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Impacts of Weather Variability on the International Tourism Receipts—Evidence from Ethiopia (1995–2019)

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Abstract: Every economic sector is susceptible to the direct or indirect effects of weather variability, and the tourism sector is no exception. In fact, the tourism industry is considered to be more vulnerable to the effects of weather variability than the general economy, with changes in weather patterns, extreme events, and environmental degradation offering substantial obstacles. Ethiopia's tourism industry, like many others, faces challenges from weather variability. This study investigates the short- and long-term effects of weather variability on Ethiopia's international tourism receipts. Utilizing data from 1995 to 2019, the research employs a vector error correction model to analyze the relationships between weather variables (temperature, rainfall), economic factors (GDP growth, inflation), political stability, and tourist arrivals. The findings reveal that in the long run, higher temperatures, rainfall, and inflation have negative impacts on tourism receipts, while political stability and past tourist arrivals have positive effects. Short-term trends mirror these, with the addition of GDP growth not showing a significant impact. To ensure the sustainability of tourism in Ethiopia, the study emphasizes the importance of understanding weather's influence, developing adaptation strategies, and promoting sustainable tourism practices.

Keywords: international tourism; vector error correction model; weather variability; Ethiopia

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1. Introduction

Weather variability refers to the fluctuations and changes in weather conditions over short periods, ranging from hours to days, weeks, or even seasons, occurring due to various factors such as natural climate patterns, atmospheric disturbances, and human-induced climate change [1,2]. Every economic sector is susceptible to the direct or indirect effects of weather variability, and the tourism sector is no exception. In fact, the tourism industry is considered to be more vulnerable to the effects of weather variability and climate change than the general economy, with changes in weather patterns, extreme events, and environmental degradation offering substantial obstacles [3]. However, tourism is a significant source of foreign exchange earnings and a primary export market for many developing nations, generating much-needed jobs and development prospects [4]. Before the pandemic, the sector played a fundamental role, accounting for one in five new jobs and contributing 10.4% to global GDP, which represents 334 million jobs worldwide [5]. Despite the challenges, the sector's contribution to global Gross Domestic Product (GDP) grew by 22% in 2022, reaching a value of USD 7.7 trillion and creating 21.6 million new jobs, totaling 295 million [6]. Also, the World Travel and Tourism Council projected a continued strong performance for the industry, with the travel and tourism GDP growing at a rate of 23.3%, reaching 9.2% of the global GDP in 2023 [6].

As observed in recent years, the tourism industry suffers from the consequences of complex challenges, including weather variability [7]. Extreme weather events in particular have not only posed direct threats to tourism infrastructure but have also altered the perception of destinations as safe and desirable [8] and led to shifts in travel behavior, affecting destination choices and tourism seasonality [9]. Despite this, there is little knowledge of the relationship between tourism company operations and weather variability [10], especially in unexplored or under-investigated geographic locations [11] like Ethiopia. Evidence shows that Ethiopia, like many African nations, is grappling with the consequences of more frequent extreme weather events, including erratic rainfall patterns and temperature extremes [12]. The country is also susceptible to land degradation, jeopardizing its diverse ecosystems and the communities that depend on them [2], making it one of the African countries most vulnerable to weather variability [13].

Despite this, the vulnerability of Ethiopia's tourism sector to weather variability remains unexplored, with no existing published work, to the best of the authors' knowledge. Thus, this study sought to address the gap in understanding the specific impacts of weather variability on Ethiopia's international tourism receipts during the period from 1995 to 2019. Specifically, the study aimed to determine the short- and long-term effects of weather variability on Ethiopia's international tourism receipts. As weather variability significantly influences destination selection [14,15], competitiveness [16], image [17], visitor participation and enjoyment [18–20], overall tourism experience [21], and even success of tourism enterprises [22], the findings of this study can contribute to developing strategies that are crucial for the long-term sustainability and resilience of Ethiopia's tourism industry. Understanding weather impacts on tourism is also crucial for effective risk management and sustainable development [23] in light of possible climate change impacts.

The structure of the paper is as follows: Section 2 gives a literature review on the impacts of weather on the tourism. Section 3 describes the statistical methodology we applied for assessing the short-run and long-run impacts of weather variability on international tourism receipts. Section 4 describes the results and findings of our analysis, and Section 5 gives conclusions and policy implications.

2. Review of the Related Literature

2.1. Relationship between Tourism and Weather

Weather variability, particularly temperature and precipitation, significantly shapes tourism around the world, with several studies revealing a complex interplay between these factors and tourism. Generally, warmer temperatures are linked to increased tourism activity [24–26]. This is especially true for cooler destinations during summer and fall [26]. However, extremes can be detrimental. Very high temperatures [27,28] and very low temperatures [29] deter tourists. A rise in temperature can lead to a rise in annual park visits [30], but there is a limit. Studies in Austria [31,32] highlight a positive correlation between temperature and domestic overnight stays, with a 1 °C increase in August corresponding to a 1.2% rise in overnight stays in the same month [33].

Regarding precipitation's role, while sunshine is often favorable [33], excessive precipitation can be negative [34,35]. Snowfall presents a unique case. It can be a boon for winter sports [36,37] but detrimental in other contexts [29]. Also, rain can have mixed effects. Light rain might encourage museum visits [38], but heavier precipitation can disrupt travel plans and outdoor activities [39,40]. Interestingly, island destinations seem to react differently to rain depending on the season [41].

Furthermore, favorable weather conditions encourage tourists to extend their vacations [42,43], while bad weather can lead to early departures [34]. Weather also influences destination preference, with some shifting towards recreational activities during poor air quality [44]. Unfavorable weather in Poland reduced tourist flows by up to 15–20% [45]. Similarly, the impact of weather can vary depending on the location and tourist demographics. Domestic tourists might be less deterred by certain weather conditions compared to international visitors [31]. Studies in Austria [31,32] and Spain [46] highlight the influence of temperature differences between origin and destination. Additionally, weather preferences can be seasonal. Winter sports thrive on snow [36], while summer vacations might favor sunshine [47]. In Cheshire, England, daily visits increased as temperatures rose up to a threshold of around 21 °C [48].

The increasing frequency of extreme weather events due to climate change is a growing concern [49,50]. While some studies suggest potential benefits from a warming climate, like extended park visitation seasons [51], the overall impact on tourism is likely negative [23]: mainly, among others, cancellations and trip alterations [22,52], impacting hotel occupancy rates and overall tourism revenue [53], disruptions [52,54], and safety hazards [55]. Although negative effects seem to outweigh positive ones, some positive consequences may be expected for the tourism sector, at least in the short or medium term. Northern regions—Scandinavia, Northern Europe, or Alaska—may benefit from a milder climate, attracting more tourists. Some new opportunities may arise from "last-chance" tourism, i.e., visiting areas that may disappear in a warmer world, such as the glaciers in Antarctica or the low-lying islands threatened by sea-level rise. The already fast increase seen in Arctic cruises can further progress due to the melting of sea ice. However, most of these positive opportunities will be short-lived [56].

In light of this, several approaches have been used to mitigate the negative consequences of weather variability, promote sustainability, maintain economic viability, and protect destinations and tourists. These fall under the following six broad categories:

- Planning: This includes acknowledging and addressing the links between environmental change and tourism and urging better adaptation plans [57–62]. Additionally, understanding the seasonality of weather patterns is vital for planning and decision-making. This involves adjusting festival dates, creating real-time information platforms, and implementing flexible vacation arrangements [62].
- Infrastructure investment: Examples include adapting coastal tourist infrastructure to account for rising sea levels and storm surge risks [63], building seawalls [64], beach erosion control [65], and diversifying tourism offerings. For instance, mountain resorts facing challenges due to decreased snowfall can explore alternative activities like hiking, nature trails, and cultural experiences to attract tourists [66]. Another good example is the introduction of artificial snowmaking in mountain areas vulnerable to climate change, which sustains winter tourism [66].
- Awareness and education: This involves educating tourists, local communities, and industry stakeholders on the need for sustainable practices [58,65], including reducing energy consumption, using renewable energy sources, adopting eco-friendly technologies, and sequestering CO_2 through carbon sinks [64,67,68].
- Research and data enhancement: More precise information about climate change, especially at smaller geographical scales, helps the tourist industry better comprehend the issue and make informed decisions [23,69]. To predict how weather patterns will shift in the future and how they will affect various tourist activities, scientists must keep digging into models and data [70,71].
- Enhanced collaboration and coordination: Improved coordination among disaster management offices, tourism administrations, businesses, host communities, and meteorological services is essential for preparing to extreme climatic events [72].
- Implementing policies and regulations: Establishing and enforcing policies are beneficial to mitigate the negative impacts of climate change on tourism. This includes supporting adaptation efforts [67,73,74], promoting low-carbon tourism [75], tax waivers for environmentally friendly practices, active encouragement for climate-adaptive establishments, and the implementation of green taxes to promote sustainability [76,77].

2.2. Modeling International Tourism Arrivals and Receipts

The past 40 years produced a vast volume of literature studies about models describing tourism performance. The core tourism literature defines factors that influence tourism arrivals and tourism revenue at a destination based on destination attractiveness and competitiveness. The models from the 1980s focus mainly on tourist arrivals and receipts (or departures and expenditures), with income, price levels, and transportation costs as the most popular explanatory variables. They typically use annual data series, though quarterly and monthly data are also often applied [78–80]. The typical model structure is a single-equation model of the following structure:

$$DT_{i,j} = f(Y_j, TC_{i,j}, RP_{i,j}, ER_{i,j}, QF_i) \tag{1}$$

where

- $DT_{i,j}$ is the tourism demand (tourist numbers, tourist nights, or tourist receipts) for destination i from origin j;
- Y_j is the income of origin j;
- $TC_{i,j}$ is the transportation cost between i and j;
- $RP_{i,j}$ is the ratio of prices in the destination i compared to the origin j;
- $ER_{i,j}$ is the exchange rate of currency unit of destination i measured per currency unit of origin j;
- QF_i is the value of qualitative factors in destination i (a measure of the attractiveness of the destination).

Most models include these explanatory variables, although other economic variables may occur, too [78,79,81,82].

Relative prices are measured by the ratio of consumer price indices (CPI_i and CPI_j) in the two locations, multiplied by the exchange rate between the currencies of the two areas. Lagged values of the dependent variable, as well as some of the independent ones, are also often included as explanatory variables [82]. It is also well established that the choice of variables may differ by destination, and some explanatory variables may be more relevant for some origin–destination pairs than for others. The model can be expanded to include various components of the demand system, i.e., revenues by categories of goods (travel, accommodation, food, entertainments) or holiday types [81,82].

The mathematical formulation of Equation (1) prefers two functional forms that are straightforward to interpret and computationally convenient while capable of serving the purposes of estimation, testing, and interpretation (including the computation of growth rates, elasticities, and marginal effects). These are the linear form and the log-linear form (with the dependent and the explanatory variables, or a subset of them, being used in logarithmic form) [78,81,83]. The log-linear model form is generated directly from a Cobb–Douglas-type equation, allowing for the non-linear relationship between the dependent and the independent variables [84–86], leading to the following structure:

$$log(DT_{i,j}) = Constant + a \times log(Y_j) + a \times log(TC_{i,j}) + c \times log(RP_{i,j}) + d \times log(ER_{i,j}) + e \times log(QF_i)$$

with $RP_{i,j} = ER_{i,j} \times CPI_i/CPI_j$ i.e., $log(RP_{i,j}) = log(ER_{i,j}) + log(CPI_i) - log(CPI_j)$, leading to the model equation:

$$log(DT_{i,j}) = Constant + a \times log(Y_j) + a \times log(TC_{i,j}) + c \times log(CPI_i) - log(CPI_j) + (d - c) \times log(ER_{i,j}) + e \times log(QF_i)$$

In this form, the price ratio is substituted by the consumer price indices of the two destinations. This approach is supported by theoretical considerations (tourists are usually well informed about exchange rates, but not about relative prices) and by the computational problem of multicollinearity between exchange rates and relative prices [78,81,82]. The approach for including an income factor in the model often varies; per capita GDP, per capita household income, or GDP growth rate are accepted alternatives [79,81,87–89]. The same modeling approach could be used to explain international tourism receipts—in this case, adding international tourism arrivals as another explanatory variable [79], with proper care to avoid collinearity between the explanatory variables.

The QF_i factor comprises many relevant features of the destination area, such as its demographic traits, level of urbanization, seasonal events, marketing expenditures, and destination attractiveness, including climate, culture, history, natural environment, political stability, and safety. This is reflected by the travel and tourism competitiveness index (TTCI), which includes the core components of a country's appeal based on 14 pillars: business environment; safety and security; health and hygiene; human resources; ICT infrastructure and ICT readiness; prioritization of travel and tourism; international openness; price competitiveness; environmental sustainability; air travel infrastructure; ground travel infrastructure; tourism services infrastructure; natural resources; and cultural resources [90,91]. Although the majority of tourism demand studies focus on economic factors [78,92], among the destination characteristics, the inclusion of natural endowments is a reasonable choice. This should include climate and landscape attributes [92]. The model used by Hamilton et al. [92] explains the logarithm of the number of international arrivals with the area of the destination, the annual average temperature, the length of the destination's coastline, and the per capita income as explanatory variables. Maddison [93] estimates the demand function of British tourists as a function of temperature and precipitation changes. Another study in 1999 [94] established that weather is the third most important factor in destination choice, following landscape and price levels, though its importance is often neglected. Recently, a growing number of empirical studies have highlighted the importance of weather in estimating international tourism demand, finding the impacts of temperature and precipitation significant in estimating international arrivals and receipts [86,94,95].

Security and safety, including political stability, are also a relevant factor influencing tourism demand [90,91,96]. The negative impact of political instability on international tourism arrivals and receipts is a generally accepted fact [87,88,97].

Based on the above, a model of international tourism receipts can reasonably be built on GDP growth rate, international tourist arrivals, inflation rate, political stability, and annual temperature and annual rainfall as explanatory variables to measure the impact of weather factors, under varying economic, and political conditions.

2.3. Econometric Models of Tourism—And VEC Models in Particular

The Vector Error Correction (VEC) Model is a multivariate time series model that is useful for estimating long-term and short-term relationships between time series. This model structure is used when the modeled variables are non-stationary and are cointegrated, which frequently occurs in economic models. In this case, a simple ordinary least squares (OLS) estimation of model parameters could lead to spurious regression results [98]. Vector error correction models are frequently applied in tourism modeling, too [80–83]. Although the length of the data series is a frequent concern in econometric modeling, secondary data of economic character are often of limited length and available on an annual basis, especially in developing countries where the quarterly or monthly values are not always available. Therefore, researchers may find it impossible to access more than 20–25 years of data. In VEC models, the data requirements are determined by the number of variables and the lag length [99,100]. A study about cointegration of wages and prices in the UK demonstrates [101] the need to impose some restrictions in realistic modeling situations with short data series and the need to establish a fairly rich model; some restrictions have to be imposed. This requires using a restricted VEC model instead of a fully identified one, imposing exogeneity restrictions on some of the model variables. This hugely increases the model's reliability even with small samples. The evaluation of the model fit according to the usual information criteria does not deteriorate with small samples when the lag is of 0 or of 1 length, and only a minor decrease in reliability occurs with lag 2 [100].

VEC modeling in tourism performance assessments faces the problem of short data series in developing countries. Ref. [8] employs a VEC model with three variables at lag 1 to estimate inbound tourist receipts in China and in Japan, using 17 years of data (1995–2011). Another study [102] applies a VEC model with five economic variables for estimating tourism receipts with 27 data points (1993–2019) and lag 1 in Sao Tome and Principe. Similarly, a study [103] applied a VEC model of four variables that included tourism expenditures for 24 years of data (1988–2011) in India, with lag 1. Ref. [82] analyses a tourism example with 33 years of annual data, with four variables, a constant, and a lag of 1. As these examples illustrate, the small sample size typical for developing countries is compensated for by applying a lower number of variables and lag 1. This is a relatively reliable and applicable method when long data series are unavailable.

2.4. Research Gap and Objectives

While the existing literature provides valuable insights into the impacts of weather variability on the tourism sector, several research gaps exist, which this study aims to fill: (i) most of the existing studies in the literature focus on global or regional assessments of weather variability impacts on tourism; however, to the best of the authors' knowledge, there is no study that specifically addresses the Ethiopian context. (ii) The existing studies generally focus on only a few years or projections into the future, but a detailed examination of historical trends of weather and tourism over time is lacking. Our analysis of the time period from 1995 to 2019 in Ethiopia allows for a nuanced understanding of how weather variability has affected tourism trends over two decades. Such temporal analysis reveals patterns, variations, and potential turning points in the relationship between weather variability and Ethiopia's tourism sector. (iii) Most studies primarily focus on how climatic variables (mainly rainfall and temperature) affect the tourism industry, generally neglecting other important variables that, if considered, would affect tourism dynamics differently, either mitigating or enhancing the effects of the weather. The present paper aimed to address this gap by considering a range of variables, including international tourism receipts, mean annual temperature, mean annual rainfall, inflation level, political stability and absence of violence, international tourist arrivals, and the real GDP growth rate. This study aims to contribute to the existing body of knowledge by addressing these gaps and providing insights that inform sustainable tourism practices and policy interventions in Ethiopia. As the following Section 3.1 describes, Ethiopia is a significant country in terms of its population and area in Africa; therefore, lessons gained from the Ethiopian example can be useful for the rest of the continent, as well as globally.

3. Materials and Methods

3.1. Description of the Study Area

Ethiopia, officially known as the Federal Democratic Republic of Ethiopia, is a landlocked nation in the Horn of Africa, neighboring Eritrea to the north, Djibouti to the northeast, Somalia to the east and northeast, Kenya to the south, South Sudan to the west, and Sudan to the northwest. Its capital is Addis Ababa, and its governance is a federal system with thirteen independent regional administrations and two municipal governments (Figure 1).

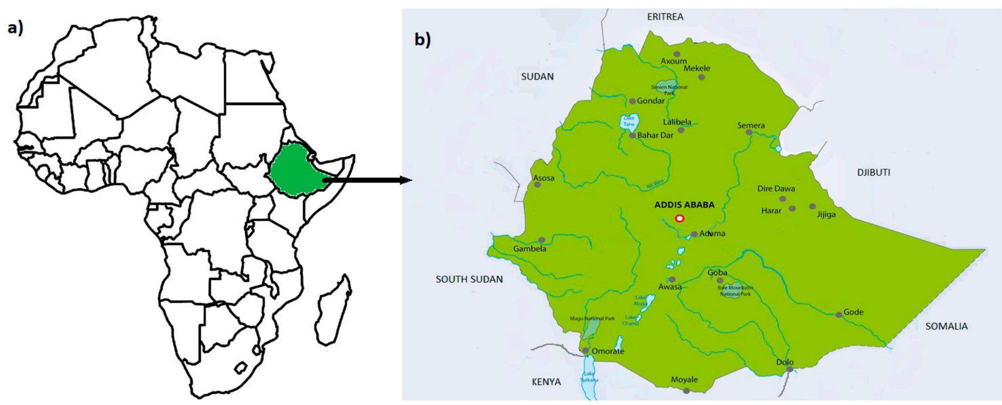

Figure 1. (**a**) Map of Africa; (**b**) map of Ethiopia (source: https://www.thetraveler.net/ethiopia/map.html (accessed on 30 April 2024), adjusted by the authors.

The study area was selected purposively based on the country's significance. With a total land coverage of 1,100,000 square kilometers (420,000 square miles), Ethiopia hosts around 113.5 million people (1.4% of the world), making it the 13th most populous nation in the world, the 2nd most populous in Africa after Nigeria, and the most populous landlocked nation on the planet [104]. Also, Ethiopia has the fastest annual pace of urbanization at 4.5%, surpassing the Sub-Saharan African average [105]. According to the World Bank [106], Ethiopia has one of the fastest-growing economies in the world due to its rapid economic growth, with a GDP per capita of USD 834.96 in 2021 and 6.3% real GDP growth in 2022. According to CSA [107], there are more than 80 different ethnic groups in Ethiopia, each with its own unique language, culture, and tradition. Most importantly, the service sector [including tourism] plays an important role in the country's growth, contributing 6.3% of the real GDP growth [108].

Ethiopia's landscape varies significantly, affecting its climatic conditions. The southeastern and northeastern regions have tropical climates with average temperatures ranging from 25 to 30 °C, while the central highlands experience cooler temperatures. Annual precipitation also varies, with lowlands having less than 300 mm and highlands having more than 2000 mm. Figure 2 shows the climatic zones of the country according to the Köpper–Geiger classification. Most of the country belongs to the following three climatic zones: tropical savannah zone, arid hot desert zone, and arid steppe zone, with smaller temperate areas in the middle of the country [109].

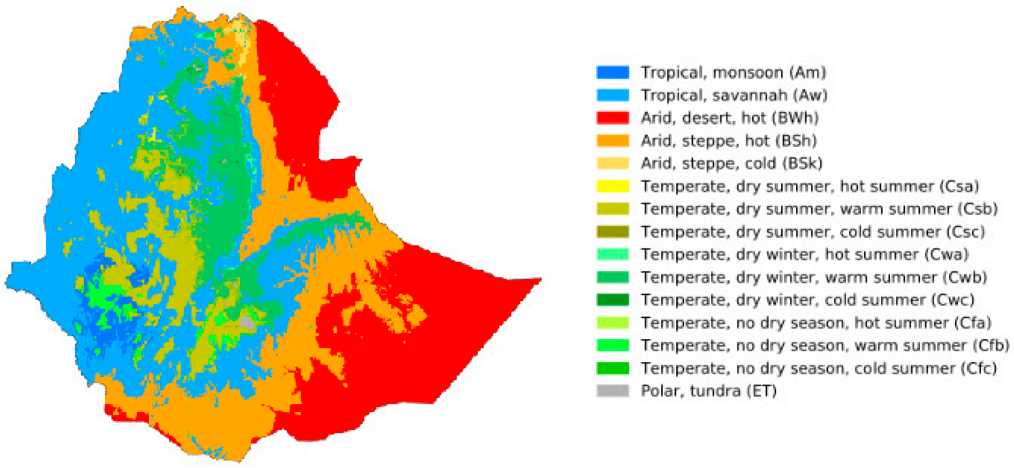

Figure 2. The Köppen–Geiger climate zones in Ethiopia (source: [109]).

The African continent in general and Ethiopia in particular are often presented with negative images in Western media, as a land of war, famine, poverty, and droughts, and this can negatively influence the prospects of tourism in the continent, although the variety of landscapes, climate, and heritage justifies a change in publicity to promote tourism in Africa. This is particularly true of Ethiopia, with its media misrepresentation often presenting a negatively biased picture of the region. This may certainly hinder the country in utilizing its outstanding resources to promote its tourism sector [110].

The country covers an altitude range from 126 m below sea level to 4620 m above sea level [78]. As home to diverse ethnic groups with unique traditions, languages, and cultural practices [110], Ethiopia is a country with a rich history, culture, and natural beauty, offering a variety of attractions for tourists. The country is currently the second African nation after South Africa in terms of number of UNESCO-registered world heritage sites, with nine properties listed on the World Heritage List [111] and many other historical sites. According to UNWTO [4], the number of tourists visiting Ethiopia reached 518,000 in 2021, with a significant portion of Ethiopian tourism coming from neighboring African countries, Europe, and the Arab world for business, historical exploration, and adventure activity-related purposes. However, in the last pre-COVID-19 year, international arrivals reached 812 thousand visitors, generating USD 3.5 billion and representing 46.5% of the country's total export. These values are considerably higher than the East and Southern African averages, representing 12.7% of total regional tourist receipts despite having only 2% of the arrivals, as well as 4 times the proportion of the total export revenues as that of the regional average [112].

3.2. Source of Data and Variables

This analysis utilized socioeconomic data from the World Development Indicator database for the years 1995–2019 [112]. This database is a comprehensive dataset that has been collected by the World Bank and is widely utilized in academic research in various fields. The information is derived from internationally recognized sources that have been formally gathered. The weather time series for Ethiopia for 1995–2019 was downloaded from the World Bank Group Climate Change Knowledge Portal [113]. Data are available for 2020–2022, too, but as the COVID-19 pandemic had a distorting influence in the tourism sector in these years, we did not include them in the analysis. Table 1 lists the variables chosen for the analysis.

Table 1. Description of variables in the analysis.

Variable	Measurement Unit	Abbreviation	Source
International tourism receipts	Current USD	ITR	WDI [112]
Mean annual temperature	Degree (°C)	TEM	WBG [113]
Mean annual rainfall	Millimeter (mm)	RF	WBG [113]
Inflation level	Percent (%)	INF	WDI [112]
Political stability and absence of violence	Percent (%)	PSAV	WDI [112]
International tourist arrivals	Number	ITA	WDI [112]
Real GDP growth rate	Percent (%)	RDGP	WDI [112]

Source: Authors' construction.

The choice of the variables was based on the literature discussed in Section 2.2. The variables were measured on an annual and national scale. Although tourism destinations may vary considerably regarding weather and weather may considerably vary by season, in the case of Ethiopia, there is a strong correlation between regional weather series and the national mean series, as well as between seasonal weather series and annual weather series. The annual precipitation time series taken from [112] for the time range 1950–2022 correlates well with the seasonal series, and the same is true for the temperature series. For precipitation, only the first quarter shows no correlation, which is not very important for the tourism industry. The following three seasons have correlation coefficients in the range from 0.575 to 0.888. For temperature, the correlations are even stronger. Although for the first quarter, the correlation coefficient is only 0.547, the other three seasons have correlation coefficients between 0.871 and 0.933 (Table 2). For this reason, using only the annual average temperature and precipitation values for tourism impact analysis is a good approximation for weather variability. Two facts justify the use of national data instead of specific tourism destinations. First, tourists may travel between various destinations; therefore, tourist receipts do not always relate to the specific destination visited. The tourist spending may be manifest in the capital or at the headquarters of some tourist agencies, while the visited attractions may be scattered between several regions. Second, as there is a very strong correlation between national mean temperature and rainfall data and regional temperature and rainfall data in Ethiopia, using national weather data is a reasonable estimate for regional weather data. As is shown in Table 2, the relevant correlation coefficients were between 0.9397 and 0.9712 for temperature and between 0.7582 and 0.9184 for rainfall data for the years from 1950 to 2022.

Table 2. Correlation of national annual weather to seasonal and regional weather, 1950–2022.

	Temperature	Precipitation
Correlation coefficients, national seasonal means to national annual mean		
1st quarter	0.5375	0.0701
2nd quarter	0.9333	0.8882
3rd quarter	0.8718	0.6499
4th quarter	0.9226	0.5750
Correlation coefficients, regional annual means to national annual means		
Addis Ababa	0.9397	0.7583
SNNP	0.9714	0.9184
Somali	0.9467	0.8197
Tigray	0.9477	0.7926
Afar	0.9486	0.8775
Amhara	0.9767	0.8217
Benishangul Gumz	0.9564	0.8118
Dire Dawa	0.9748	0.9134
Gambela	0.9425	0.8090
Harari	0.9622	0.8746
Oromia	0.9888	0.9813
Sidama	0.9456	0.8723

Source: Authors' own computation based on data of [112].

As we aimed to assess the weather impacts on tourism, the international tourism receipts (ITR) time series, the temperature (TEM), and the rainfall (RF) were the main independent variables. The other variables were chosen for their known influence on ITR as control variables. International tourist arrivals (ITAs) influence ITR, but the relationship between them is not quite straightforward. It is also well known that political stability, safety, and security are important considerations for tourists when choosing a destination. Therefore, an indicator for these (PSAV) is also included. The price level, the quality of life, and tourism infrastructure are also important factors in the competitiveness of the destination, which are captured by the inflation rate (INF) and the growth rate of real GDP (RGDP) as further control variables in our analysis.

3.3. Econometric Model

Based on the prior discussion in Section 2.2, the influence of weather on international tourism receipts can be depicted as follows, using the notations of Table 1:

$$ITR = f\ (TEM, RF, INF, PSAV, ITA, RGDP) \tag{2}$$

This equation illustrates the impact of weather (mean annual temperature and annual rainfall) on international tourism receipts, together with the effects of international tourism arrivals, real GDP growth, inflation rate, political stability, and absence of violence as control variables. To account for the possible non-linear effects of the independent variables, a Cobb–Douglas-style production function was utilized on the relevant time series.

$$ITR_t = \beta_0 \times TEM_t^{\beta 1} \times RF_t^{\beta 2} \times INF_t^{\beta 3} \times PSAV_t^{\beta 4} \times ITA_t^{\beta 5} \times RGDP_t^{\beta 6} \times \in_t$$

Taking the natural logarithm on both sides of the equation, we arrive at Equation (3):

$$LnITR_t = Ln\beta_0 + \beta_1 LnTEM_t + \beta_2 LnRF_t + \beta_3 LnINF_t + \beta_4 LnPSAV + \beta_5 LnITA_t + \beta_6 LnRGDP_t + Ln \in_t \tag{3}$$

In this equation, $\beta 0$ denotes the intercept, $\beta_1, \ldots, \beta_6$ represents the slope coefficients, $\in$ stands for disturbance, and t stands for time.

Equation (3) may be estimated using OLS regression, but it is well known that OLS results may be deceptive (spurious) if derived from non-stationary time series [98]. Granger [114] showed that linearly merging non-stationary series often yields stationarity. This suggests cointegration and a long-term link between variables. Therefore, before estimating the equations, the tests for data stationarity, cointegration, OLS diagnostics of normality multicollinearity, and heteroscedasticity must be carried out, and finally, after estimating the model, diagnostic testing of the model goodness is to be conducted [98].

The usual test for stationarity, i.e., that the variance and mean of the series are constant and covariance depends only on temporal distance, is the unit root test, usually performed using the Augmented Dickey–Fuller (ADF) test and the Phillips–Perron (PP) test [98].

To test the existence of cointegration for variables that are stationary after differencing, i.e., to establish that the first differenced variables have a linear combination that is stationary, the Johansen cointegration test is the established method [115]. If the variables show cointegration, then the vector error correction model is the proper model to apply [98]. This model assumes that all variables are endogenous, and it can identify short-run disequilibrium and long-term equilibrium relationships between them.

Finally, after estimating the VEC model coefficients to describe the relationships between variables, diagnostic tests are essential for ensuring the accuracy, predictability, and reliability of the models. This includes tests of residual autocorrelation using the Breusch–Godfrey Lagrange Multiplier (LM) test, the tests for normally distributed error terms using, e.g., kurtosis and skewness tests, multicollinearity of variables using the Variance Inflation Factor (VIF) test, heteroskedasticity using the Auto-Regressive Conditional Heteroskedasticity (ARCH) test, and the stability test for the VEC model using the eigenvalue stability condition test.

4. Results and Discussion

This section gives the econometric test findings and estimated model outputs, along with their interpretations, using the estimation methods indicated in the methodology section. It comprises the results of the descriptive statistics, unit root, diagnostics test, and estimation of long-run and short-run relationships.

4.1. Descriptive Analysis

Descriptive analysis refers to the statistical characterization, aggregation, and presentation of the relevant constructs or relationships between them [116]. Table 3 gives the mean, standard deviation, and the minimum and maximum values of the original and the ln-transformed variables.

Table 3. Descriptive statistics of the model variables.

Variable	Mean	Std. Dev.	Min	Max
ITR (million)	1213.16	1085.62	152.00	3548.00
TEM	23.44	0.33	22.86	24.11
RF	994.13	88.70	810.37	1193.52
INF	10.04	11.36	−8.48	44.36
PSAV (%)	11.48	5.77	5.69	25.53
ITA (thousand)	419.00	295.00	103.00	933.00
RGDP (%)	8.09	4.40	−3.46	13.57
lnITR	20.40	1.12	18.84	21.99
lnTEM	3.15	0.01	3.13	3.18
lnRF	6.90	0.09	6.70	7.08
lnINF	2.66	1.03	(0.65)	3.98
lnPSAV	2.82	0.47	2.20	3.75
lnITA	12.67	0.79	11.54	13.75
lnRGDP	2.33	0.77	(0.62)	2.87

Source: Authors' computation based on [112,113].

As Figure 3 illustrates, Ethiopia has seen a steady rise in international tourism receipts and arrivals over the years, notably experiencing a significant boost from 2003 to 2004, followed by continuous growth until 2018.The international tourism receipts in Ethiopia reached a maximum of 3548 million USD in 2018, but by 2019, the value slightly declined to 3529 million USD. In the same way, international tourist arrivals slowly grew up to 2017, reaching their peak with 933 thousand tourists, then started to decrease, reaching 812 thousand tourists in 2019. The considerable increase in tourism receipts between 2017 and 2018, in spite of the decreasing number of international arrivals, is explained by the improved performance of the national airline, transportation infrastructure, and the associated increased average spending by visitors.

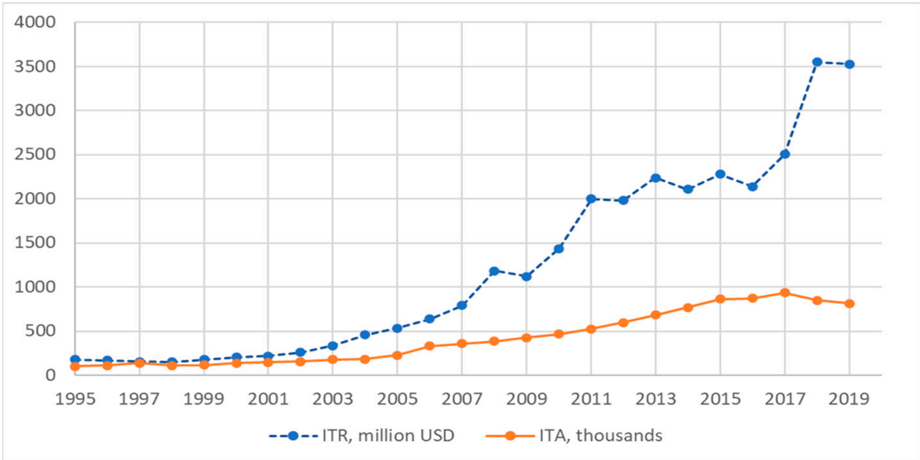

Figure 3. International tourism arrivals (ITA) and international tourism receipts (ITR). Source: Authors' own construction based on data of [112].

This upward trend of international tourism receipts reflects a growing interest in Ethiopia as a tourist hotspot, and is likely fueled by its rich cultural heritage, diverse landscapes, and historical attractions, coupled with government initiatives to promote tourism. The slight dip of international tourism arrivals in 2019 compared to 2018 could be attributed to various factors, such as economic fluctuations, shifts in travel trends, unforeseen events like natural disasters.

Despite steady arrivals, Ethiopia's import-dependent economy, often plagued by inflation, has seen a notable increase in international tourism receipts. Inflation and escalating costs in the tourism sector, leading to higher prices for goods and services, are responsible for this rise. This, in turn, prompts tourists to increase their spending. This trend underscores the substantial impact of inflation and price fluctuations on the performance of Ethiopia's tourism sector and its broader economic development. Additionally, Ethiopia faces challenges in international tourism, due to underdeveloped infrastructure, a lack of effective marketing, and safety, and security issues [117]. Seasonality, media costs, security threats, shortage of facilities, skilled human resources, weak promotion, and political will also hinder growth [118].

4.2. Diagnostic Tests for the Econometric Analysis

As it was described in the Materials and Methods section, before estimating the parameters of the econometric model and analyzing the impact of weather variability on international tourism receipts, diagnostic tests had to be performed.

Table 4 presents the tests for stationarity and for cointegration. The first part of the table shows that variables became stationary after taking differencing. Taking the first differences of the variables of mean annual temperature, mean annual rainfall, political stability and absence of violence, and real GDP growth rate, both the ADF and the PP tests give test statistics higher than the 5% critical values, implying stationarity. The same is true for the second difference of international tourism receipts and international tourist arrivals.

Table 4. Stationarity and cointegration tests for the VEC model.

Tests for stationarity: Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test (5% critical value = −3.000)				
Variable	ADF test statistics	*p* value	PP test statistics	*p* value
d.LnITR	−4.606	0.000 *	−4.621	0.000 *
d.LnTEM	−5.668	0.000 *	−6.250	0.000 *
d.LnRF	−5.577	0.000 *	−5.679	0.000 *
d.LnINF	−6.710	0.000 *	−8.359	0.000 *
d.LnPASV	−4.729	0.000 *	−4.725	0.000 *
d.LnITA	−4.230	0.000 *	−4.280	0.000 *
d.LnRGDP	−6.251	0.000 *	−7.250	0.000 *

Johansen cointegration test					
Max. rank	Parms	LL	Eigenvalue	Max statistic	5% critical value
0	56	119.906	.	127.82	45.28
1	69	183.816	0.997	69.886	39.37
2	80	218.759	0.958	45.879	33.46
3	89	241.699	0.875	41.337	27.07
4	96	262.368	0.847	16.247 #	20.97
5	101	270.492	0.522	10.475	14.07
6	104	275.729	0.378	6.735	3.76
7	105	279.097	0.263		

*: 1% significance; #: rank (i.e., the number of cointegrating relationships). Source: Author's own computation by STATA 14 version based on [112,113]

The second part of Table 4 reports the Johansen cointegration tests with the maximum eigenvalue test. As test shows, the test statistics value falls below the critical value first at rank 4, indicating that there are 4 cointegrating relationships among the variables. Therefore, the VEC model is appropriate to estimate their relationships.

Before presenting the results of the VEC model estimations, the diagnostic tests for the accuracy, predictability and reliability of the model are also presented in Table 5. The heteroscedasticity test output in Table 5 indicates a high *p*-value (0.899), which suggests that the residual variance remains consistent, indicating homoscedasticity. The Breusch-Godfrey Lagrange Multiplier (LM) test for residual autocorrelation has a large *p*-value of 0.1259, i.e., there is no evidence of serial correlation in the model's residuals. The normality test of the model residuals shows, that with 25 observations, both skewness probability (0.785) and kurtosis probability (0.470) are higher than 0.05, suggesting that skewness and kurtosis indicate an asymptotically normal distribution. Furthermore, the chi-square value is 0.41, exceeding the threshold of 0.05, indicating statistical significance at a 5% level, thus the residuals have a normal distribution. Finally, the multicollinearity test of variables reveals that the variance inflation factor (VIF) values are below 4.16 with a mean below 2.70, indicating the model is free from multicollinearity. The weak correlation coefficients among independent variables (each below 0.7) indicate the absence of any strong linear relationships between the predictor variables. This means that there is no issue of potential collinearity concerns.

Table 5. Diagnostic tests of the VEC model.

Test for heteroskedasticity				Breusch-Godfrey LM test for residual autocorrelation					
lags(p)	chi^2	Df	p > chi^2	lags(p)	chi^2			Df	p > chi^2
1	0.016	1	0.899	1	2.343			1	0.1259
Test for residual normality									
Joint Variable	Observation		Probability (Skewness)	Probability (Kurtosis)			chi^2(2)		p > chi^2
Residual	25		0.785	0.470			1.98		0.41
Test of multicollinearity									
	Correlation matrix							Variance inflation factors (VIF)	
Variables	lnTEM	lnRF	lnINF	lnPSAV	lnITA	lnRGDP		VIF	1/VIF
lnTEM	1.00							2.96	0.337
lnRF	0.233	1.00						1.18	0.846
lnINF	0.068	0.264	1.00					2.14	0.466
lnPSAV	0.292	−0.025	0.284	1.00				4.11	0.243
lnITA	−0.537	−0.237	−0.210	0.367	1.00			4.16	0.240
lnRGDP	0.479	0.067	0.306	0.534	−0.264	1.00		1.65	0.604
Mean VIF								2.70	

Source: Authors' own computation based on [112,113].

4.3. Short-Run and Long-Run Relationship Derived from the VEC

The VEC model can analyze interactions between unit root and locally stationary variables [119]. The VEC model is highly valuable for measuring changes in the predictability of non-stationary variables and for evaluating the periodic soundness of economic theories [120]. Additionally, it enables the calculation and analysis of both short-run and long-term coefficients, as well as the identification of lag duration, cointegration level, and parameter consistency.

While the long-run relationship describes the overall trend of the variables during the analyzed time span, the short-term relationship describes how fast the annual value can return to the long-term trend when discrepancies occur. Studies on the impact of weather variability and international tourism receipts generally expect short-term effects to occur within the same year of travel. In the preceding year, outbound tourist flows tend to be particularly sensitive to climate variability. Conversely, long-term effects extend beyond the immediate year, influencing tourism demand for several years thereafter [121–123]. Therefore, the short-term effects of weather variability on international tourism receipts in Ethiopia are often observed in immediate fluctuations in tourist arrivals and spending, while the long-term effects reflect the overall perception of Ethiopia as a tourist destination.

4.3.1. Long-Run Error Correction Estimates

After confirming the cointegration of variables, the coefficients for both the short-term and long-term variables were calculated. The vector error correction model can estimate both short-run and long-run variables. The research calculated the error correction term with the normalized long-run coefficients. The error correction term (ECT) substituted all the other terms in the model. Table 6 presents the outcomes of the error correction model. As the table shows, all variables proved to have significant effects at the 5% level, except inflation rate and the constant.

Table 6. Long-run error estimates.

Variables	Coef.	Std. Err.	z	$p > z$
ln_ITR	1	.	.	.
ln_TEM	12.277	1.215	10.10	0.00
ln_RF	0.184	0.109	2.69	0.00
ln_INF	0.185	0.012	14.86	0.00
ln_PSAV	−0.495	0.044	−11.15	0.00
ln_ITA	−1.878	0.073	−25.49	0.000
ln_RGDP	−0.152	0.021	−7.24	0.000
_cons	−34.48	-	-	-

$ECT_{t-1} = 1.000\text{LnITR}_{t-1} + 12.277\text{LnTEM}_{t-1} + 0.184\text{LnRF}_{t-1} + 0.1851\text{LnINF}_{t-1}$
$-0.495\text{LnPSAV}_{t-1} - 1.878\text{LnITA}_{t-1} - 0.152\text{LnRGDP}_{t-1} - 34.48$

Source: Authors' calculation based on [112,113].

A 1 °C positive difference in the annual temperature was associated with 12.27% lower international tourist receipts, and there was a direct link between them. As warmer months are the typical holiday periods (except for snow destinations), higher temperatures may result in decreasing visitor numbers, shorter stays, and decreasing tourism receipts due to the inconvenience of outdoor activities in unpleasant heat. Warmer temperatures can also impact cultural and heritage tourism, and extreme heat may lead to shorter and rarer visitations. Hot and dry weather can also cause natural heritage to deteriorate. Temperature changes can affect certain festivals or cultural events, impacting the timing and attractiveness of these activities to tourists. This is in line with Elsayed [124]. Warmer temperatures can have positive impacts on tourist destinations located at higher altitudes, such as non-ski mountain destinations [125], but tropical destinations may fare much worse [126].

A 1 mm (mm) higher mean annual rainfall caused international tourist receipts to decrease by 0.184 percent. In the long run, higher mean rainfall can improve the appeal of currently too-dry destinations, but it can also make outdoor activities unpleasant, and the occurrence of floods and extreme humidity may have adverse effects on tourist perceptions. Although, according to De Medeiros et al. [127], rainfall does not hinder the practice of tourism, in mountainous destinations relying on snow-based hiking, changing precipitation patterns can severely harm the hiking routes, leading to fewer and shorter hikes, i.e., lower tourism revenues [128]. This may also be relevant for higher latitudes in Ethiopia.

Political stability, the absence of violence, has a positive impact on international tourism receipts in Ethiopia, which is in line with the general tourism theory.

In the long run, the impact of international tourist arrivals on international tourism receipts is statistically significant and positive, with a 1% increase in international tourist arrivals raising international tourist receipts by about 1.878 percent. Although more international tourist arrivals do not always generate higher tourism receipts, e.g., when destinations attract mainly budget tourists, our model results show that in Ethiopia, tourist arrivals positively affect tourism spending, which may be related to economic stability and low exchange rates that increase destination competitiveness for the country.

An increase of one percent in the real GDP growth rate—e.g., from a 5% growth rate to a 5.05% grow rate—causes the international tourist receipt to increase by 0.152 percent. As a country's real GDP grows, the strengthening economy leads to improvements in the general and tourism infrastructures in the facilities of transportation, accommodation, and attractions. This makes the country more attractive for international travelers, and the better facilities usually generate higher spending. Similar results were found in Asian Pacific countries [83,102,129].

The relationship between international tourist receipts and inflation in Ethiopia shows that for every one percent increase in the inflation growth rate, there is a corresponding decrease of 0.185 percent in international tourist receipts. This relationship stems from the potential impact of high inflation rates on increased costs for tourists, such as elevated prices for accommodation, transportation, and goods and services. Consequently, these increased costs could dissuade tourists from choosing Ethiopia as their destination. This is consistent with the findings of [83,130] and with the economic theory of tourism [78].

4.3.2. Short-Run Error Correction Estimates

Short-run error correction estimates allow us to understand the dynamics of the relationship between variables in the short run. This is particularly useful for policymakers [131]. It enables us to correct discrepancies between the actual and long-run values of variables, leading to a more accurate understanding of the system. The short-run error correction estimates are presented in Table 7.

Table 7. Short-run error estimates.

Variables	Coef.	Std. Err.	Z	$p > z$
_ce1	0.759	0.263	2.88	0.000
LD.ln_TEM	−1.290	0.474	−2.72	0.007
LD.ln_RF	−0.080	0.035	−2.29	0.022
LD.ln_INF	0.004	0.002	1.79	0.073
LD.ln_PSAV	0.055	0.015	3.54	0.000
LD.ln_ITA	0.057	0.030	2.47	0.014
LD.ln_RGDP	0.004	0.003	1.49	0.137

$$LnITR_t = -1.29\text{LnTEM}_{t-1} - 0.08\text{LnRF}_{t-1} + 0.004\ \text{LnINF}_{t-1} + 0.055\ \text{LnPSAV}_{t-1} + 0.057\text{LnITA}_{t-1} + 0.004\text{LnRGDP}_{t-1} + 0.759ECT_{t-1}$$

Source: Authors' own computation based on [112,113].

The short-run estimates suggest that a 1 degree Celsius higher annual temperature is reflected in a corresponding reduction of 1.29% in the international tourist receipts in the next period, and there exists an indirect link here. Temperature fluctuations have a temporary impact on tourism demand and activities. Hurricanes can cause rapid economic damage to tourism markets [132]. High temperatures can also affect nature-based activities, as well as festivals and cultural events, affecting their timing and appeal to tourists. If these changes damage the visual appeal or accessibility of specific places, it could indirectly harm international tourism earnings in Ethiopia. This is in line with the findings of Caldeira and Kastenholz [133].

There is a short-term inverse link between rainfall and international tourism receipts. Higher precipitation reduces international tourism and lowers the profit of hospitality businesses. Rain can also affect destination images and trip planning, with a significant impact on destination perceptions. Overall, rainfall variability and its impact on international tourism receipts essentially—and often negatively—influence the tourism sector, as rainy destinations are less appealing to tourists than dry ones, according to tourism demand studies [134].

The political stability and the absence of violence are statistically significant and positive at 5% of the level of significance, and they are associated with higher international tourism receipts. Tourists desire safe, peaceful places without political instability or danger. Political stability often stimulates economic growth and improved infrastructure. Stable governments invest more in tourism infrastructure like airports, highways, hotels, and attractions. This enhances the tourism experience and attracts more tourists. This, in turn, boosts the international tourism revenues of the country. Therefore, political stability and the absence of violence create a positive destination image and attract tourists to a country, leading to an increase in tourism demand and receipts. This study supports Bozkurt et al. [135], Bassil and Yap [136], and Gaberli et al. [137].

An increase in international tourist arrivals causes the international tourist receipt to increase by 0.057 percent in the short run. Having more international visitors to a country results in increased spending on accommodations, attractions, food, transportation, and other tourism-related services, which is reflected by higher international tourism receipts.

As a result, an increase in tourist arrivals tends to correlate with an increase in tourism receipts. This agrees with the findings of Rodríguez [138] and Dücan and Bozkurt [139].

The real GDP growth rate did not influence tourism receipts in the short run at all, while the inflation rate had a weak effect of a 1% rise leading to a 0.004% rise in tourism receipts, but this impact was significant only at the 10% level.

The significance of the error correction term suggests that the short-term deviations from the long-run equilibrium are corrected at a speed of 0.759, i.e., any discrepancy from the general trend is corrected within 1/0.759 = 1.3 time periods (years).

5. Conclusions

Weather variability significantly impacts international tourism receipts in Ethiopia, affecting visitor numbers, travel patterns, and revenue generation. The study examined impacts of weather variability on international tourism receipts using time series analysis based on World Bank Group's Climate Change Knowledge Portal and the World Development Indicator database, covering the years 1995–2019. This study applied both descriptive and econometric data analyses. For long-term and short-term relationships, an aggregate Cobb–Douglas production function and the VEC model were applied. The results show that the model has constant residual variance, no serial correlation, and is free from multicollinearity. The data fit the normal distribution and have the correct number of cointegrating vectors.

The study from 1995 to 2019 revealed that the average annual international tourist receipts ranged from USD 152 to 3549 million, while the annual mean value of international tourist arrivals was USD 318 thousand, with the highest and lowest values being 936 thousand and 102 thousand, respectively. Ethiopia has seen a steady rise in international tourism receipts and arrivals over the years, notably experiencing a significant boost from 2003 to 2004, followed by continuous growth until 2018, but by 2019, the value slightly declined due to economic fluctuations, shifts in travel trends, and unforeseen events like natural disasters. Meanwhile, the average annual rainfall was 992.2 mm, while the annual mean temperature was 23.3 °C, both of which had a low standard deviation.

Climate change affects many areas of the economy, and most importantly those that exceedingly rely on natural resources, such as agriculture and tourism. Long-term assessment of the impacts of weather variability have been used to estimate the future impacts of climate change based on the effects of weather variability in the past decades [140] Tourism resources are often intertwined with those of agriculture, as landscape and rural livelihoods are often attractions for foreign tourists, who see distant destinations as exotic. This is particularly true for Africa, and of Ethiopia [141]; thus, climate change may threaten both sources of income at the same time. Historical weather data can help us better understand the expected impacts of climate change. The climate projections indicate an annual temperature rise of 0.03–0.08 °C for Ethiopia [11], while the historical rate was 0.025 °C between 1960 and 2020. Rainfall projections are rather controversial; some models suggest a 0.7 mm decrease per year while others show no change or an increase up to an annual rate of 5 mm, while historical data show an average 2.4 mm decrease over the past 4 decades. This suggests that if the current trends continue, we have good reason to expect similar impacts on tourism flows, tourism revenues, and other nature-based sectors of the economy, too.

According to the study's findings, mean annual temperature and mean annual rainfall had significant long-term negative effects on international tourism receipts, and higher inflation rates further strengthened this negative effect. However, the real GDP growth rate, political stability and absence of violence, and international tourist arrivals had significant long-term positive effects. The short-run effects, depicting the deviations from the long-run relationships, show that temperature and rainfall had significant negative effects. International tourist arrivals, political stability, and the absence of violence had a significant positive effect, such as in the case of the long-run impacts. In the short run, inflation and the real GDP growth rate did not have an impact on international tourist receipts. The error correction mechanism of the modeled dynamic patterns shows that discrepancies from the long-run trend are adjusted within 1.3 years on average. Our results are in line with the majority of former empirical studies, indicating that Ethiopia's tourism sector experienced similar weather dependencies as were seen elsewhere in the world. It is also worth noticing that rising temperatures go along with less precipitation; therefore, the negative impact of heat may be somewhat mitigated by less wetness. This indicates a complicated relationship because, although in the presently analyzed temperature (22.8–24.1 °C) and rainfall ranges, the impacts on tourism may be beneficial, with higher temperatures and less precipitation, the relationship may turn to the opposite.

The limitations of this study are mainly related to the choice of weather variables. Only temperature and rainfall were considered, although an equally severe consequence of weather variability is the change in the frequency and severity of extreme weather events such as storms, severe drought periods, or heavy rainfall leading to floods. Another limitation is the time span of the past 25 years, since longer time series may provide more insight to weather impacts. The analysis could also be expanded in the direction of seasonal data instead of annual data and to the regional level instead of the whole-country level, though these are limited by the availability of seasonal and regional historical time series. Additionally, the range of variables may also be expanded to include other socioeconomic variables, like population, trade openness, and several other variables. Due to the frequent media coverage of famine and drought, most tourists from Europe and North America are likely surprised by Ethiopia's climatic diversity, which leaves room for further investigation of this potential explanatory variable. One possible approach is to conduct a media analysis using the number of stories on the country as an independent variable and climate/drought/famine as a variable to see if it has a negative impact on tourism arrivals. Similarly, considering the varying climatologies across the nation, the effects of variability should theoretically differ. So, if data allow, future works could examine regional linkages and determine whether they deviate from national outcomes. Furthermore, there is a call by Scott et al. [142] for increased collaboration between tourism academics and climate change researchers to elevate tourism content in future assessments and ensure that the future of tourism is considered in a rapidly decarbonizing and climate-disrupted economy. Finally, as advocated by Scott and Gössling [143], future research should prioritize interdisciplinary approaches to address the complexity of climate change and tourism. Future research will be directed to cope with these limitations if data availability permits it.

6. Policy Implication

To address the impacts of weather variability on tourism receipts in Ethiopia, several key policy recommendations can be considered. Acknowledging and addressing the links between environmental change and tourism is crucial, urging the development of better adaptation plans [73]. Also, understanding the seasonality of weather patterns is vital for planning and decision-making, necessitating adjustments to festival dates, creating real-time information platforms, and implementing flexible vacation arrangements [75]. Infrastructure investment and diversifying tourism offerings are also crucial [58,62,144,145]. Awareness and education initiatives are critical, involving educating tourists, local communities, and industry stakeholders on sustainable practices such as reducing energy consumption, using renewable energy sources, adopting eco-friendly technologies, and sequestering CO^2 through carbon sinks [58,64,146–148]. Research and data enhancement efforts are also necessary to provide more precise information about climate change, especially at smaller geographical scales, helping the tourism industry comprehend the issue and make informed decisions [23,66]. Enhanced collaboration and coordination among disaster management offices, tourism administrations, businesses, host communities, and meteorological services are essential to preparing for extreme climatic events [65]. Implementing policies and regulations is beneficial to mitigate the negative impacts of weather variability on tourism by supporting adaptation efforts, promoting low-carbon tourism [63], providing tax waivers for environmentally friendly practices, actively encouraging climate-adaptive establishments, and implementing green taxes to promote sustainability [68,69].

These implications may be useful in light of climate change, as well as the mitigation of its impacts.

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