling during the COVID-19 pandemic, which supports the idea of adopting green tourism during this period. Mackenzie and Goodnow [37] investigate more unique directions of change that may emerge in the industry, particularly in the realms of micro-adventures and localism, as post-pandemic tourists are expected to shift their focus to domestic tourism due to limited mobility. Manta et al. [38] find, through their bibliometric analysis of tourism literature, that digitization and green finance are perceived as the most effective tools for sustainable tourism in the post-pandemic era. Talwar et al. [19] argue that Virtual Reality (VR) tourism encourages tourists to explore eco-tourism and sustainable travel options. Jiang and Lv [39] argue that a more digitized economy can mitigate the harmful environmental impacts of tourism, and thus, digitization can lead to a more sustainable tourism industry. All these changes and strategies suggested by different literatures can be tied to the idea of digitization to improve the efficiency of disseminating information and technology, as well as to enhance sustainability in the TI.

The TI balances itself on two primary components: physical interaction with destinations and information about the destinations [40]. The aggressive use of information to drive the growth of the physical counterpart has been accelerating with the increased adoption of information technologies, enabling faster and more meaningful communication among stakeholders and giving rise to digitized technology and innovation. Ghorbani et al. [41] theorize the concept of e-services and New Tourism Marketing Methods (NTMM) in Smart Tourism Organizations (STOs), which incorporates structural, human, organizational, environmental, and emotional intelligence to expedite tourism services. Yang et al. [42] analyze the use of Artificial Intelligence (AI) and robotics to simplify and revolutionize personalized services to tourists worldwide. Various other studies highlight the niche digitization in the TI, including chatbots [43], blockchain technology [44], and Mobile Financial Services (MFS) [45].<sup>1</sup>

## 2.3. Gap in literature from Bangladesh's perspective

The relationship between tourism and economic growth, as well as the impact of digitization on tourism, has been demonstrated in numerous studies utilizing CGE analyses. However, the emphasis on the impact of the TI in the context of Bangladesh is sparse in the literature. Previous studies about the TI in Bangladesh have looked at other areas, such as the nexus of economic growth and tourism [46–48], tourism and local community development [49–51], the nexus of energy and tourism [52], among others. Although the aspects of COVID-19 on tourism activity are reported in the existing literature [12,53–55], the impact of COVID-19 through economy-wide quantitative modeling and policies to push forward the industry in the aftermath of the pandemic is scarce. The closest study examining the impact of the pandemic on the TI is Amin et al. [56], who utilize a large, multi-industry CGE model to assess the macroeconomic effects of the pandemic, with a focus on the TI. However, there is a lack of previous research on digitization and sustainable tourism in the context of Bangladesh. We aim to fill this gap by bridging the two into a conceptual framework supported by a CGE analysis. With the country's rapid growth, it is essential to adopt sustainable approaches to the development of key industries, such as the TI in Bangladesh. Moreover, literature outlining the scope of digitization in Bangladesh, not just in the TI but also in other industries, is relatively scarce. We explore the practical applications of digital technologies and innovations that can enhance the productivity of the workforce in Bangladesh.

<sup>1</sup> A more comprehensive list of digitization technology is discussed in Section 4.2.

### 3. Theoretical modelling and analysis

#### 3.1. The CGE model

This paper utilizes a CGE model designed to analyze the effect of digital innovations on the TI. CGE models can be used to easily compute industry-specific shocks and simultaneously simulate their impacts from both the supply and demand sides of the economy, whereas econometric models only allow us to estimate the conditional expectations of different variables without considering supply and demand interactions. Therefore, simulations of policy experiments and the impact of large adverse economic shocks, such as COVID-19, are easily tractable within the CGE modeling framework. We employ a model similar to the one used by Timilsina and Pargal [57] to generate output for their paper. Consequently, we consider the 2019 Social Accounting Matrix (SAM) of Bangladesh as the primary database for the model, which encompasses 86 activities and 86 commodities. Since the productivity shock due to the pandemic occurred in 2020, using the 2019 SAM provides the best baseline scenario for the policy experiments.<sup>2</sup>

The model accounts for all individual separations related to products, firms, resources, and institutions included in the SAM for computational purposes. The process is built upon a nested structure (Fig. 2). The Leontief function identifies the most advanced technology to ensure a fixed share of inputs. The Constant Elasticity of Substitution (CES) function is used to define the value added in this model. The Leontief function, on the other hand, characterizes the model's segregated intermediate inputs, which remain unchanged by price variations and other structural changes, resulting in a zero substitution effect. In this production technology structure, a set number of commodities are produced by each activity. It should be noted that the activity level, yields, and producer-level commodities prices determine the activity's revenue. This type of modeling structure is commonly used in tourism modeling, as employed by Ponjan and Thirawat [58], Meng [59], Amin et al. [56], and Nowak and Sahli [60], among others. On the other hand, Export demand is determined by international pricing. Import, on the other hand, is dependent on both global market supply and a shortage of domestic output.

The model's Linear Expenditure System (LES) structures the household spending pattern from various activities. The government's primary objective is to collect taxes, save revenue, and distribute it as subsidies or to purchase goods and provide cash distributions to individuals and businesses. It is further assumed that the economy's overall labor demand follows the Walras rule. Because the elasticity parameters of substitutes across industries are difficult to measure experimentally, we acquired elasticity parameters from Amin et al. [56].

Each market's domestic commodities and services are combined via the CES aggregator function. Additionally, imperfect transformability affects the entire domestic output, which is divided into export and domestic sales and is characterized by a functional structure known as the Constant Elasticity of Transformation (CET). The availability of commodities on the global market and the lack of indigenous manufacturing have an impact on imports. Moreover, Imports and imperfectly substitutable domestic output comprise the composite commodity, as expressed by the CES aggregation function. Numerous routes, including household consumption, government spending, intermediary usage, and investment, influence the demand for the composite commodity. As a result, the model limits the best possible replacement and transformation, reflecting the real economic circumstances.

#### 3.2. CGE simulation and analysis

This section explains the results of the key industrial output by the CGE simulation, followed by analyzing the commodity demand of the TI

in Bangladesh, the effects of direct tax, and finally, the overall macro-economic scenario after each shock (a shock is an unexpected event that causes either a positive or negative changes in the economy) is being experienced by the economy. The simulations are based on the following types of shocks: (i) COVID-19 shock on Bangladesh's economy (SIM1), (ii) Total Factor Productivity (TFP) shock (SIM2), and (iii) extended TFP shock (SIM3).<sup>3</sup>

##### 3.2.1. COVID-19 shock and Bangladesh's economy

The pandemic, due to its subsequent casualties and the government of Bangladesh's forceful imposition of a nationwide lockdown, is considered a negative shock to the economy. The country experienced a sharp decline in economic activity, followed by an unprecedented unemployment scenario, and wage rates for various types of labor decreased [56,61]. So, the estimated factor availability for SIM1 assumed a 50–60% reduction in labor availability. The factor wage rates experienced a varied reduction, depending on the locality and educational attainment, ranging from 10% to 30%. For instance, if the educational qualification of a labor was high, then the decrease in wage rate was low, and vice versa.

Fig. 3 shows the effect of the COVID-19 shock (SIM1) over the different industries of the economy. Among others, the textile, clothing, and leather goods industries, the highest contributors to export earnings in Bangladesh, have experienced a sharp decline in output, with a 63.8% decrease. Furthermore, the cancellation of international flights due to COVID-19 led countries to halt trade during the pandemic, which in turn reduced exports and resulted in a decline in value added. Furthermore, some forward linkage due to the demand linkage with the TI is also one of the reasons why the textile, clothing, and leather goods industry's value-added was hampered.

On the other hand, the education, manufacturing, finance and insurance, and tourism industries were also negatively affected, with industry shares dropping by 54.6%, 46.5%, 35.8%, and 27.8%, respectively. The nationwide outbreak of COVID-19 cases led institutions, including schools, colleges, and universities, to implement prolonged closures, thereby hindering education. Industrial output in the TI was reduced due to the lack of tourists as the government implemented lockdowns, quarantines, and other significant restrictions on national and international mobility.

Lastly, the power and resources, wholesale and retail trade, agriculture, construction, health, and social work, and beverages and tobacco industries were relatively less affected, yet hampered, as outputs went down by 27.5%, 27.1%, 24.9%, 23.2%, 15.8%, and 15.2% respectively. Interestingly, the strong backward linkage between the beverages, tobacco, agriculture, and construction industries, as well as tourism, contributes to reduced output. The reduction of outputs is consistent with the results of Amin et al. [56] and Pham et al. [30].

##### 3.2.2. TI Policy experiments

Concerning the baseline simulation of reducing factor availability and wage rates, SIM2 additionally considers a 10–15% TFP increase in the TI and a 25% TFP increase in the innovation industry to design the shock process. In our analysis, the innovation industry refers to the Information and Communication Technology (ICT) sector, as it is the key industry for facilitating digitization in Bangladesh, as in other countries worldwide. Shocks in the ICT industry can simulate the broader impact

<sup>3</sup> For sensitivity analysis, we simulated the model with different elasticities of substitution between key factors. Following conventional practice, we used the Stroud method. The minimum and maximum values used are, set to 0.25, 0.5, and 1.5 times of the parameter values used in the simulations. Although some changes in results are evident, none of the sensitivity analysis resulted in the change in the direction of results or drastic changes in magnitudes (for instance, GDP recovery in different simulations). These results are not reported to avoid unwanted space wastage. Nonetheless, they can be delivered upon request.

<sup>2</sup> 2019 SAM has been prepared by applying RAS algorithm on 2018 SAM.

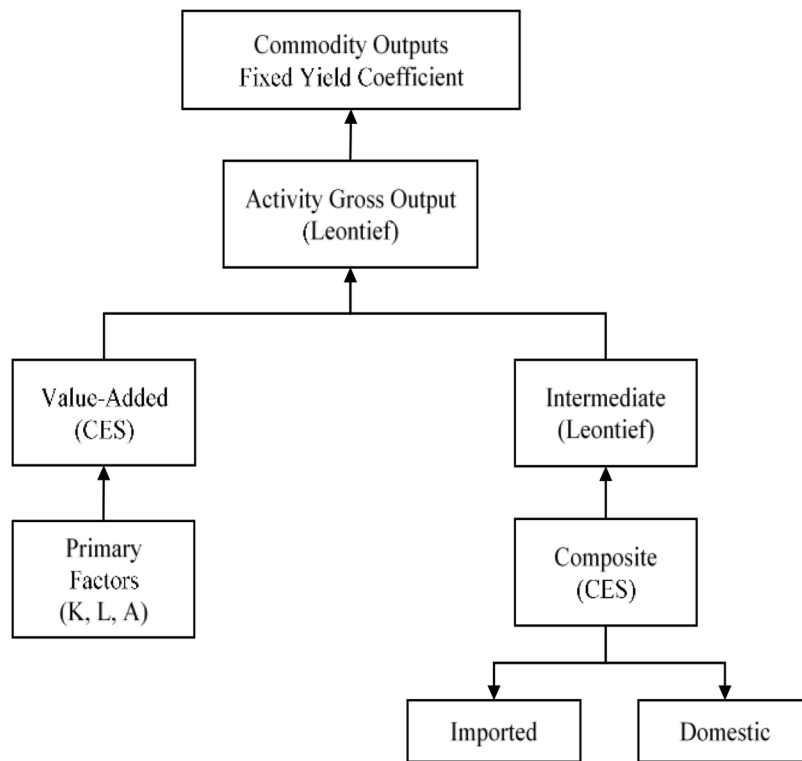


Fig. 2. Structure of production technology.  
Source: Authors' curation

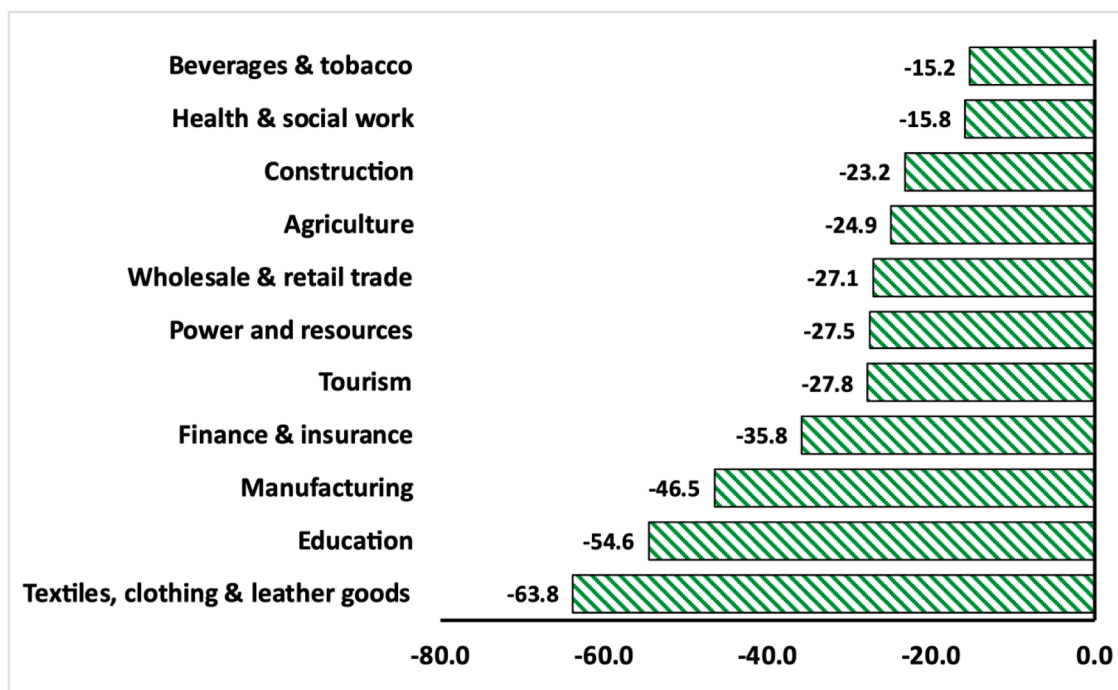


Fig. 3. Effects of COVID-19 on different industries of the Bangladesh economy.

of digitization on economic activities through both direct and indirect channels, as evident in previous general equilibrium investigations [62–64]. An additional TFP shock in the TI is introduced, enabling a more pronounced multiplier effect for the digitization shock in the TI. A further tax cut of 1.5% is administered in the tourism and innovation industries. Tax-cut policies aimed at alleviating the negative impacts on

tourism economies are also prevalent in the existing literature [58,65].

We designed SIM3 by setting a 5–15% decrease in factor availability, rather than the 50–60% reduction observed in other simulations, due to increased worker mobility resulting from government-implemented social distancing policies. Moreover, SIM 3 assumes that the economy continues to operate at a staggering pace, with the varying wage rates of

labor now altered at a moderate reduction of 10–15%. Furthermore, it considers lower TFP shocks in the tourism (10%) and innovation industries (15%), and higher tax cuts of 1.5–2.5% in these industries to compensate for the increased factor availability.

Our paper defines the TI as the aggregate of three sub-industries: (1) Transportation and Storage, (2) Accommodation, and (3) Restaurant and Food Services. Fig. 4 illustrates the overall outcomes of the three simulations on the disaggregated output of the TI of Bangladesh, showing deviation (in %) from the base value. The accommodation industry was most severely affected, followed by restaurants and food services, and transportation and storage were relatively less impacted. When it came to the rate of recovery, we find that food services and restaurants recovered from the COVID-19 shock more quickly than lodging, transportation, and storage services. Some of the change rates may not be rapid or equivalent to others even though the operations or commodities belong to the same broad category, as Timilsina and Pargal [57] emphasize in their paper, due to the nested structure.

Forward and backward linkages affect the rate of change. For instance, among others, the strong backward linkage of TI with textile clothing and leather goods resonates with high COVID-19 impact as well as the recovery rates in policy simulations. This mainly happens because the accommodation sub-industry substantially uses intermediate inputs from the former industry. Given that there is no substitution effect, the adverse effects (i.e., loss in gross output) of the pandemic, coupled with relatively slow recovery rates due to policy simulations in the textile, clothing, and leather goods industries, result in such a scenario in the accommodation sub-industry.<sup>4</sup> Nevertheless, for a variety of additional reasons, it is normal for the accommodation sub-industry's operations to require some time to recover. A few additional potential causes include customer fee restructuring, maintenance time, and service standard inspections prior to reopening, particularly for luxury hotels. Thus, we observe a gradual improvement in accommodation from -44.7% in SIM1 to -35.4 in SIM2, and finally, a recovery of 0.8% in the output in SIM3. The impact of the accommodation sub-industry also produces a forward linkage through the demand channel with other sub-industries of the TI, as evident from the results.

Apart from its own backward and forward linkages, restaurants and food services in tourist areas typically offer takeaway and delivery services to the locals, hence recovering from temporary losses. Output for restaurants and food services progressed from -22.3% in SIM1 to -18.6% in SIM2 and then to 1.7% in SIM3. Similarly, transportation and storage utilities are redirected towards alternative uses such as private rentals or warehousing. The output in this sub-industries also improves from -16.3% in SIM1 to -9.5% in SIM2 and eventually rises by 5.6% in SIM3.<sup>5</sup> The results are consistent with Amin et al. [56].

### 3.2.3. Commodity demand analysis

The results indicate a favorable impact on demand for tourism-related products and services, considering the demand side of the economy. Economic consumption rises due to the increasing demand for tourism-related products and services from the producing side. Fig. 5 shows that the consumption of tourism-related commodities, including transportation and storage, accommodation, restaurants, and food services, gradually improved as the TFP shocks (SIM2 and SIM3) were administered following SIM1, the pandemic shock. Results show that accommodation demand rises from -30.1% in SIM1 to -23.7% in SIM2 and then to -0.3% in SIM3. The demand for transportation and storage decreases from -6.1% in SIM1 to -9.5% in SIM2 and then increases to

<sup>4</sup> Other major industries with backward linkages according to Amin [52] are: broad manufacturing, wholesale and retail trade, construction, finance and insurance, etc.

<sup>5</sup> Some notable backward and forward linkages for both sub-industries in this CGE analysis are broad agriculture, mineral and resources, beverage and tobacco, and broad service industries.

5.6% in SIM3. Furthermore, a rise from -16.6% in SIM1 to -4.1% in SIM2, and finally to 6.8% in SIM3, was noticed in restaurants and food services.

Hence, with improved factor availability, enhanced factor productivity, and higher wage rates in the TI, economic activity, as well as demand for tourism goods and services, increased. As tourists' confidence in the industry grew, so did their demands for its services.

### 3.2.4. Direct tax effect

Table 1 presents the simulation effects on direct tax distribution in rural agricultural, rural non-agricultural, and urban enterprises. According to our modeling framework, the government increases tax rates for other activities or commodities to compensate for the tax reductions, thereby maintaining optimal tax revenue after providing tax incentives for tourism activities. For instance, direct taxes increase by 0.0031% in SIM1 and SIM2, followed by 0.0042% in SIM3 in case of rural-farm enterprises. On average, the increase in direct taxes in all three simulations was no more than 0.0034%, 0.003%, and 0.019%, respectively, for the rural-farm, rural-non-farm, and urban enterprises. Since these activities or commodities have a negligible impact on taxation, the tax incentive for the TI and innovation industry does not hinder economic activity in the remaining major enterprises. This can be reflected in the overall macroeconomic effect shown in the following section.

### 3.2.5. Comparison of overall macroeconomic situation

In Table 2, we present the complete macroeconomic scenario following the administration of three different shocks. The last simulation effectively provides the best picture with optimal output levels. Without any influence on TFP, factor availability, and tax incentives, every crucial macroeconomic component faces a substantial decline. For instance, after injecting SIM1, investments decline by 51.1% but improve after SIM3 by 16.43%. On the other hand, exports decrease by 59.39% and imports decrease by 34.86% in SIM1, which rise to -10.4% and -9.04% in SIM3. Similarly, aggregate consumption falls by 13.20% in SIM1 after the COVID-19 shock, improves by 9.58% in SIM2, and remains stable at 0.89% in SIM3. Additionally, GDP improves at both the market price and the factor price. GDP decreases by 27.04% and 27.96% at factor price and market pricing, respectively, from the SIM1. The situation improves slightly as we introduce TFP and tax incentives in the tourism and innovation industries (SIM2), and then significantly improves in SIM3, where factor availability is increased at various rates.

## 4. Digitization of TI in the post-pandemic world

In this section, we demonstrate how various countries are increasingly embracing digitization as a strategic approach to revive and promote sustainable tourism in the post-pandemic era in support of the green transition. An examination of the current state of digitization in Bangladesh follows this. Based on the discussion, we propose a digitization framework for the tourism and innovation industry in Bangladesh.

Technology and innovation have long played a crucial role in promoting a greener and more sustainable economy. Halls and William [66] observed that among all the other industries, TI, too, has the potential to be a powerful driving force for transmitting innovation in the economy. There has been growing research to analyze the effectiveness of the application of digitization and digitalization as an innovative approach for sustainable tourism as more and more countries are leaning towards strengthening their TI to increase the GDP as well as portray one's nation to the world [67]. With the pandemic introducing physical and geographic barriers in an industry that relies heavily on mobility, digitization can permeate the industry to enhance mobility while guiding stakeholders toward more sustainable approaches.

The use of technology in the tourism industry is not new; instead, it has been significantly impacted by the expansion, growth, and extensive use of Information and Communication Technology (ICT), and it

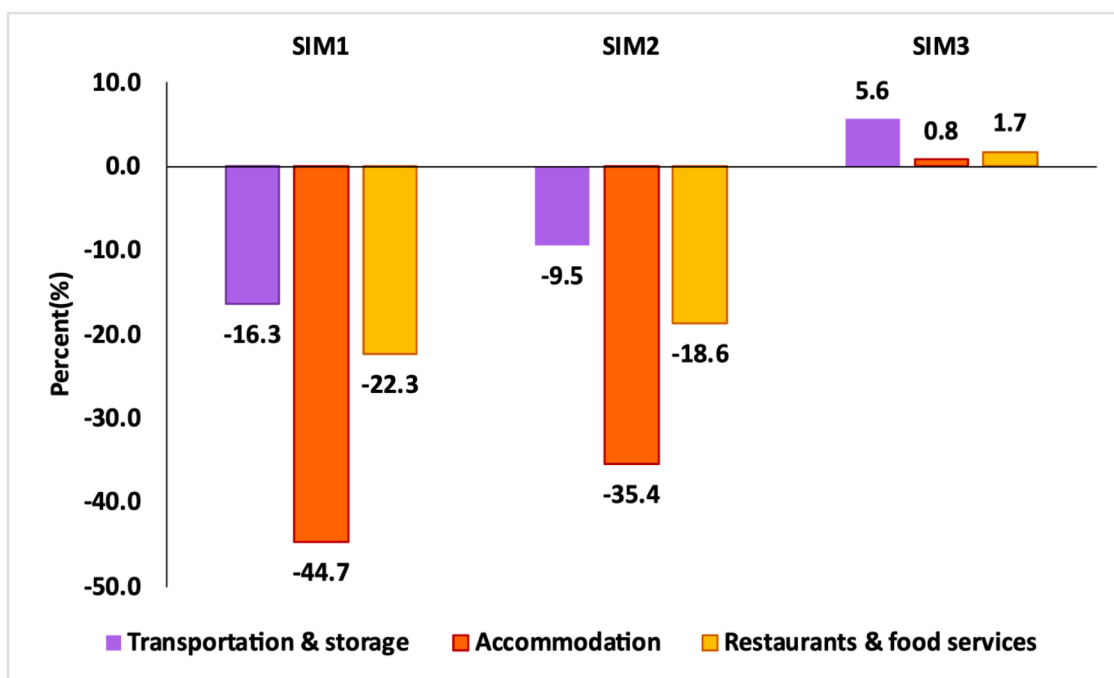


Fig. 4. Change in output of the TI in Bangladesh.

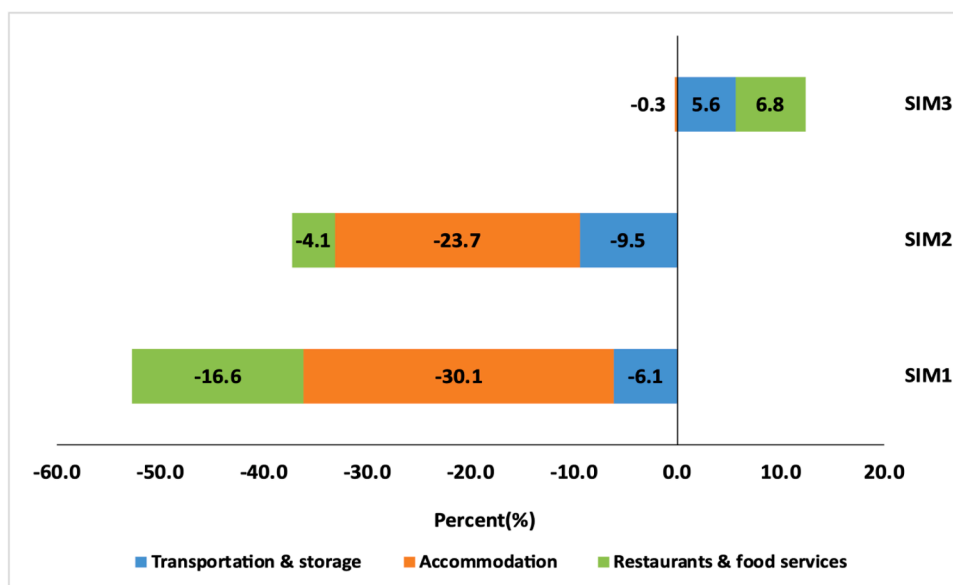


Fig. 5. Impact of the pandemic on commodity consumption in Bangladesh.

**Table 1**  
Comparison of direct tax effects.

Enterprise	Base	SIM1	SIM2	SIM3
Rural-Farm	0.0042	0.0031	0.0031	0.0042
Rural-Non-Farm	0.0034	0.0027	0.0028	0.0035
Urban	0.0219	0.0182	0.0196	0.0215

Note: Simulation outputs are percentage changes from base value

remains one of the main factors driving change in the industry [68,69]. Developed countries have consistently worked to integrate digital innovations into tourism, differentiating themselves in the competitive and rapidly growing global market. Countries such as the UAE,

**Table 2**  
Comparison of the macroeconomic situation.

Criteria	Base	SIM1	SIM2	SIM3
Consumption	11.35	-13.20	-9.58	-0.89
Investment	5.22	-51.10	-78.18	-16.43
Exports	3.21	-59.39	-45.35	-10.40
Imports	-3.69	-34.86	-39.44	-9.04
GDP at market prices	17.11	-27.96	-28.69	-4.10
GDP at factor cost	16.25	-27.04	-27.21	-3.75

Note: Simulation outputs are percentage changes from base value

Singapore, and China have incorporated digital facilities extensively for a considerable period. The introduction of virtual guide apps, transit apps, blockchain services, and electronic payment facilities, among others. The application of robotic technology has also been on the rise. For example, Haidilao International Holding Ltd partnered with Panasonic Corporation to launch the first-ever staff-less, robot-facilitated kitchen-based restaurant in Beijing, China, in 2018. The Hilton McLean Tysons Corner Hotel, along with IBM, launched the robot hotel concierge [70]. Adopting digital innovations to enhance TI has thus become an established and profitable strategy for attracting tourists by making TI more accessible and safer.

Unfortunately, no country was exempt from the adverse effects of the COVID-19 shock. A period when going outside even to earn a livelihood was at a halt, travelling had become a myth. With all domestic and international travel being restricted, tourist destinations suffered, just like any other industry, or even more. However, during late 2020, things started to improve with limited access to traveling given the tourists follow a list of new travel principles- getting vaccinated and getting tested for COVID-19 24 hr prior to traveling, going to quarantine for 2 weeks after landing in the destination, maintaining social distance and last but not the least, wearing masks most of the time. With all these restrictions being introduced into the system, people slowly began to adapt to specific health measures and practices while also starting to enjoy the online facilities that had emerged during the pandemic period. In Russia, the government established hundreds of QR codes for the registration of visitors to enter public places like malls and theatres, many hotel chains such as Marriott International, Hyatt and Hilton have announced to implement of digital technologies (such as electrostatic sprayer, robot cleaners) as their new cleanliness measures [71]. Technology has also enabled a transition toward digitally self-guided tourism, eliminating the need for group travel and aligning with the ongoing social distancing norms expected to remain in place for an extended period [72]. For example, a Web 2.0, technique-based, self-guided museum tour app has been proposed and found to be effective in increasing the participating museums' network activity and attracting audiences [73].

Hence, many countries have adopted digitization and digitalization to provide their guests with facilities such as contactless payment, online reservations, personal vehicle rentals, robots, and digital communication, along with other strategies to recover their tourism industries (TIs) in the post-pandemic era. Digital adoption has been growing exponentially due to the pandemic, and thus, there is a scope for developing countries, such as Bangladesh, that are yet to adopt these technologies. Moreover, the nature of this innovation and technology allows for easier integration of sustainable frameworks, as demonstrated in the conceptual digitization framework. The inclusion of innovations will improve productivity in the industry and boost the economic performance of sub-industries of TI, such as transportation and storage, accommodation, restaurants, and food services, that were negatively affected during the pandemic, as shown in the CGE simulations.

#### 4.1. Current state of digitization in Bangladesh

Bangladesh has experienced rapid growth in technology and innovation, driven by policies such as the ICT Acts (2009 and 2013), ICT Policies (2009, 2015, and 2018), and the Right to Information Act 2009, all of which have been implemented by the government of Bangladesh. The Strategic Priorities of Digital Bangladesh 2011 report, published in January 2011 by the a2i (Access to Information) program, outlined the strategic priorities needed to implement more advanced, mobile, and digitalized kinds of initiatives in Bangladesh. Establishing a universal access policy, creating a legislative and regulatory framework for ICT development, and increasing the amount of digital material on government websites were all priorities in Bangladesh's Perspective Plan, which was published in April 2012 and 2020 [74]. Additionally, extending device and network connectivity, facilitating access,

communication, and financial technologies, and digitizing through the use of sensors, blockchain, artificial intelligence, 5 G broadband, data analytics, and cloud computing were the main objectives of the 8th Five Year Plan, which was published in December 2020 [75]. Recently, the government has adopted a post-pandemic recovery roadmap that outlines implementation strategies for various digital services across industries to enhance efficiency. Additionally, the government has been encouraging innovation by providing financial support, mentorship, networking opportunities, and investment readiness to creative firms at various stages of growth nationwide [76].

With the introduction of targeted policies and initiatives by the government, the digital environment of Bangladesh has seen a significant improvement in the past years, including the digitization of essential services like e-passport from the Department of Immigration and Passports, digitized mass vaccine program called Surokkha by the Security Services Division, Ministry of Home Affairs, and many other private platforms for digitized services. The growth of Mobile Financing services (MFS), such as Bkash and Nagad, online banking services, and the expansion of mobile internet use have recently propelled the digitization drive in Bangladesh. Besides, to boost e-commerce activity in the country, Bangladesh Bank has launched a national payment switch to ensure the interoperability of various payment channels. Specific infrastructure, such as the development of High-Tech Parks, has been implemented to expand the reach of digital services nationwide. To increase ICT education at the grassroots level, the government, with the help of relevant stakeholders, is implementing numerous programs and workshops for all population groups.

E-tourism services in Bangladesh have begun to emerge, featuring digitized booking systems, information collection systems, 5 G internet connections, travel agent management, and more; however, their full potential has yet to be realized in terms of implementation and efficiency [77]. Given that a strong structure and foundation are necessary for sustainable growth through digitization, there is scope for exponential improvements in the TI and ways to recover from the adverse shocks due to the pandemic.

#### 4.2. Scope of digitization in the TI of Bangladesh

We argue that digitization is the most effective form of digital innovation in the TI. We have seen the potential of Bangladesh to enable a digitized industry. We can assert with confidence that the digitization of tourism services, government policy, and nudging tourist behaviors is achievable. This also enables domestic tourism due to improved incentives to travel short distances, enjoy personal tourist adventures, and explore their own culture by Bangladeshi tourists. Moreover, reduced waste, increased efficiency, enhanced trust and transparency in transactions, decentralization of services through the elimination of intermediaries, and improved food supply chains foster a culture of tourism, driving it toward a pathway leading to green tourism. This is a practical pathway towards sustainable growth of the TI. Table 3 presents both incumbent technology and digitization, as well as possible ways to digitize and spur digital innovation in the TI through domestic and green tourism.

The imminent need for digitization primarily stems from the shift in tourists' perceptions and behaviors during the pandemic. Tourists have become keener on traveling shorter distances. Concerns about health, safety, and hygiene have increased drastically. There has been a shift in the demographics of tourists, with a rise in young travelers, and an appreciation of the local environment and authenticity has increased among tourists [97]. In Bangladesh, domestic tourism is primarily driven by young tourists who are eager to interact with local communities and participate in recreational activities during their trips [98]. Furthermore, a study by Amin [99] suggests that tourists in Bangladesh are already transitioning to embrace domestic and green tourism, with their patterns and behavior leaning towards environmentally and socially sustainable methods of travel. Thus, digitization can catalyze

**Table 3**  
Overview of digitization and innovation in the TI.

Technology	Application	Benefit	Refs.
Blockchain	Creates a peer-to-peer transaction system with accurate, consistent, timely and complete data through a decentralized database system. Example: DeskBellChain, Provenance, Tranexus.	Traceable transactions improve trust, transparency, and accountability between stakeholders.	Tyan et al. [78]
Smart Contracts	Automated payment and bookings, without the need of external approval.	Faster, safer transactions, limiting the scope of cyber and accounting crime.	Bodkhe et al. [79]; Nam et al. [80]
Decentralization Apps (DApps)	Allows consumers to interact with blockchain technologies in more user-friendly ways, such as smartphone applications. Example: Accenture, Sandblock.	Personalized service, reward systems and tokens, and better consumer experience.	Ozdemir et al. [81]
Digital Supply Chain Management	Digitizes the food supply chain and other related services.	Less waste, reduced pollution.	Wong et al. [82]
Chatbot	Automates interaction between service providers and tourists.	Instant service, personalization, recommendations, and swift information.	Nica et al. [83]; Upkabi et al. [84]; Calvaresi et al. [43]
Digital Assistants and Robots	Artificial intelligence that provides augmented reality for tourism services. Automated services, such as food delivery and hospitality, are provided. An example is "City Brains" adopted in China.	Consumer analytics can be collected quickly, efficiently, and in a non-discriminatory manner, providing better service.	Pencarelli [18]; McCartney and McCartney [85]
Contact Tracing Apps	An application that tracks users to understand their interaction patterns and isolate potential threats to safety, including the contraction of viruses.	Enhances safety, facilitates more accurate forecasting of a surge in the infected population, and enhances niche and specific policymaking.	Konidaris et al. [15]
Virtual Travel Organization	Connects service providers and tourists in a concise system, providing them with relevant information.	Enhances information dissemination, streamlines service access, and personalizes tourism experiences.	Toylan and Çakirel [86].
Online Travel Agency (OTA)	An online platform that creates a marketplace for tours, transport,	Easy access to tourism services, comparable services, and easier	Chang et al. [87]; Lv et al. [88]

**Table 3 (continued)**

Technology	Application	Benefit	Refs.
	trips, and other tourism services. Examples include TripAdvisor, Booking.com, and Expedia.	planning and execution of trips.	
Social Media and Websites	A hub of media, communication, and information is available online and accessible to all—for example, Facebook, Twitter, and tourism websites like Beautiful Bangladesh.	Extensive access to information, communication, and data (e.g., number of check-ins, reviews, etc.). Enables digital marketing and content mining.	Hays et al. [89]; Zeng and Gerritsen [90]
Recommendation Software	A database of information that provides tourist destination recommendations based on a user's preferences and tastes.	Improves decision making and selecting points of interest (POI).	Koceski and Petrevska [91]; Massimo and Ricci [92]
Difficulty Assessment Platforms	Provides ways to assess tourist spots personally before embarking on a journey.	Improving decision-making and destination choices enhances the personal tourism experience.	Calbimonte et al. [93]
Online Payment Software	Facilitates mobile and online payment for quick booking of trips and flights.	Easier to manage finance and forecast costs.	Cheng et al. [94]; Law et al. [95]
Sharing Economy Platforms	Platforms that connect tourists with hosts who are willing to share their possessions like house, car temporarily. Examples- Airbnb, Uber,	Affordable service than hotels, expands the range of location, enrich the local community	Konstantinova, S [70]
Travel Apps/ Virtual Guide	Provides tourists with information regarding accommodation and transportation within the selected destination	Access to different types of information under one platform	Pajorska, Z [96]

these changes by increasing tourist arrivals, improving decision-making, reducing costs, and expediting logistics and technical operations. With access to better and timely information, tourists can make informed decisions to reduce their carbon footprints and engage in more sustainable behaviors during their travels. Moreover, collecting metadata is much easier when stakeholders utilize digital technologies, making data analytics for tourism recovery more accurate. Tourist service providers can improve their services based on tourists' reviews and attract more tourists in the future.

Due to the volatile industry environment in the post-pandemic era, tourists are increasingly concerned about cancellation policies, late bookings, and sudden changes in plans. Digitized payment systems, including blockchain, smart contracts, mobile payment services, and chatbots, can significantly enhance these services, making tourists more inclined to plan and execute their trips. Furthermore, the trips that are short in distance and closer to home have less logistical complications. Hence, better information about nearby destinations on websites like Beautiful Bangladesh and social media sites like Facebook, Instagram, and Twitter, Personalized Point of Information (POI) recommendations

by recommendation software about short trips and vacations close to home can drastically improve the ability of tourists to embark on their journeys. This also enables better real-time decision-making by tourists and personalizing their travel itineraries according to their preferences. Moreover, the introduction of digital assistants and automated services utilizing artificial intelligence and robots in hotel management has the potential to mitigate the health and safety concerns associated with the pandemic. Additionally, the gamification of services through Augmented Reality and Virtual Reality in smart tourism and e-tourism services can significantly improve the experience of domestic tourists and the extent of their recreation, attracting more young tourists [100]. The gamification includes reward mechanisms, token systems, and overall digitized applications adopted by many Online Travel Agencies (OTA) that keep tourists engaged with the services provided. This enhances the domestic tourism environment in Bangladesh, attracting more local tourists, which also improves the industry's structural infrastructure for future sustainable growth.

#### 4.3. Digitization and sustainability in the TI of Bangladesh

The benefits of implementing digitization in the TI of Bangladesh are irrefutable because, by the results of the CGE model simulations, we observe the positive impact on the economy of Bangladesh due to the increase in output of the TI through digitization. Moreover, the drive towards digitization encourages tourists, tourism service providers, and tourism enterprises to adopt a sustainable tourism environment, where domestic tourism and green tourism are achieved, as shown in Fig. 6 below. This ensures that, in the long run, the environmental damage caused by tourists and tourism services can be mitigated, allowing the industry to flourish sustainably.

With the change in tourist behavior and demography, it is possible to digitize the industry to a path leading to sustainable tourism by the inclusion of rural tourism, an increase in sustainable tourists, and the preservation of local tourist spots, leading to green tourism. Pulido-Fernández and López-Sánchez [101] found that the number of tourists with high "sustainable intelligence" is growing. With the pandemic and increased concern for health and hygiene, the number of tourists who are willing to pay a higher amount for more sustainable services has also increased. With faster services enabled by automation, trustworthy and traceable transactions facilitated by blockchains, and improved

information dissemination, sustainable behavior among tourists has been expedited. In Bangladesh, the main tourist destinations primarily comprise green environments, local tourist attractions, and rural areas that showcase the country's natural beauty. Hence, with the digitization of services in tourism, it is easier to include local tourism service providers and help protect the sanctity of destinations, conserving biodiversity and mitigating unsustainable practices by tourists. Bangladesh is already well-equipped with green climate funds, which are allocated to environmental improvement. A proportion of these funds can be allocated towards the TI, and the adoption of green tech and digitization in green FinTech, including the establishment of proper regulatory incubators and structures, can further propel development. Furthermore, with the introduction of recommendation software, Bangladesh can encourage local tourists to adopt sustainable practices and promote green tourism, offering higher rewards to those who demonstrate sustainable behavior. Moreover, the introduction of contact tracing apps and effective vaccination drives can further encourage tourists to travel, thanks to increased safety and hygiene measures. Furthermore, digital supply chain management can significantly reduce waste and transform service providers into more environmentally responsible stakeholders. This can drive the tourism environment in Bangladesh to adopt green tourism methods, as portrayed in Fig. 6, while increasing the number of tourist arrivals and preparing the industry structurally for future environmentally conscious and sustainable policies.

Therefore, enabling digitization in TI can work as a catalyst for improving sustainability by nudging each stakeholder into greener and more sustainable practices. With the imminent need to improve productivity and recover from the pandemic shock, digitization can be the perfect pathway to achieve sustainable green growth in the TI of Bangladesh.

#### 5. Conclusion and policy recommendations

This paper aims to examine the effects of COVID-19 on Bangladesh's TI and discuss how innovation and digitization initiatives might help this industry grow in the years to come. A multi-industry CGE modeling approach is used to construct and analyze the three simulated scenarios. The overall findings that emerge from our analysis are that TFP in the innovation and TI amidst the pandemic enhances industry-level activity and boosts commodity demand, while tax incentives provided to the TI

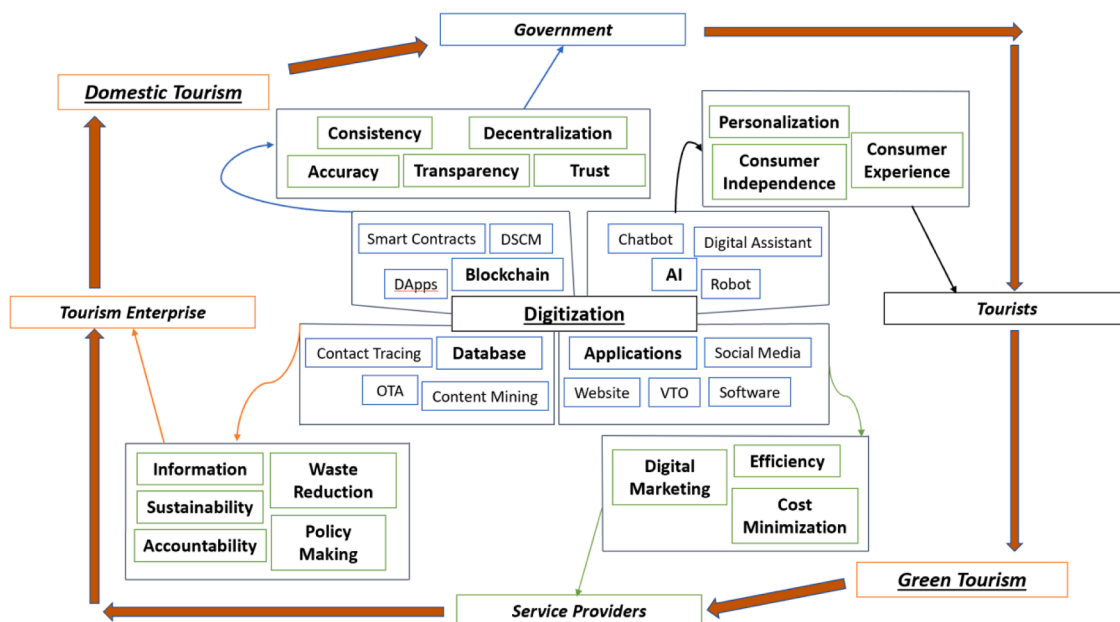


Fig. 6. Conceptual framework of the digitized transformation of Bangladesh TI.

do not affect the remaining economy. Thus, innovation such as digitization will ensure better overall economic performance in Bangladesh. Moreover, this paper proposes a conceptual framework to facilitate tourism activities that revive the industry, with a focus on domestic and green tourism. Digitization is imminent for Bangladesh, with its growing ICT industry permeating every aspect of the economy. Moreover, trends in tourism have not previously focused on sustainable approaches, and thus, nudging tourists towards green tourism will gradually steer the industry towards sustainable growth.

To that extent, the government should formulate appropriate policies, facilitate their implementation in the TI, and implement changes in tourism policies by addressing loopholes that hinder sustainable tourism expansion. Revising tourism regulations to include greener tourist destination planning, sustainable standards, and detailed stakeholder mappings would enable more green innovations throughout various tourism supply chains and services offered by tourism businesses. We have shown how many firms worldwide have already adopted these greener innovations. Furthermore, enhancing public and private tourism organizations is crucial for fostering interaction with tourist-related firms to identify potential barriers to sustainable growth and gain a deeper understanding of local market and community perspectives. This will facilitate the effective implementation of green tourism initiatives within tourist destinations.

Moreover, the government should focus on increasing the TFP of the ICT industry in Bangladesh to facilitate an enhanced digitization multiplier effect. One way of achieving higher productivity is to improve technical and mechanical efficiency through skills development. According to the labor force surveys of Bangladesh, it is evident that the labor force of the ICT industry is predominantly composed of low- and medium-skilled workers. As a result, there is an immense need to develop skills within the existing labor force by strengthening the prevailing skills development programs of the ICT ministry. Additionally, the government needs to collaborate with startups and think tanks to design and implement skills training workshops for different categories of the ICT labor force.

Moreover, a notable gap exists in the distribution of the labor force between urban and rural areas. Amin [76] highlights that 75% of the ICT labor force of the ICT industry is employed in urban areas. Such disparity could lead to hindrances in the long-term digitization process. Therefore, we advocate for the implementation of district-level digital literacy programs through vocational colleges to bring about changes in the distribution of the ICT labor force. On the other hand, the government must also implement policies to support the modern digitization process outlined in post-COVID-19 roadmaps and strategies (e.g., blockchain strategy, startup ecosystem, digital commerce, innovation of new digital technologies, software development, etc.) to increase the success rate of the aforementioned policies.

Non-technological aspects need to be strengthened to absorb the multiplier effects of digitization along with tax restructuring. In doing so, we advocate that the government, in collaboration with relevant tourism organizations, should focus on introducing environmental management systems, developing new tourism business models with Environmental, Social, and Governance (ESG) components, revising marketing and organizational methods, and innovating social and institutional structures. Nevertheless, this should be done in consultation with the firms involved in the tourism activities and the host communities of the tourist area to achieve maximum success.

Additionally, facilitation of the generation of a Factor Productivity Enhancement roadmap, with extensive government programs alongside research and development. Apart from this, addressing the National Hotel & Tourism Training Institute (NHTTI) to include thorough training that improves human capital while adhering to government healthcare guidelines and regulations will pave the way for post-pandemic recovery.

It would also be helpful to have regular talks between regional tourism stakeholders, including investment promotion organizations.

Similarly, cross-border tourist investment organizations and private-public partnership facilitators should be encouraged to attract sufficient investment into the industry, which can boost the accessibility of digitized services in the industry. There should also be an endorsement from the government to the private sector to increase green investments in the TI, which can be improved by providing subsidies and tax cuts for greener innovations in this industry. We have found evidence of the recovery effect of tax cuts in this industry; therefore, tax cuts can be targeted toward implementing sustainable options.

However, the effectiveness of the policy agenda's design, as derived from the conceptual framework, remains a topic of debate. We contend that the range of time frames for policy formation should be medium- to long-term. This is because incorporating digitalization into a policy framework is still a relatively new process; as such, a learning-by-doing approach should be the foundation of policy design. Thus, the results of this paper have broader implications for policymakers. Instead of relying exclusively on associated public institutions, the formulation process should encourage cooperation from all parties involved, including both public and private entities. To that end, it would be appropriate to establish a national committee comprising members from the numerous industries directly involved in the supply and demand sides of the market. Pareto optimality will be ensured by establishing a national council to develop and implement specialized policies promoting the sustainable growth of the TI.

Moreover, institutional reforms to facilitate tourism market development should come from strengthening the regulatory legitimacy of institutions. Regulatory legitimacy can be defined as the structure of standard rules, policies, and procedures within the bureaucratic process. The fragmentation of centralized systems, a common characteristic of South Asian countries such as Bangladesh, creates bureaucratic distortions and institutional loopholes that limit progress [102]. Hence, institutional reforms that enhance regulatory legitimacy are crucial for ensuring sound financial, technological, and infrastructural development in policy implementation planning, diffusion, and decision-making.

Since the given CGE model is static, one of the limitations is that it cannot capture the time-variant effects of the policy shocks. An extension of this paper could be to develop a dynamic recursive CGE model, allowing for the observation of policy shock effects over a time dimension. Moreover, our model assumed homogeneity of agents, which can be upgraded to include heterogeneous agents in a hybrid model. This can capture the agents' behavior in both on and off-equilibrium states. This will enable policymakers to see the short-term and long-term impacts of policy shocks, in both equilibrium and disequilibrium, making more informed policy decisions. Another avenue to extend this model is to incorporate stochasticity into the shocks. This can be achieved by formulating a dynamic stochastic model that allows for the integration of different exogenous policy interventions, such as digital adoption metrics, FinTech innovation, or green finance, into the model separately. Moreover, the modeling can include parameters such as carbon footprint, energy efficiency, and digitization and innovation to capture the effect of digitization in the growth of sustainable tourism in both competitive and rigid market environments.

Moreover, a quasi-experimental behavioral study can be designed to understand the pros and cons of tourism digitization from tourists' and tourism service providers' perspectives. Another extension avenue could be to conduct a regional collaborative study. We welcome empirical analysis to check the framework's effectiveness. Additionally, appropriate structural changes can be introduced based on the empirical outcomes, if necessary, to stimulate ideas for future research.

## Inclusion and diversity

While citing references scientifically relevant for this work, we also actively worked to promote gender balance in our reference list. The author list of this paper includes contributors from the location where

the research was conducted who participated in the data collection, design, analysis, and/or interpretation of the work.

### CRedit authorship contribution statement

**Sakib Bin Amin:** Writing – original draft, Supervision, Conceptualization. **Mahatab Kabir Khandaker:** Writing – original draft, Formal analysis, Data curation. **Bismi Iqbal Samia:** Project administration, Methodology, Formal analysis. **Farhan Khan:** Writing – review & editing, Visualization, Software. **Farhad Taghizadeh-Hesary:** Writing – review & editing, Validation, Resources.

### Declaration of competing interest

No potential conflict of interest was reported by the authors.

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### Data availability

Data will be made available on request.

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