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An investigation of climate change and tourism climatic suitability in Narok county, Kenya

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3.1 Introduction

Weather, climate, and tourism are closely intertwined, with highly multifaceted and complex interactions between them (Gossling et al., 2012; UNWTO, 2009; Scott & Becken, 2011; Simpson et al., 2008). Tourism has been defined as the entirety of the relationships, phenomena, and experiences that arise from people's travel and overnight stay in locations or areas other than their usual residence (Matzarakis, 2006). Climate affects when, why and where tourists travel. Temperature, wind, humidity, drought, storms, snow conditions and the amount of sunshine extant in a particular area influence, to a great degree, tourists' decision to visit the area, their satisfaction, and the extent of their spending (Curtis et al., 2011). Climate determines the nature and location of many tourist attractions, with many sun, sand and sea travel decisions based mainly on perceptions of warm and sunny environments. It is a crucial element in the marketing of many destinations, and it shapes tourists' expectations, experiences and memories, influencing whether they return and where they will go next (Gossling & Hall, 2006a). Because of this sensitivity, it is logical that perturbations in a wide range of climatic variables occasioned by climate change would have significant implications on tourism activities.

The effects of climate change appear unavoidable (Bowles, Butler & Morisetti, 2015; Lu, 2018). The Intergovernmental Panel on Climate Change (IPCC, 2014), combining global average land and ocean surface temperatures, estimates that the world climate has warmed up and will continue to get warmer. Further, it estimates that since the 1950s, there has been a reduction in the frequency of extremely low temperatures with a concomitant but smaller increase in the frequency of extremely high temperatures. Annual precipitation has increased in the northern hemisphere but decreased in the southern hemisphere, while oceans have warmed, acidified and risen. For instance, average precipitation has decreased by 2.4% per decade in African tropical rainforest regions, and by 4% per decade in West Africa (Bloschl & Montanari, 2010).

Numerous studies have documented the potential effects of climate change on tourism and outdoor recreation (for instance, Alizadeh et al., 2021; Askew & Bowker, 2018; Hamilton et al., 2005; Nicholls, 2006; Todd, 2003; Winter et al., 2020; Yañez et al., 2020). Mendelsohn and Markowski (1999) argued that climate change can affect outdoor recreation in three ways: (1) the availability of recreation opportunities through longer summer seasons and shorter winter seasons; (2) the overall comfort and enjoyment of recreation activities; and (3) the quality of the recreation experience. Such changes will have different effects in diverse parts of the world. For example, Hall (2008) predicts that higher temperatures could cause tourism to shift northwards, as cooler regions enjoy warmer summers, while warmer regions, such as Africa, suffer increased heatwave frequency and reduced water availability. In addition, Lise and Tol (2002), in an examination of the Organisation for Economic Cooperation and Development (OECD) group of countries, reported that visitors tend to prefer temperatures of around 21°C at their holiday destination of choice, and they suggested that global warming could therefore lead to a shift away from some destinations that either become too hot or too cold.

African countries such as Kenya that are heavily dependent on tourism, could suffer considerably if climate change negatively affects tourism. Tourism is a big revenue generator industry, second only after agriculture in foreign exchange earnings, and providing approximately 11% of the country's GDP (GoK, 2015; Nyika, 2021; Nechifor et al., 2021; Signé, 2018; Samoei & Kipchoge, 2021). In 2014, for instance, the tourism industry generated an export income of about Kshs. 160 billion (approx.. USD 1.4 billion) (18.3% of total exports), and employed about 9.2% of Kenyan workers (GoK, 2015; WTTC, 2008). Besides, it provides a livelihood to many other Kenyans, such as food suppliers to tourist hotels, transport providers to tourists, and manufacturers of curiosities sold to tourists. The impressive performance of the industry has caused it to be identified as one of the six pillars of economic growth in Kenya's Vision 2030, a development blueprint for the country (GoK, 2007).

The relationship between tourism and climate change can be analysed by looking at how the latter modifies the attractiveness of holiday destinations. This is usually accomplished by computing climate indices of travel destinations and analysing how climate change affects these indices. The formulation of such climate indices has evolved from the more general development of climate indices in sectors such as health (for example, the Wind Chill and Humidex) and agriculture (e.g. various drought indices) (Galdies, 2015). A key plank in their construction is the selection of the right weather variables. Smith (1993) and Matzarakis and Moya (2002) suggested that the weather parameters affecting tourists' comfort and safety should include air temperature, humidity, radiation intensity, wind, cloud cover, sunshine duration and precipitation. On the other hand, De Freitas (2003) classified climate according to its thermal, physical and aesthetic aspects. The thermal aspect incorporates air temperature, humidity, wind and solar radiation; the physical aspect includes rain and wind; and the aesthetic aspect relates to sunshine or cloud conditions. One of the most comprehensive and widely used metrics in tourism climatology is the Tourism Climatic Index (TCI), developed by Mieczkowski (1985). The framework attempts to reflect the destination's climatic suitability for "average" tourists engaged in light physical outdoor activities such as sightseeing and shopping. It consists of five sub-indices, each calculated from one or two monthly climate variables. The five sub-indices (Table 3.1.) are daytime comfort index (maximum daily temperature [in °C] and minimum daily relative humidity [%]), daily comfort index (mean daily temperature [°C] and mean daily relative humidity [%]), precipitation (total precipitation, in mm), sunshine (total hours of sunshine), and wind (average wind speed, in km/h).

Table 3.1
Sub-indices within Mieczkowski's Tourism Climatic Index

Sub-index	Variable(s)	Climate influence on TCI
Daytime comfort index (CID)	Maximum daily temperature (0C) and minimum daily relative humidity (%)	Represents thermal comfort when maximum temperature occurs
Daily comfort index (CIA)	Mean daily temperature (0C) and mean daily relative humidity (%)	Represents thermal comfort over the full 24h period
Precipitation (P)	Total precipitation (mm)	Reflects the negative impact precipitation has on outdoor activities
Sunshine (S)	Daily duration of sunshine (in hours)	Long duration rated as positive for tourism but can be negative
Wind speed (W)	Average wind speed (in Km/h)	Variable effect depending on temperature

Source: Adapted from Mieczkowski (1985, pp. 228-9)

The index is weighted and computed as follows:

$$TCI = 8CID + 2CIA + 4R + 4S + 2W \qquad \text{Equation 1}$$

CID = daytime comfort index, CIA = daily comfort index, R = precipitation, S = sunshine, and W = wind speed.

With an optimal rating for each variable of 5.0, the maximum value of the index is 100. Based on a location's index value, its suitability for tourism is then rated on a scale from –30 to 100. Mieczkowski (1985) divided this scale into 10 categories, ranging from ideal (90 to 100), excellent (80 to 89), and very good (70 to 79), to extremely unfavorable (10 to 19) and impossible (9 to –30) (Table 3.2.).

Table 3.2
Classification of TCI score

Numeric value of index	Description of comfort level for tourism activity
90 – 100	Ideal
80 – 89	Excellent
70 – 79	Very good
60 – 69	Good
50 – 59	Acceptable
40 – 49	Marginal
30 – 39	Unfavourable
20 – 29	Very unfavourable
10 – 19	Extremely unfavourable
-30 – 9	Impossible

Source: Adapted from Mieczkowski (1985, pp. 228-9)

The TCI has been widely used to explore the possible effects of climate change on the climatic suitability of various areas for tourism. Amelung and Viner (2006) predicted that TCI scores for the Mediterranean region would improve during the spring and autumn but deteriorate considerably in the summer. Scott et al. (2004) assessed the spatial and temporal distribution of climate resources for tourism in North America, while Farajzadeh and Ahmadabadi (2010), applying the concept of TCI in Iran, reported that in summer the whole country has unfavourable tourism climatic conditions whereas during winter months, excellent conditions subsist in the southern parts of the country. Nemeth (2013) used TCI to analyse tourism climate potential in the Lake

Balaton region of Hungary during the last half-century and reported summer months to have the best tourism climatic conditions. Amelung et al. (2007) measured the climatic suitability of the whole world, using TCI among other methods. Few studies have, however, explored how climate change could affect tourism resources in Kenya. This question formed the basis of our study, whose objectives were to determine changes in five climatic variables (temperature, relative humidity, precipitation, sunshine, and wind speed) in Narok County, Kenya, and to establish changes in tourism climatic suitability for Narok County over a 21-year period.

3.2 Materials and Methods

The study was conducted in Narok, a town situated in the Great Rift Valley of Kenya, 149 Km west of Nairobi. Located at an altitude of 1827 metres, its geographical coordinates are 1^{0} 5΄ 0” South and 35^{0} 52’ 0” East. The main economic income in the region is derived from tourism and wheat farming (Zecchini, 2000). The choice of the study area was due to its proximity to major tourist destinations including Maasai Mara National Reserve and Hell’s Gate National Park in Naivasha (Figure 3.1). For the purposes of this study, climatological data from Narok Meteorological Station (NMS) were also used.

Climatological data for the years 1986 and 1992 to 2011 was obtained as an Excel file from the NMS. The data consisted of daily recordings (for every year) of the following variables: maximum and minimum temperature, total precipitation, relative humidity (RH) at 06Z (Zulu or Universal Time Coordinated) and 12Z, which represented 9 am (maximum humidity) and 3 pm (minimum humidity) local times, total sunshine hours and wind speed (km/h). The mean daily temperature was obtained by summing up the maximum and minimum daily temperatures and then taking an average. The mean daily RH was similarly obtained by adding daily RH at 06Z and 12Z and then obtaining the average. The daily data were used to calculate monthly and yearly summaries of the variables by obtaining averages. The yearly averages were plotted on graphs to determine their annual changes over the study period.

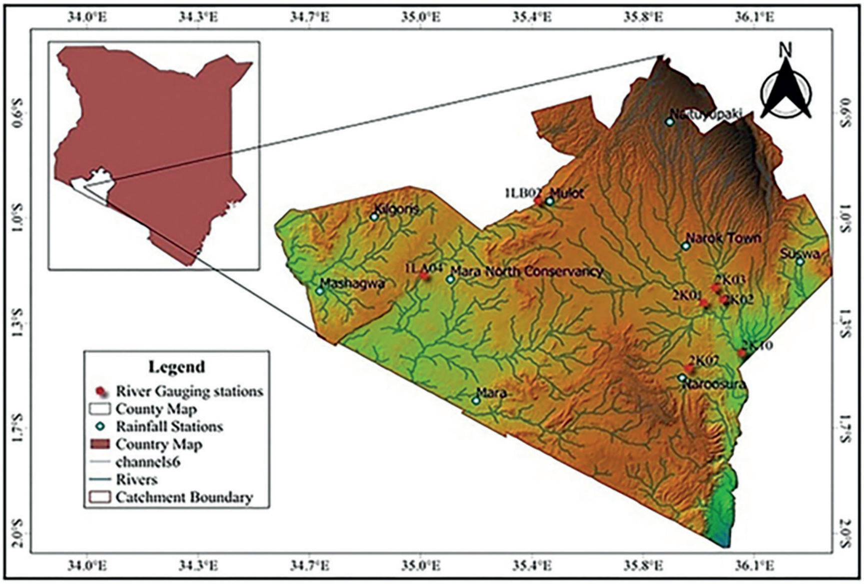

Figure 3.1

Location of the study area (Source: Opere et al., 2022)

Using the daily or monthly summaries of the above variables, the TCI sub-indices of daytime comfort index (CID), daily comfort index (CIA), precipitation, sunshine and wind speed were rated between 0-5, following the original classification by Mieczkowski (1985). The first two sub-indices, CID and CIA, combine temperature and humidity into effective temperature. At high temperatures, perceived temperature is higher than real temperature if humidity is high and lower than real temperature if humidity is low. The five sub-indices were then used to compute the TCI according to Equation 1, given above. The ensuing yearly TCI values were then plotted on a graph to establish their changes over the study period.

To determine trends in changes of the climatic variables and TCI over the study period, linear regression models were fitted to the data and the significance of the ensuing slopes (b coefficients) computed. The fit of the models was assessed by computing R square values. All statistical tests were analysed with the Statistical Package for Social Sciences (SPSS), version 18 and Excel, 2007. All statistical tests were two-tailed. Significant levels were measured at 95% confidence level with significant differences recorded at $p<0.05$.

In climate and tourism sustainability studies, several models are applied. One such model is Mieckowski's TCI framework which has been widely used to quantify/assess indicators of climatic suitability for tourism. Other models applied in tourism studies include the Holiday Climate Index (HCI), the Multivariate ENSO Index (MEI), the Temperature Humidity Index (THI), the Southern Oscilation Index (SOI), and the Relative Climate Index (RCI), among others. The paradigms make use of a set of selected indices to assess and describe climatic variability conditions and metrics favourable for tourism activities (tourism climate comfort) (Dubois et al., 2016; Hassan et al., 2015; Domínguez-Castro et al., 2020; Hasanah et al., 2020; Scott et al., 2016; Fitchett et al., 2019; Arya, 2014; Li et al., 2018).

3.3 Results

Changes in selected climatic variables

The maximum, minimum and mean temperatures all showed increasing trends over the study period as described by the equations in Figure 3.2 below. Both the coefficients for mean temperature ($b=0.38$, $\beta=0.73$, $t=4.64$, $p<0.0001$) and minimum temperature ($b=0.07$, $\beta=0.77$, $t=5.29$, $p<0.0001$) were significantly different from zero, which showed that a substantial increase in minimum and mean temperatures occurred over the study period.

The model predicts that every year the minimum and mean temperatures in Narok have increased by 0.07^{0}C and 0.04^{0}C, respectively, over the period under study. The variable 'Years' could explain a hefty 60% and 53% variance in minimum and mean temperatures, respectively. However, the coefficient for maximum temperature ($b=0.01$, $\beta=0.18$, $t=0.78$, $p=0.44$) was not significantly different from zero. The results show that a considerable increase in night temperatures has caused a significant elevation of the mean temperature in the study area.

Although the mean relative humidity decreased over the years, as described by the function in Figure 3.3, the relationship was not found to be significant ($b=-0.06$, $\beta=-0.13$, $t=-0.56$, $p=0.58$). The variable 'years' could explain only about 2% of the variation in relative humidity.

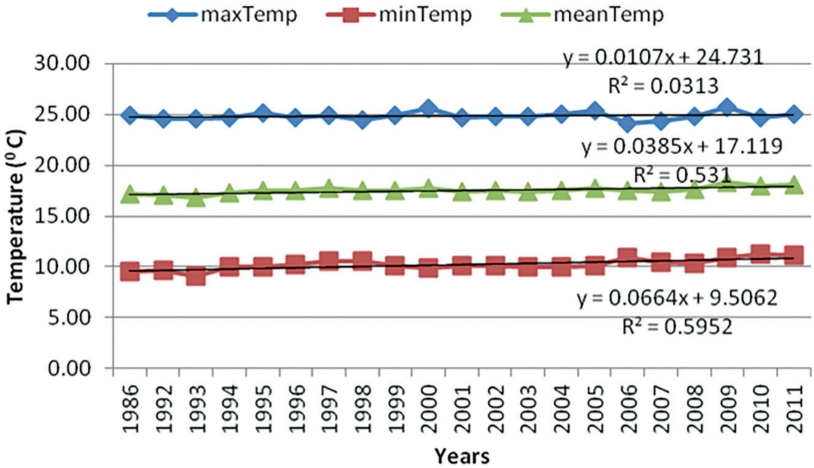

Figure 3.2

Changes in maximum (max), minimum (min) and mean temperatures (Temp)

Source: Authors' data (2016)

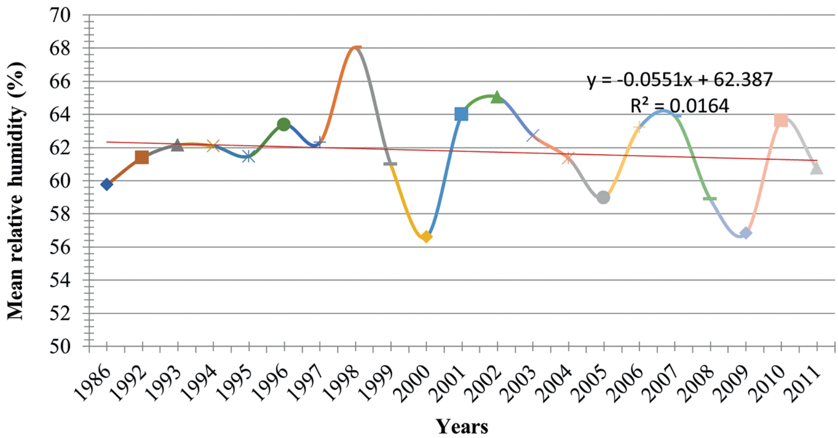

Figure 3.3

Predicted (red) and observed (blue) changes in relative humidity (1986 and 1992-2011)

Source: Authors' data (2016)

Monthly precipitation in the study area increased (Figure 3.4) over the study period, but the increase was not significant (b=0.54, β=0.21, t=0.93, p=0.37). The years could only explain roughly 4% of the variation in precipitation. In fact, when precipitation data was plotted from 1960 onwards (results not shown), a logarithmic regression model showed a significant decrease in monthly precipitation in Narok (b=-7.79, β=-0.36, t=-2.72, p=0.009, R^2=0.13).

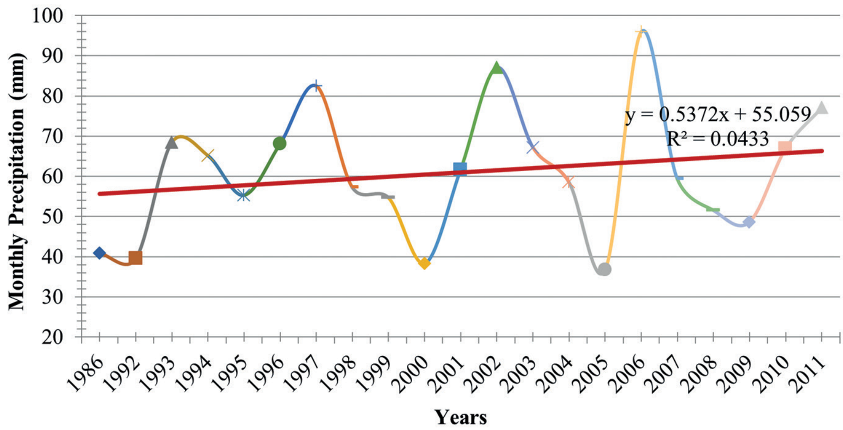

Figure 3.4

Predicted (red) and observed (blue) changes in monthly precipitation (1986 and 1992-2011) Source: Authors' data (2016)

The daily amount of sunshine hours was found to have slightly increased over the study period (Figure 3.5). However, the rise was found not to be significant (b=0.002, β=0.034, t=0.15, p=0.88).

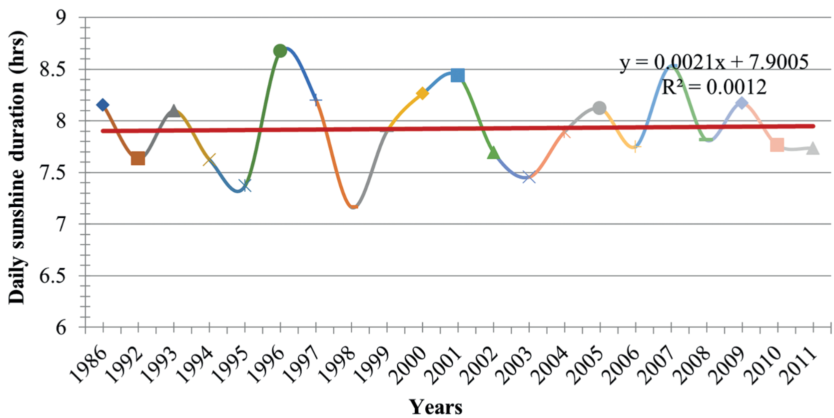

Figure 3.5

Predicted (red) and observed (blue) changes in the daily duration of sunshine (1986 and 1992-2011) Source: Authors' data (2016)

The study area was found to have become significantly more windy (Figure 3.6) over the study period (b=0.002, β=0.034, t=0.15, p=0.88). The passage of time was found to explain about 43% of the variance in wind speed.

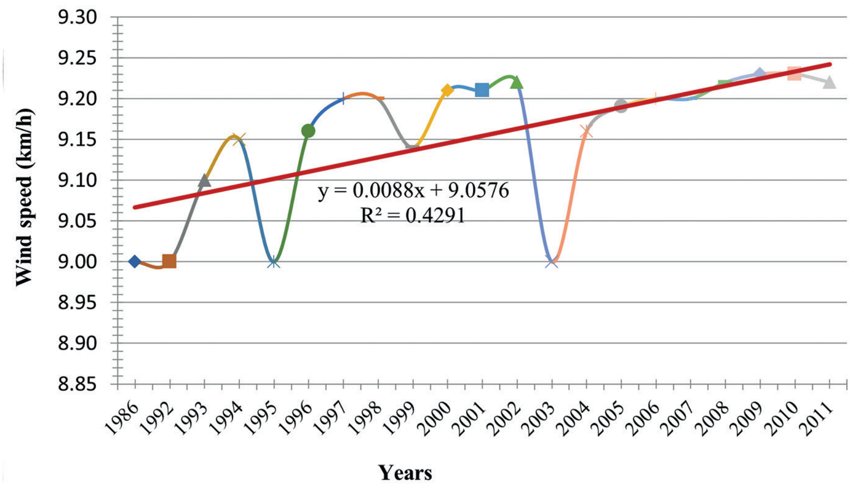

Figure 3.6

Predicted (red) and observed (blue) changes in wind speed (1986 and 1992--2011)

Source: Authors' data (2016)

Changes in TCI in Narok

The minimum and maximum TCI scores for Narok were 71 and 86 (Table 3.3), respectively, which showed that tourism conditions for the area ranged from very good to excellent. The mean TCI index was 80.48, indicating that conditions for tourism in the study area, according to Mieczkowski's (1985) index for outdoor activities, were generally excellent. The standard deviation for the TCI was three, showing that conditions varied from very good to excellent.

Table 3.3

Summary statistics for Narok's TCI

n=21	Min.	Max.	Mean	Std. Dev.	Skewness	SE	Kurtosis	SE
TCI	71	86	80.48	3.29	-1.13	.501	2.24	.97

Key: N=number of respondents; Min. = minimum; Max. = maximum; Std. Dev. = standard deviation; SE = standard error

A linear regression model fitted over the data (Figure 3.7) showed that the TCI has decreased over the years in the study area, from an initial value of about 84 in 1986, to 76 in 2011. The study found that the decrease in TCI over the 21-year study period was significant, (b= -0.34, β= -0.64, t= -3.61, p=0.002, R^2=41). From the regression equation in Figure 3.7, the study predicts that the TCI has decreased by 0.34 points every year over the 21 years. Thus, cumulatively, the TCI has shrunk by about seven points over the study period. Passage of time was found to explain a considerable 40% of the variance in TCI.

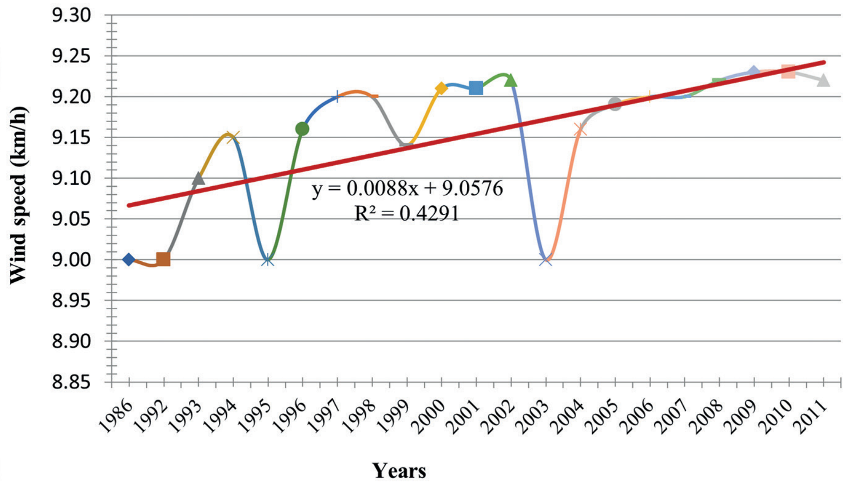

Figure 3.7

Predicted (red) and observed (blue) changes in TCI in Narok (1986 and 1992-2011)

Source: Authors' data (2016)

Several linear regression equations were used to analyse the effect of the contribution of each of the five TCI sub-indices (CID, CIA, precipitation, sunshine, and wind speed) on the possible deterioration of TCI over the years. The indices are summarised in Figure 3.8. Both comfort indices, CID and CIA, which combine temperature and humidity into effective temperature, were significantly influenced by time. Whereas CID was found to have significantly deteriorated over the years (b=-0.03, β=-0.50, t=-2.52, p=0.02, R^2=0.25), the CIA was found to have significantly increased over the years, (b=0.17, β=0.55, t=2.84, p=0.011, R^2=0.30), which can be seen from scores in Figure 3.8. However, precipitation, (b=-0.02, β=-0.26, t=-1.17, p=0.26, R^2=0.07), sunshine, (b=-0.01, β=-0.16, t=-0.70, p=0.491, R^2=0.03), and wind speed, (b=-0.01, β=-0.25, t=-1.11, p=0.28, R^2=0.06) scores were found not to be significant.

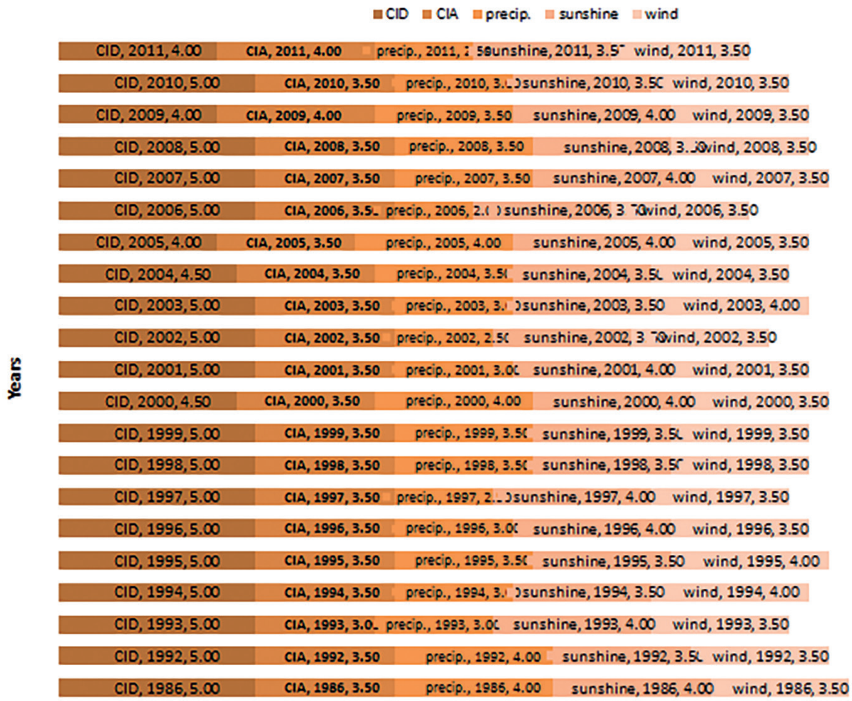

Figure 3.8

A summary of TCI sub index scores for Narok over the years

Source: Authors' data (2016)

3.4 Discussion

This study shows that both the minimum and mean temperatures in Narok have increased significantly, by about 0.07°C and 0.04°C, respectively, every year. However, the maximum temperature was found to have more or less stagnated. This finding is similar to the GoK (2010) results for Nairobi, which indicated that both the minimum and maximum temperatures for the city have increased over the last few decades. In contrast, the diurnal range of temperature has decreased.

Mean daily relative humidity generally and insignificantly decreased over the years. On the other hand, precipitation, daily sunshine hours, and wind speed all showed positive insignificant trends over the study period. The GoK (2010) report showed that most of the places investigated in Kenya did not show any significant trends with respect to rainfall. Annual rainfall showed either neutral or slightly decreasing trends, due to a general decline in the long rains season that extends from March to May, whereas the short rains season between October and December, on the other hand, shows a positive trend in some locations.

With a mean TCI of 80, conditions for tourism in the study area were generally very good. This is in accordance with the Mieczkowski (1985) scores. However, the study shows that the TCI for the area has significantly shrunk and deteriorated over the years. The main explanation for the shrinkage of the TCI is the concordant and significant decrease in the CID, which accounts for the largest part of the index at 40% (Mieczkowski, 1985). The CID, just like the CIA, is a comfort index combining temperature and humidity into effective temperature – a measure of perceived temperature. At high temperatures, the perceived temperature is higher than the real temperature if humidity is high and lower than the real temperature if humidity is low (Amelung et al., 2007; Mieczkowski, 1985). The decrease in CID, especially in later years, was caused by the observed temperature being greater than 25^0C during those occasions, with high minimum relative humidity causing the effective temperature to be higher than the real temperature. Higher effective temperatures reduced the CID scores and hence TCI. GoK (2010) adduced the significant increase in temperature in Kenya to climate change. Thus, the worsening TCI in Narok could be directly linked to climate change. This could be the first empirical report that links climate change to the deterioration of tourism climatic conditions.

The study further shows that CIA has significantly increased over the years. This, however, has not improved the TCI, probably because in the computation of the weighted TCI, CIA only contributes 10% as opposed to CID, which accounts for 40% (Amelung et al., 2007). The improvement in CIA was caused by the increase in mean daily temperatures. However, a continued increase in mean daily temperatures above 25^0C, coupled with high mean daily relative humidity, will result in a decrease of the CIA scores. This study suggests that climate change, unless mitigated, could worsen tourism climatic conditions by both increasing maximum daily temperatures (which would have the greatest impact) and minimum daily temperatures.

Precipitation, sunshine, and wind speed sub index scores were found not to be significantly influenced by the passage of time. The results therefore suggest that for Narok, these components of TCI did not contribute to degrade the index over the study period. Both sunshine and precipitation contribute 20% each to the TCI whereas wind contributes 10% (Amelung et al., 2007; Mieczkowski, 1985). Climate change is likely to impact greatly on precipitation, more so than on the other two elements (IPCC, 2014) and hence, it is the former that is likely to affect TCI. However, as the GoK (2010) reports, rainfall trends in the country show mixed signals, with some locations indicating trends towards wetter conditions in recent years, whereas the majority of locations are not showing any significant trends. Wetter conditions would degrade the TCI (Scott et al., 2004) but a clearer trend for this element is required to delineate its possible contribution to TCI in the study area.

3.5 Conclusion and recommendations

This study investigated changes in five climatic variables (temperature, relative humidity, precipitation, sunshine, and wind speed) over the study period in Narok, Kenya, and established the changes in tourism climatic suitability for the area using TCI. The study showed that both the minimum and mean temperatures in Narok have increased significantly, by about 0.07^{0}C and 0.04^{0}C, respectively, every year, over the study period. However, the maximum temperature was found to have more or less stagnated. Mean daily relative humidity generally decreased over the years although the reduction was not significant. On the other hand, precipitation, daily sunshine hours, and wind speed all showed positive trends over the study period, although the rises were not significant.

The mean TCI index for Narok was 80, indicating that conditions for tourism in the study area according to Mieczkowski (1985) were generally excellent, ranging from very good to excellent. However, the study showed that the TCI for the area has significantly deteriorated over the years, having shrunk by about seven points. This was principally caused by the concordant significant decrease in the CID, resulting from a significant increase in temperature owing to climate change. This study could be the first empirical report that links climate change to deterioration in tourism climatic conditions in Narok, Kenya. The study recommends that the country should take action to minimise the deleterious effects of climate change through deliberate approaches such as accelerated reforestation, sustainable land use practices, and conservation enactments, among others.

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