# 2

# Perceived effects of climate change on plants and its potential impact on tourism – a perspective of the local residents of Maasai Mara National Reserve, Kenya

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## 2.1 Introduction

The magnitude of the climate changes in the 21st century is comparable to the level of warming during the last deglaciation (Buizert et al., 2014; Corrick et al., 2020). For instance, according to the Intergovernmental Panel on Climate Change (IPCC, 2014), the global climate has warmed up by approximately 1.18⁰C over the period from 1880 to 2020. This is also supported by other agencies such as the Goddard Institute of Space Sciences and the American Meteorological Society that postulate that global temperatures will continue to rise (Lindsey & Dahlman, 2021; Hawkins et al., 2017). Furthermore, extreme precipitation events will become more intense and frequent, while oceans will continue to warm, acidify and rise. A study by Thomas et al. (2004), which modelled the expected impact of gradual climate change on 1,103 species, predicted that 15-37% of these species would be committed to extinction by 2050. The Kenyan Government (GoK) contends that both minimum (nighttime) and maximum (daytime) temperatures have increased by 0.7⁰C-2.0⁰C and 0.2⁰C-1.3⁰C, respectively, since the early 1960s (GoK, 2010). Rainfall has become more irregular, unpredictable, and intense (Mwenda et al., 2020; Omonyo, Wakhungu & Oteng'i, 2015). Whereas precipitation has generally decreased in the main rainfall season between March and May, it has increased in the previously much shorter rain season between October and December. Moreover, severe floods are occurring (or are predicted to occur) along the coastal strip and the northern parts of the country in seasons which are normally dry such as that between September and February (Parry et al., 2012; Marigi, 2017; UNEP, 2021; GoK, 2010).

Human activities have been found to be by far the major cause of climate change, through their continuous release of greenhouse gases and aerosols into the atmosphere, through changing land surfaces, and through depleting the stratospheric Ozone Layer (Abdollahbeigi, 2020; IPCC, 2014; Foukal et al., 2006; Krishnan et al., 2020; Schmale, Zieger & Ekman, 2021). No wonder an increasing band of researchers are suggesting that the current age be named the 'Anthropocene', a new division of geological time, in recognition of the tremendous impact that *Homo sapiens* has on the planet (Zalasiewicz et al., 2015). Like other developing economies in Africa and further afield that rely on tourism as a generator of foreign exchange, Kenya depends heavily on the outdoor recreational opportunities presented by its natural environment, which include pristine nature, spectacular landscapes and seascapes, rare species, and wildlife in their natural habitat (Akama, 1999; GoK, 2010; Maingi, 2020; Nampushi & Nankaya, 2020; World Bank Group, 2010). Apart from these, idyllic climatic conditions are an enabler of yet another major tourism pull factor – beach tourism (Smith, 1993; Hein et al., 2009; Papageorgiou, 2016).

Adverse impacts of climate change, however, threaten to scupper this source of livelihood, through their assault on biodiversity. Vegetation forms a substantial segment of the earth's biomass (Fleming, 2015; Thompson, 2018), and hence, the greatest impacts of climate change in the country result from its influence on plants. Moreover, plants are the autotrophs in an ecosystem, and hence, their depletion will affect other organisms, for instance, animals. Paleo-ecological evidence suggests that organisms respond to climate change usually by migrating, whereas evolutionary adaptation plays only a minor role (Huntley, 1991). Given the limited dispersal and/or migratory capacity of most plants, they are likely to be prone to climate change effects. Drought may cause some tree species to disappear and, as a consequence, affect both vegetation structure and species composition (February et al., 2007). Models of future biome distributions in tropical South America predict the substitution of Amazonian forest cover by savannah-like vegetation (Salazar et al., 2007; Lapola et al., 2009). Barlow and Peres (2008) expect forest dieback in West and Southern Africa as a result of climate change. Parmesan and Yohe (2003) reported that alpine herbs are shifting poleward, 6.1 km per decade on average. Further, studies of plant phenology have attributed longer growing seasons, earlier onset of flowering, and earlier harvesting times to climate warming (Parmesan, 2006).

Evidence has suggested that climate change is caused by both natural and man-made factors over a period of time (Earth Science Communications, 2021; Oreskes, 2004; USEPA, 2020; USGS, 2021). The natural processes implicated in climate change include volcanic eruptions, variations in the sun's intensity, as well as very slow changes in ocean circulation or land surfaces which occur on time scales of decades, centuries or longer. The influence of diverse external factors on the climate can be broadly estimated using the concept of radiative forcing – a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth. A positive radiative forcing warms the surface (for instance, greenhouse gases), while a negative radiative forcing cools the surface (for example, some types of aerosols) (IPCC, 2001).

The most important greenhouse gases that have been found to cause positive radiative forcing include carbon (IV) oxide ($CO_2$), methane ($CH_4$), and nitrous oxide/nitrogen (I) oxide ($N_2O$) (Dupar, 2020; Shakoor et al., 2021). In addition, halocarbon gases that have been found to be both ozone-depleting, and greenhouse gases include trichlorofluoromethane ($CFCl_3$), dichlorodifluoromethane ($CF_2Cl_2$), chlorodifluoromethane ($CHF_2Cl$) and 1, 1, 1, 2-tetrafluoromethane ($CF_3CH_2F$) (IPCC, 2014; IPCC, 2001). The radiative forcing due to increases in the greenhouse gases from 1750 to 2000 is estimated to be 2.43 $Wm^{-2}$: 1.46 $Wm^{-2}$ from $CO_2$ (60%); 0.48 $Wm^{-2}$ from $CH_4$; 0.34 $Wm^{-2}$ from the halocarbons; and 0.15 $Wm^{-2}$ from $N_2O$ (IPCC, 2001).

Amidst this inundation of information on climate change and how deleterious its impacts are or could be, it remains underexposed how people, especially those living in marginal areas and likely to be adversely affected by climate change, perceive climate change effects on plants. For instance, an assessment carried out by Mutimba et al. (2010) on climate change vulnerability and adaptation preparedness in Kenya, concluded that climate change awareness, especially in the countryside, was quite low. A Gallup poll carried out between 2007 and 2008 by Pelham (2009) reported that 56% of Kenyans had some knowledge of global warming, whereas 44% had no notion of climate change whatsoever. However, also those who had some knowledge of global warming, were often not well versed in various climate change issues, such as adaptation and mitigation arguments (Pelham, 2009). This is in agreement with related studies locally and further afield (see Sraku-Lartey et al., 2020; Nash et al., 2019; Takakura et al., 2021; Mutekwa, 2009; Van Aalst et al., 2008 and Scheffran et al., 2012). The studies concur that these locals, given their living in remote locations, strained economic capabilities and/or low literacy levels, profess their ignorance about climate change and its effects. According to a study by Froehlich and Al-Saidi (2018), a reason for this might be that some view climate change as a natural occurrence and its management as a government policy issue.

Therefore, this study seeks to establish the perceived causes and manifestations of climate change amongst the community[1] in, and adjacent to, the MMNR, and to determine the perceived effects of climate changes on plant communities in the region.

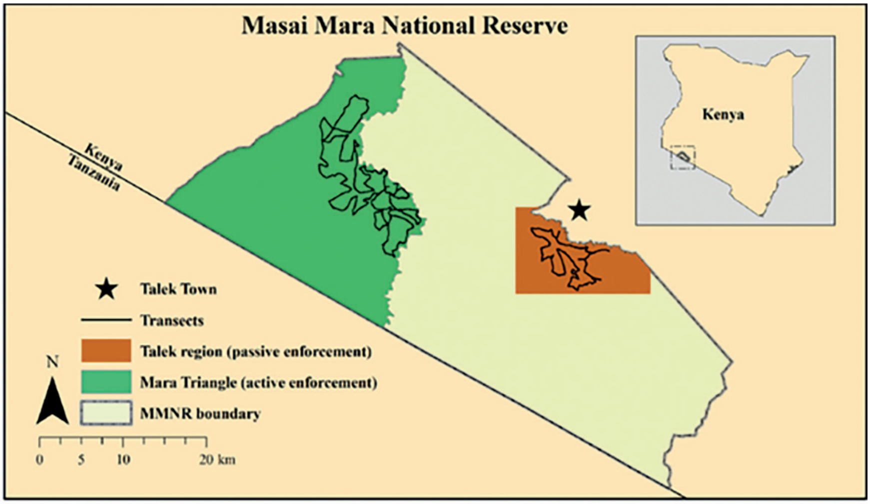


Figure 2.1
**The Maasai Mara ecosystem** (Source: Farr et al. 2019)

## 2.2 Materials and Methods

The study was carried out in the Maasai Mara National Reserve and its environs (the Mara ecosystem) (Figure 2.1). Located approximately 180 km west of Nairobi, the reserve adjoins the Serengeti National Park, forming an extensive wildlife dispersal area (Maasai Mara National Reserve, 2021; UNESCO, 2021). To the north, east and west of the reserve are large parcels of land demarcated as group ranches, owned and inhabited by the semi-nomadic pastoral Maasai people.

This study employed both a survey research design, which enabled it to obtain the requisite information from a large segment of the populace over a short period of time, and an exploratory research design, which allowed for

1 The term local/community residents in the context of this study refers to people living in and adjacent to the MMNR. It includes both the staff of MMNR (managers), community leaders, and the local rural folk.

deeper probing of respondents' attitudes, preferences and opinions (Oso & Onen, 2008). These designs used questionnaires and face to face interviews respectively.

The target population consisted of 1,500 residents of MMNR, including opinion leaders of the local community, local community members, and managers of the MMNR. This study collected data from 400 respondents, constituting 27% of the target population. This was close enough to the caveat suggested by Mugenda & Mugenda (2003) and Montgomery (1977), who stated that 30% of the accessible population would suffice for a descriptive study if the population units were more than 30. To ensure a proportionate representation, the sample consisted of 200 community members and staff members of the MMNR. The field study was conducted between the months of May and June of 2013[2]. A sampling frame of the respondents was obtained from either the reserve or the villages which served to select the participants for the study, using simple random sampling. The study employed two methods: questionnaires and interview schedules, to collect both qualitative and quantitative data. The data collection tools were administered by the researcher, two supervisors and six trained enumerators. Descriptive statistics, for instance, were used to describe, summarise, and organise the data. Chi-square ($\chi^2$) cross-tabulations were used to test if there were any significant relationships between the study variables. Means from the study were compared using t-tests and Analysis of Variance (ANOVA). The t-tests were used to compare two independent groups. More than two means were compared using Analysis of Variance (ANOVA) and post-hoc analysis carried out by Tukey's Honestly Significant Difference (HSD) test.

Frequencies were used to analyze the perceived causes and manifestations of climate change amongst the Maasai community in and adjacent to the MMNR. Structural Equation Modelling-Path Analysis (SEMPATH), implemented using the Analysis of Moment Structures (AMOS), was used to examine the perceived effects of climate change on plant communities in MMNR. The model (Figure 2.2) hypothesised that climate change could influence changes in plant species distribution, species composition, changes in adaptation strategies, changes in species diversity, the emergence of alien plant species, changes in vegetation cover, and extinction of plant species. Climate change was specified as an exogenous measured variable, while the perceived effects were postulated as observed endogenous variables.

2 The data, though collected a little earlier, has not been presented elsewhere and is thus scientifically valid.

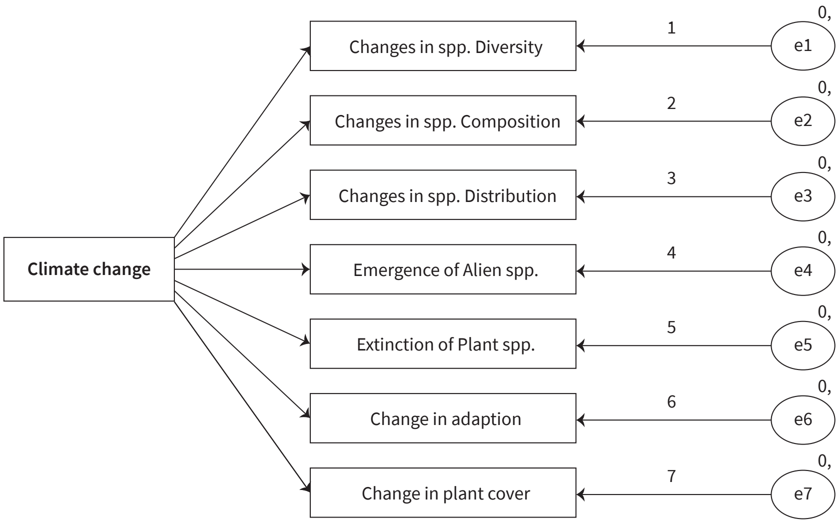


Figure 2.2

**Path diagram of perceived effects of climate change on plants; spp. = species**

All the above statistical tests were analysed with the Statistical Package for Social Sciences (SPSS) version 18, and STATA version 12. All statistical tests were two-tailed. Significant levels were measured at a 95% confidence level, with significant differences recorded at p<0.05.

## 2.3 Results

### Response rate

From a target population of 1.500 local residents and a sample of 400 respondents, the study gathered 386 usable responses. This was a response rate of 96.5%, which was considered sufficient for analysis (Mugenda & Mugenda, 2003).

### Sample characteristics

Gender distribution (Table 2.1) showed that the respondents were disproportionately male (staff: male=80%, female=20% and local community: male=94%, female=6%). The preponderance of male respondents in the study may be adduced to the traditional cultural roles among the Maasai people, the predominant community living around MMNR (Allegretti, 2018). Older men usually take the advisory role in their homestead, whereas women build houses and are responsible for childcare and all household chores, and young men are in charge of security. On the other hand, young boys herd livestock (Bitange, 2005). Since women are tied down to tasks that occur mainly around the home, one is likely to interact with men rather than women when carrying out a study.

Most of the respondents were aged between 31 and 40 years (staff=70%, local community =84.5%), suggesting that the bulk of the respondents had lived long enough to be aware of changes in the climate. Fewer respondents belonged to the 21-30 years (staff=25.5%, local community=11.5%) and 41-50 years (staff=4.5%, local community=4%) age brackets. The results indicated that while the majority of staff had secondary education (n=110, 55%), the bulk of the local community possessed primary education (n=154, 77%). Interestingly, there were slightly more people with college or university education among the local community (15.5%) compared to the staff (12%), suggesting that pockets of the local community are reasonably well educated.

Table 2.1
**Respondents' Characteristics**

| Biographic information | Respondent type | Categories | Per cent |
|---|---|---|---|
| Respondents' gender | Staff | Male | 80.0 |
| | | Female | 20.0 |
| | | **Total** | 100.0 |
| | Local community | Male | 94.0 |
| | | Female | 6.0 |
| | | **Total** | 100.0 |
| Respondent's age | Staff | 21-30 years | 25.5 |
| | | 31-40 years | 70.0 |
| | | 41-50 years | 4.5 |
| | | **Total** | 100.0 |
| | Local community | 21-30 years | 11.5 |
| | | 31-40 years | 84.5 |
| | | 41-50 years | 4.0 |
| | | **Total** | 100.0 |
| Highest education level | Staff | None | 5.0 |
| | | Primary | 28.0 |
| | | Secondary | 55.0 |
| | | College | 5.0 |
| | | University | 7.0 |
| | | **Total** | 100.0 |
| | Local community | None | 2.0 |
| | | Primary | 77.0 |
| | | Secondary | 5.5 |
| | | College | 6.5 |
| | | University | 9.0 |
| | | **Total** | 100.0 |

Source: Survey data (2013)

### Awareness of climate change in the community

Awareness of climate change among the respondents was estimated, as this knowledge could help shape the appropriate interventionist strategies. The study found that 96% (n=192) and 97% (n=194) of employees of the MMNR and the neighbouring Maasai community had heard of climate change, respectively. This suggested that the climate change message could be pervasive in the community. A $\chi^2$ cross-tabulation to determine if awareness of climate change was influenced by membership of the local community or staff was found to be non-significant ($\chi^2$ =0.29, df=1, p=0.586), indicating no significant differences between the staff and members of the local community with respect to awareness of climate change.

However, the majority of the respondents (n=308, 77%) considered themselves as 'somewhat knowledgeable' about climate change as compared to only 20% (n=78) and 2% (n=7), who felt that they were 'knowledgeable' or 'experts', respectively. The results suggested that although most respondents knew something about climate change, they might be ignorant of the technical details of the process.

Respondents' gender ($\chi^2$ = 5.857, df=1, p=.016); age ($\chi^2$ = 76.037, df=2, p<.001) and education ($\chi^2$ = 63.09df=4, p<.001) were found to significantly influence their perception of their own knowledge about climate change. More females (Table 2.1.) perceived themselves to be knowledgeable about climate change (33.3%) compared to the males (18.3%), whereas more males were found to be somewhat knowledgeable (81.7%) compared to the females (66.7%). This could be related to the fact that the females in the study were older and better educated than the males. Furthermore, it could be deduced that the younger and less educated members of the local community were reluctant to participate in the study – an aspect that could be attributed to the cultural structure of the Maasai community, where the young are customarily supposed to serve their community through chores (Obeja, 2015; Kerubo, 2016). This conclusion was buttressed by the demographics that respondents aged between 41-50 years had the highest proportion of knowledgeable people with respect to climate change (76.9%) compared with those in the 31-40 years age bracket (11.2%). The results in Table 2.2 indicate that education was positively correlated with the level of knowledge about climate change, with respondents having college and university education rating themselves highest with regard to climate change knowledge (68.2% and 55.2%, respectively).

Table 2.2

**The relationship between climate change knowledge and biographical variables**

| Respondents' category | | | Level of knowledge: Somewhat knowledgeable | Knowledgeable | Total |
|---|---|---|---|---|---|
| **Gender** | Male | Frequency | 276 | 62 | 338 |
| | | Percentage | 81.7 | 18.3 | 100.0 |
| | Female | Frequency | 32 | 16 | 48 |
| | | Percentage | 66.7 | 33.3 | 100.0 |
| | **Total** | **Frequency** | 308 | 78 | 386 |
| | | **Percentage** | 79.8 | 20.2 | 100.0 |
| **Age** | 21-30 years | Frequency | 36 | 34 | 70 |
| | | Percentage | 51.4 | 48.6 | 100.0 |
| | 31-40 years | Frequency | 269 | 34 | 303 |
| | | Percentage | 88.8 | 11.2 | 100.0 |
| | 41-50 years | Frequency | 3 | 10 | 13 |
| | | Percentage | 23.1 | 76.9 | 100.0 |
| | **Total** | **Frequency** | 308 | 78 | 386 |
| | | **Percentage** | 79.8 | 20.2 | 100.0 |
| **Education** | None | Frequency | 6 | 2 | 8 |
| | | Percentage | 75.0 | 25.0 | 100.0 |
| | Primary | Frequency | 184 | 25 | 209 |
| | | Percentage | 88.0 | 12.0 | 100.0 |
| | Secondary | Frequency | 98 | 20 | 118 |
| | | Percentage | 83.1 | 16.9 | 100.0 |
| | College | Frequency | 7 | 15 | 22 |
| | | Percentage | 31.8 | 68.2 | 100.0 |
| | University | Frequency | 13 | 16 | 29 |
| | | Percentage | 44.8 | 55.2 | 100.0 |
| | **Total** | **Frequency** | 308 | 78 | 386 |
| | | **Percentage** | 79.8 | 20.2 | 100.0 |

## Perceived causes and manifestations of climate change

The respondents perceived that climate change could be caused by deforestation, human settlement, agriculture, overutilisation of natural resources, greenhouse emissions, infrastructure and overharvesting of indigenous trees (Table 2.3). Most respondents (81%) considered deforestation to be the most important cause of climate change, followed by overharvesting of indigenous trees (72%) and human settlement (71%). The findings are corroborated by other studies carried out by Bennet (2017), Schlamadinger et al. (2005), and

Malhi et al. (2008), among others, who documented the deleterious effects of the loss of forest cover. The least important cause, according to the respondents, were greenhouse emissions (11%), followed by the construction of infrastructure (20%).

Most respondents (n=311, 78%) reported that erratic rainfall patterns were the most important manifestation of climate change, followed by droughts (n=286, 72 %), floods (n=213, 53%), and lastly, increased temperatures (n=184, 46%).

**Table 2.3**
**Frequencies of response on causes of climate change**

| | Causes of climate change | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Name of variable** | **Least important** | | **Less important** | | **Important** | | **More important** | | **Most important** | |
| | Fq | % | Fq | % | Fq | % | Fq | % | Fq | % |
| Deforestation | 21 | 5.3 | 22 | 5.5 | 12 | 3.0 | 21 | 5.3 | 324 | 81.0 |
| Human settlement | 11 | 2.8 | 51 | 12.8 | 30 | 7.5 | 22 | 5.5 | 286 | 71.5 |
| Agriculture | 11 | 2.8 | 50 | 12.5 | 32 | 8.0 | 174 | 43.5 | 133 | 33.3 |
| Overutilisation of natural resources | 13 | 3.3 | 20 | 5.0 | 54 | 13.5 | 107 | 26.8 | 206 | 51.5 |
| Greenhouse emissions | 258 | 64.5 | 18 | 4.5 | 47 | 11.8 | 33 | 8.3 | 44 | 11.0 |
| Construction of infrastructure | 20 | 5.0 | 249 | 62.3 | 29 | 7.3 | 23 | 5.8 | 79 | 19.8 |
| Overharvesting of indigenous trees | 22 | 5.5 | 11 | 2.8 | 38 | 9.5 | 41 | 10.3 | 288 | 72.0 |

Key: Fq = Frequency

## Perceived effects of climate change on plants

An overwhelming proportion (99%, n=198) of local community members felt that climate change affected plants, compared to 81% (n=162) of the staff of MMNR who held a similar opinion. Most respondents (Table 2.4) felt that climate change influenced changes in plant species composition, species distribution patterns, changes in plants' adaptation strategies, changes in plant species diversity, the emergence of alien plant species, and changes in vegetation cover (each accounting for 16% of the 2529 responses). However, very few respondents thought that climate change was causing the extinction of plant species (6% of the 2529 responses).

For this question, the number of responses (2529) was more than the number of respondents in the study (400), showing that most respondents felt that climate change had more than one influence on plants (the question was a multiple response type question). Additionally, the total percentage of cases was 632.3, indicating that, on average, each respondent felt that climate change had six (632.3/100) types of influence on plants.

Table 2.4

**Perceived impacts of climate change on plants**

| Plant impacts | Responses | | Per cent of cases |
|---|---|---|---|
| | N | Per cent | |
| Changes in plant species diversity | 394 | 15.6 | 98.5 |
| Changes in plant species composition | 396 | 15.7 | 99.0 |
| Changes in plant species distribution patterns | 397 | 15.7 | 99.3 |
| Emergence of alien plant species | 393 | 15.5 | 98.3 |
| Extinction of plant species | 162 | 6.4 | 40.5 |
| Changes in plants' adaptation strategies | 396 | 15.7 | 99.0 |
| Changes in vegetation cover | 391 | 15.5 | 97.8 |
| **Total** | **2529** | **100.0** | **632.3** |

Face-to-face interviews with older members of the community supported the above findings. One elder asserted:

> After flooding, new or alien plants grow on bare ground, hence colonising the whole area, thus affecting the original vegetation. This brings about changes in plant species and the distribution patterns of plants. The floods and drought have brought changes in this area, hence the vegetation cover change.

Another stated:

> The change in temperature, soils, and rainfall patterns has brought significant changes in the following: changes in plant species, changes in plant distribution patterns and introduction of alien species of plants. Some plants have been forced to adapt to the current state of the climate. You get some plant species growing where you least expect them.

To determine whether the perceived effects of climate change influenced plants in the MMNR, a SEMPATH analysis was conducted. The resultant path diagram is presented in Figure 2.3.

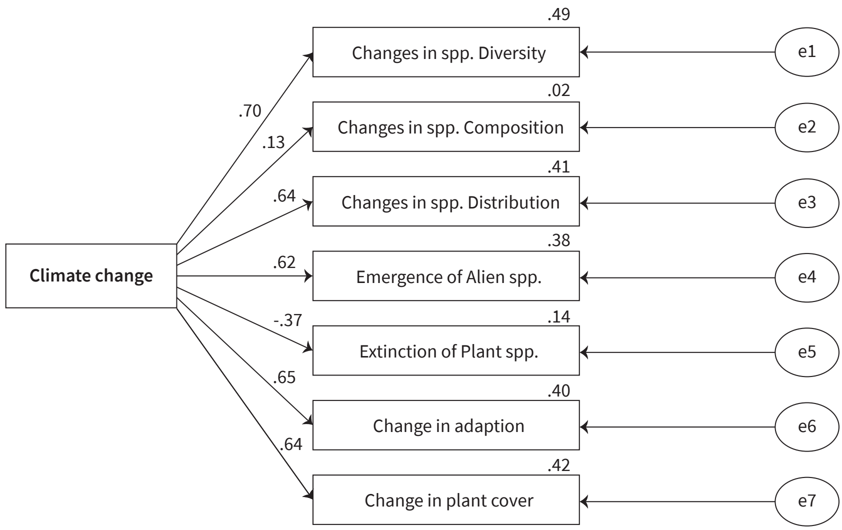


Figure 2.3
**SEMPATH output of the perceived effects of climate change on plants**

All the regression coefficients for the model were significantly different from zero beyond the 0.01 level. Except for the perceived effect on the extinction of plant species (coefficient = -0.37), all the path coefficients for the remaining six hypothesised relationships were positive. This indicated that when climate change increases, it causes changes in plant species diversity, plants' adaptation strategies, and species distribution. It also causes changes in the plants' vegetation cover, causes the emergence of alien species, and brings about changes in species composition. However, climate change was perceived to reduce the extinction of plant species. This implied that the respondents viewed climate change as having minimal effects on this variable.

## 2.4 Discussion

This study found a high awareness of climate change in the community (about 97%), which was unlike studies by Mutimba et al. (2010) and Pelham (2009), who reported that only 56% of Kenyans had some knowledge of global warming, whereas 44% knew nothing. The findings could suggest that climate change mitigation initiatives, public sensitisation, and awareness programmes such as the National Climate Change Response Strategy 2010 as well as other reafforestation and carbon offset projects undertaken by the government, NGOs, and the media might have been effective. Other current projects include the Kenya Adaptation Action Plan (2015-2030), and the National Climate Change Action Plan (2018-2022). Although most respondents were found to know something about climate change, they were likely to be ignorant of the technical details of the process, as supported by Pelham (2009) who found out that many Kenyans who reported knowledge of climate change were not altogether well versed in various climate change issues such as adaptation and mitigation processes.

The perception of respondents about their own knowledge of climate change was found to be influenced by their gender, age and education level, with older age, better education and being female being associated with greater knowledge. Many studies report that in public, men demonstrate greater scientific knowledge and scientific literacy than do women (Miller, 2007; Hayes, 2001), largely due to differences in the way men and women experience science and mathematics education. In addition, many studies demonstrate that women are less confident in displaying their scientific knowledge and abilities than do men (for instance, McCright, 2010; Jacobs & Simpkins, 2006). From the findings, the percentage of female respondents was small but those who participated in the survey were more knowledgeable than their male counterparts. However, this is contrary to the documented expectations and might be related to the fact that the females in the study were older and better educated than the males. In this vein, older people have often been found to be more knowledgeable about climate change than their younger counterparts. For example, Ogunleye and Yekinni (2012) found a positive correlation between the age of crop farmers in Ilorin East, Nigeria and their knowledge of climate change.

Deforestation was perceived as the strongest cause of climate change, followed by overharvesting of indigenous trees, agriculture, and human settlement, while the least important causes were considered to be greenhouse emissions and the construction of infrastructure. Deforestation or logging has been a major concern amongst Kenyan conservationists. According to Cochrane and Laurence (2002), logging does not only lead to loss of habitat for animals in the forests but also to changes in the microclimatic environment, the erosion of soil and modification of fire regimes. The impact depends on the type of logging: commercial mechanised logging with heavy equipment, or local exploitations of timber through, for example, pit-swaying and firewood collection.

Forests play a huge role in the carbon cycle on our planet by absorbing carbon (IV) oxide and releasing oxygen during the day. When forests are cut down, not only does their carbon absorption cease, but the carbon stored in the trees is released into the atmosphere as $CO_2$ if the wood is burned, or even if it is left to rot after the deforestation process (Karl & Trenberth, 2003). Hence, deforestation contributes to climate change by increasing the level of carbon (IV) oxide, the most dominant human-influenced greenhouse gas. It is estimated that more than 1.5 billion tons of carbon dioxide are released into the atmosphere due to deforestation, mainly the cutting and burning of forests, every year. In fact, whereas cars and trucks have been found to account for about 14 per cent of global carbon emissions, 15 per cent is usually adduced to deforestation (Stott et al., 2000). Overharvesting of indigenous trees, agriculture, and human settlement contribute to climate change for similar reasons as does deforestation, because all these activities involve the cutting down of some trees. In addition, agricultural activities produce gases such as methane ($CH_4$), nitrogen (I) oxide ($N_2O$), nitrogen (II) oxide (NO) and ammonia ($NH_3$), which are all implicated for their radiative or chemical effects in the atmosphere (IPCC, 2014; Li, 2000; Bollman & Conrad, 1998).

This study found that the climate change impacts on plants that were perceived as important were changes in plant species, plants' adaptation strategies, changes in the distribution of plants, changes in vegetation cover, the emergence of alien species and changes in plant composition, whereas the least important impact was considered to be the extinction of plant species. These findings are in line with research by Mackey and Currie (2001), which indicated that temperature and water availability account for more than 75% of the variability in plant species richness over broad spatial scales. Changes in climate will also alter interactions between species, including patterns of competition, symbiosis, mutualism, predation, and dominance. Climate change, in the form of altering rainfall patterns (for instance, increased droughts) and temperature, could explain the observable changes in plant species, their distribution and vegetation cover in this study.

Changes in plant distribution and an extended range of pests and pathogens caused by climate change can allow for an invasion by alien species (McCarty, 2001). For instance, *Prosopis juliflora* ('mathenge') has become dominant in important ecosystems of Baringo, Tana River, Garissa and other semi-arid areas of the country. In addition, an excessive growth of some tree species has been observed, including that of *Acacia reficiens* (acacia) after the 1997 El-Nino in North-Eastern Province (NEP), suppressing the growth of various species that make up grasslands for wildlife and livestock (Mutimba et al., 2010). Increases in temperature could lead to a shift of vegetation to higher elevations, which are cooler, while some species could become extinct. Indeed, across the country, some tree species, including *Melia volkensii*, *Terminalia spinosa, Delonix elata*, and *Hyphenea corriaceae* in North Eastern Province, as well as *Psychotria* species in the Taita Hills, Coast Province, have either gone extinct, or else their numbers have dramatically reduced. In addition, the projected rise in temperatures and long periods of drought could lead to more frequent and more intense fires, with estimates showing that Kenya has lost more than 5,700 ha of forests per year to forest fires over the past 20 years (Mutimba et al., 2010).

The vulnerability of natural resources such as plants to climate change could have major implications for Kenya's tourism industry, because long-term environmental shifts could alter the destination attractiveness for vacationers (Papageorgiou, 2016; Martín, 2005; Forster et al., 2012). Unless carefully monitored, the impacts could lead to the downgrade and ultimately the collapse of the climate-sensitive coastal, marine and wildlife industry in Kenya.

## 2.5 Conclusion and recommendations

This study has shown that practically every respondent drawn from the employees of MMNR and the local community has heard of climate change, demonstrating that awareness of climate change in the locale can be very pervasive. No significant differences were found between the MMNR staff and members of the local community with respect to their awareness of climate change, suggesting the ubiquitousness of the climate change message among the two groups. However, the results suggested that although most respondents knew something about climate change, they could still be quite ignorant of the technical details of the phenomenon (Mutimba et al., 2010; Nanyingi et al., 2012). The perception of respondents about their knowledge of climate change was also found to be influenced by gender, age and education level.
Deforestation was perceived as the strongest cause of climate change, followed by overharvesting of indigenous trees, agriculture and human settlement, greenhouse emissions and construction of infrastructure. Erratic rainfall patterns were found to be the most important manifestation of climate change, followed by droughts, floods, and increased temperatures. Most respondents felt that climate change influenced changes in plant species com-

position, species distribution patterns, changes in plants' adaptation strategies, changes in plant species diversity, the emergence of alien plant species, and changes in vegetation cover.

The study recommends that the government and other environmental agencies should disseminate appropriate knowledge about climate change to the public and take immediate steps to discourage habitat destruction (for instance, deforestation, infrastructural and superstructural development in and adjacent to protected areas, overharvesting of trees, large-scale agriculture, indiscriminate harvesting of trees, and human settlement in forests) as this contributes to climate change. Most importantly, climate change's pernicious impacts on nature need to be controlled locally, regionally and internationally. For instance, marine and terrestrial spatial and seasonal quantifications of climate resources through Tourism Climatic Indices could inform sustainability planning for outdoor tourism in Kenya.

## References


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