



Influence of Environmental Impact Assessment in Minimizing Climate Change Impacts on Transport Infrastructure in Kenya

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ABSTRACT

Transport sector infrastructure is highly vulnerable to the impacts of climate change. Over the past few decades, Kenya has witnessed a number of extreme rainfall events with consequent damage on transport infrastructure. This calls for a paradigm shift in the planning, design and construction of infrastructure. Environmental Impact Assessment (EIA) as a planning tool has the potential to minimize climate change impacts on transport infrastructure. This study therefore aimed at reviewing the impact of extreme rainfall on Kenyan road infrastructure, analyse the contribution of EIA practice in the minimization of these impacts and examine the barriers to the integration of climate change issues into EIA practice. Mean monthly rainfall anomalies were computed using data from nine representative meteorological stations in Kenya covering the period 1980 to 2017. These anomalies guided a review of climate impacts on the transport infrastructures that were retrieved from various archived information sources. Systematic sampling method was applied in selecting 71 EIA reports from the National Environment Management Authority (NEMA) database and a survey conducted among 105 EIA Experts and 8 Key Informants. Results of the study revealed that extreme rains associated with climate variability and change caused unprecedented damage to transport infrastructure in Kenya and the contribution of current EIA practice in handling climate change impacts was found to be very low. Findings from the survey undertaken cited weak institutional monitoring and enforcement capacity (75.3%), inadequate knowledge of climate change science among EIA experts (74.3%), unavailability of reliable climate data (50.5%) and inadequate EIA regulations (46.7%) as the main barriers to climate change integration into EIA practice. The effectiveness of EIA in addressing climate change impacts and adaptation would therefore be enhanced through training of EIA experts, strengthening the capacity of monitoring and enforcement institutions, continued research on climate change and revision of EIA regulations among others.

1. Introduction

Transport sector infrastructure plays a key role in the socio-economic growth and development of any country. It facilitates social interaction, access to services and enhances both internal and external trade (Pregolato et al., 2015). Nevertheless, this sector is faced with serious planning challenges in the context of a changing climate. Available evidence now indicates that the earth is warming due to an increase in Green House Gas (GHG) emissions emanating from human activity (IPCC, 2013). According to NASEM (2016), climate change can now be linked to the changing frequency, intensity and duration of some extreme weather events such as heavy precipitation and increased temperatures. In Kenya, it is projected that

temperature will increase up to around 3°C by the year 2060 (UK Met office, 2011; GOK, 2016a). Similarly, a number of model projections indicate an intensification of heavy rainfall in some regions in Kenya while others show a reduction in severity (SEI, 2009). Although there is uncertainty in future rainfall projections for Kenya, the occurrence of extreme rainfall events is expected to increase (UK Met office, 2011; GOK, 2016a; Ongoma et al., 2017). Subsequently, incidences of extreme rain events will become more frequent and intense impacting negatively on transport infrastructure and other sectors of the economy of Kenya (GOK, 2010).

It is therefore important that climate change impacts be adequately considered in the planning, design, construction, operation and maintenance of infrastructure owing to their long life spans and huge amount of resources they consume to step up (Picketts et al., 2015; Bhave et al., 2016; Rowland et al., 2007; Hanaoka & Regmi, 2011).

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Effective planning would take into account impacts of climate variability and climate change. Koetse and Rietveld, (2012) have noted that in the short term, impacts associated with climate variability on infrastructure require more urgent attention than changes in mean climatic conditions. In the last four decades, this has been witnessed in Kenya whereby increases in the occurrence of extreme rains associated with El-Niño phenomenon have been experienced causing unprecedented damage on transport infrastructure.

Environmental Impact Assessment (EIA) has been recognized as one of the tools that has the potential to address climate change impacts in development planning. Various authors have pointed out that EIA frameworks would provide suitable entry points for incorporating climate change mitigation and adaptation measures (Jiricka et al., 2016, Chang & Wu 2013, Sok et al., 2011) into the early phases of project development. International multilateral development banks such as the World Bank have also identified the essence of using EIA as a tool that can be used to climate proof infrastructural development projects (Agrawala et al., 2010). However, this has not been adequately realized in Kenya and climate change integration into EIA has largely remained very low (GOK, 2010; Kamau & Mwaura, 2013). In spite of the fact that Kenya has made great progress in climate change related legislation, strategies and plans, it is not clear why there is slow uptake of climate change interventions into the EIA practice.

As a planning tool, EIA was first adopted and used in the United States of America through the National Environmental Policy Act of 1969 (Jay et al., 2007; Agrawala et al., 2010) and since then it has been widely used by different countries all over the world. In Kenya, EIAs were introduced through the enactment of the Environmental Management and Coordination Act of 1999 and became effective through the EIA regulations of 2003. According to the EIA and Audit (Amendment) Regulations of 2016, all transport infrastructures are required to undergo EIA before they are licensed for construction (GOK, 2016b). Climate change impacts and adaptation assessments are not explicitly demanded in the current EIA regulations in Kenya; nevertheless, the regulations do not prevent consideration of climate change into the EIA process (Kamau & Mwaura, 2013). In providing guidelines for content of an EIA study report, Part IV, Section 18 of the EIA regulations stipulate that any other information related to the project should be provided (GOK, 2003). This therefore opens an opportunity for the EIA consultant to consider impacts of climate change as circumstances may demand. Agrawala et al. (2010) has noted that even in situations where climate change guidelines are lacking, some projects have been known to take into account climate change adaptation measures.

In the last decade, Kenya has made concerted effort to create an enabling environment for the integration of climate change issues into development planning through the formulation and enactment of various legal and policy instruments. These include the Climate Change Act 2016, National Climate Change Response Strategy 2010, National Climate Change Action Plan

2013, Kenya National Adaptation Plan 2015-2030, Green Economy Strategy and Implementation plan 2016-2030, East African Community Climate Change Policy 2011 and the draft Kenya Climate Change Policy 2016. All these instruments recognize that transport infrastructure is highly vulnerable to the impacts of climate change and there is need to integrate climate change risks and opportunities in the design, operation and management of infrastructure. The Climate Change Act 2016 specifically requires that Climate risk and vulnerability assessment be integrated into impact assessments (GOK, 2016c).

Research on the impacts of climate variability and change on transport infrastructure and EIA studies in Kenya is scarce. Available literature mainly focuses on the impact of climate change on agriculture and food security and human related emergency response activities. Nevertheless, there are few studies that have done assessments of climate change impacts on transport infrastructure and integration of climate change into EIA studies. In the aftermath of the 1997/98 El-Niño, a comprehensive assessment was done on the impacts and damages of the El-Niño rains on transport infrastructure in Kenya (Glantz, et al., 2000). With the input of various government ministries and institutions, the study documented physical damage on specific transport infrastructure and estimated the cost of rehabilitation. The report was a wake-up call for the government to design and plan its infrastructure to be more resilient to future extreme rain events. Kamau and Mwaura (2013) conducted a study on climate change and EIA studies in Kenya, though not specific on the transport sector infrastructure. Therefore, this study sought to focus specifically on the contribution of EIA in addressing climate change impacts in the transport sector in Kenya.

2. Materials and Methods

2.1 Scope and Study Area

The scope of the study covered road, rail and airport transport infrastructure within Kenya's boundaries (figure 1). Only roads that are managed by Kenya National Highways Authority (KeNHA), Kenya Rural Roads Authority (KeRRA) and Kenya Urban Roads Authority (KURA) were sampled for this study. Road infrastructure under the management of Kenya Wildlife Service, County Governments and private roads were not studied in this report. Geographically, Kenya lies along latitudes 5°N and 4° 40" south and covers a total area of 582,646 km² (GOK, 2015). The country is made up of different rock formations with a diverse topography ranging from plains, plateaus, hills, and mountains (GOK, 2015). There are also numerous types of soils including loamy, alluvial, volcanic, black cotton and sandy soils. In addition the country has four distinct weather zones namely; Western Kenya, Rift Valley and Central Highlands, Arid and Semi-arid lands and Coastal region with a wide variation in temperature and rainfall received (GOK, 2015). It is within this environment that planners and engineers endeavor to plan and design transport infrastructures amid the increasing occurrence of adverse extreme climatic events.

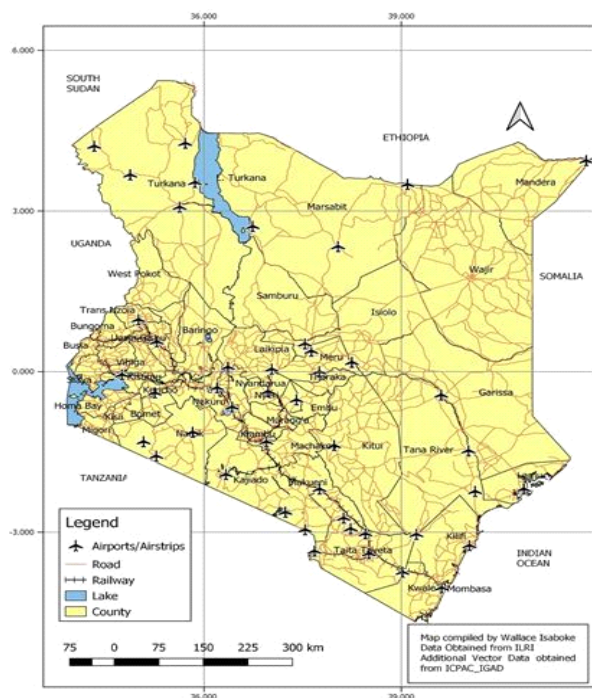


Figure 1: Map of transport infrastructure in Kenya

2.2 Data

Data for this study were obtained both from primary and secondary sources. Primary data sources mainly consisted of information obtained through questionnaires and key informant interviews. These were undertaken between June – August 2018. Secondary sources of data included mean monthly rainfall data obtained from Kenya Meteorological Department (KMD) headquarters in Nairobi for the period 1980 to 2017, archived information on impacts of extreme rains on Kenyan roads and review of transport infrastructure EIA reports from the National Environment Management Authority (NEMA) database.

2.3 Sampling Approach

In order to realize the objectives of the study, different sampling approaches were adopted. The selection of meteorological stations for rainfall anomaly analysis was done by overlaying vector data layer for meteorological stations over the flood prone sections identified by KeNHA using QGIS Version 3.2. The stations were then selected in consideration of their proximity to flood prone sections and general distribution over Kenya. The stations selected include Mombasa, Makindu, Narok, Nakuru, Moyale, Garissa, Lodwar, Meru and Kitale.

Systematic sampling method was applied in the selection of transport infrastructure ESIA/EIA reports from the NEMA database. A total of three hundred and fifty five ESIA/EIA reports spanning the period 2010 to 2018 were obtained. This period was chosen due to the fact that a climate change act, strategies and plans already existed in Kenya and it was expected that they could influence the EIA practice. A list of the reports was then generated following the order of the year in which they were submitted to NEMA. In this method, sampling begins with a random start and then continues with the selection of elements at regular intervals from a list (Bhattacharjee, 2012). The sampling interval is

determined by dividing the total population by the desired sample size (Bhattacharjee, 2012). Due to time and financial constraints, only 20% of the reports were selected constituting a sample of seventy one reports. Sixty eight of which were from the roads subsector, two for airstrips and one for the railway subsector. A checklist was used to extract information from particular sections of the reports on climate change integration into EIA.

Survey participants were selected through purposive sampling method. Total Population Sampling a type of purposive sampling was applied in reaching the EIA experts. This technique applies to relatively small populations that conform to a certain criteria such as shared skills and experience (Etikan et al., 2016). Therefore the method was thought applicable since all EIA Lead experts in Kenya are trained in EIA and are required to have a certain minimum number of years of experience before allowed to practice. A questionnaire was then circulated as an email attachment to the whole population of Lead EIA experts in the Environment Institute of Kenya (EIK) database as at 31st May 2018.

Only 105 responses were received out of the one thousand, three hundred and forty four experts that were contacted. Online based surveys have been noted to have much lower response rates compared to paper based surveys (Nulty, 2008). Key informant interviews were conducted to triangulate the results of the email based survey and give an in-depth understanding of the barriers to climate change integration into EIA practice. Participants were selected based on the knowledge and experience they possessed (Etikan et al., 2016) and their involvement in monitoring, enforcement and compliance to EIAs. They consisted of officers from the environment departments of KeNHA, KeRRA, KURA, Kenya Airports Authority, Kenya Railways Corporation, NEMA and EIK.

2.4 Data Analysis

Rainfall data for each of the selected stations was quality controlled, organized and any missing data values estimated using long term average value. Single mass curves were used to test for data homogeneity and consistency in each of the selected stations. The data was then analyzed and rainfall anomaly graphs generated for each station using Microsoft Excel data analysis function. Extreme rainfall periods were then identified which guided a literature review of impacts of extreme rains on Kenyan road infrastructure from secondary sources.

Information extracted from the EIA reports was categorized into baseline and projected climate information as well as adaptation measures. This was then coded and entered into an excel sheet. The information was then labelled and analysed using exploratory statistics.

Responses received from the email based questionnaires were checked for any errors, numbered and saved in a folder. Each individual questionnaire was read and similar responses from the open-ended questions were highlighted and grouped into subtitles relevant to the study for easier analysis.

They were then coded and data entered into a spreadsheet. Analysis results mainly constituted of frequencies and percentages presented in the form of bar graphs.

3. Results and Discussion

3.1 Impact of extreme rainfall on road infrastructure in Kenya

Results of the rainfall anomaly analysis for Lodwar, Narok, Nakuru, Mombasa and Kitale meteorological stations showed an increasing frequency of extreme rainfall events in Kenya. While Makindu, Garissa, Meru and Moyale stations showed a decreasing frequency from 2006. These stations received varying degrees of extreme rains during the years 1982, 1988, 1989, 1997/98, 2002/03, 2006/07, 2011/2012 and 2015. Years with a standard deviation of more than 1 standard unit were considered to have experienced extreme rainfall. Figure 2 shows rainfall anomaly graph for Narok.

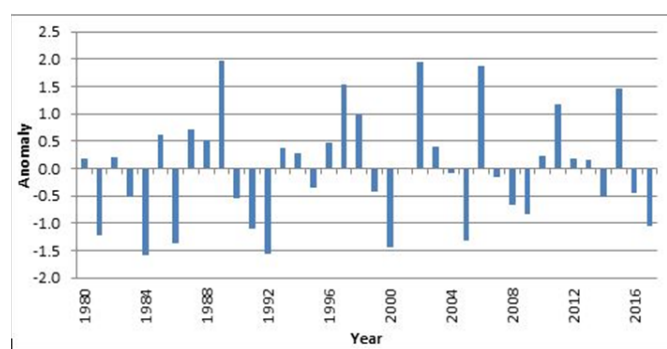


Figure 2: Time series of annual mean rainfall anomalies at Narok meteorological station (Source: Author, 2018)

Based on the rainfall anomaly analysis for the nine stations and studies by Glantz, et al., 2000; NDMU 2016a; NDMU 2016b and KeNHA 2018, impacts of extreme rainfall on infrastructure can be summarized as flooding, erosion and damage to infrastructure, siltation, landslides and mud spots. Flooding was found to be the most common impact on most road networks in Kenya. This may be accompanied with erosion and damage to infrastructure. Sections of roads or bridges identified as vulnerable include Kainuk Bridge along Turkana Road (Plate 1), Nairobi – Mombasa Road at Sultan Hamud, Masarura Bridge in Narok County, Marere Bridge in Kwale, Nanyuki Town Bridge in Laikipia County, Lesonkoyo Bridge in Kajiado among others (KeNHA, 2018). Flooding may lead to rain induced land-slides (SEI, 2009; KeNHA, 2018).



Plate 1: Flooding and damage at Kainuk Bridge in Turkana County. (Source: KeNHA, 2018).

Landslides are a common occurrence in central Kenya especially in Murang'a, Nyeri and Meru Counties

(Glantz, et al., 2000, UNOCHA, 2018). Plate 2 shows a landslide occurrence along Iten-Kabarnet road. Extreme rainfall results in heavy run-off that may carry soil particles from higher areas and deposit them on road sections in low lying areas. This will normally paralyze transport activities and cause blockage of drainage facilities exacerbating flooding. Road sections that were identified as prone to siltation include Narok-Maai Mahiu road, Kimana area along Emali-Loitoktok Road and Kiti area along Subukia – Nyahururu Road in Nakuru County (Glantz et al., 2000, KeNHA, 2018).



Plate 2: Landslide along Iten-Kabarnet Road (Source: KeNHA, 2018)

3.2 Climate Change Considerations in Transport Infrastructure EIAs

Analysis of the 68 road ESIA reports showed that 98.5 percent (Figure 3) of the reports recorded baseline temperature and mean annual rainfall in the project environments from existing literature or from the nearest meteorological stations. On the other hand, none of the reports had future temperature or rainfall projections. Development of climate change scenarios is important to the planning and design of adaptation measures based on the projected impact on infrastructure. As for the risks emanating from climate change, only 1.5% of the reports indicated that hydrological studies were done using flood forecast models to establish the size of bridges with specific return periods in consideration. Results of this analysis corroborate the findings of the online survey whereby 38.1% of the respondents indicated that current EIA practice had low contribution to the management of climate change issues and 3.8% thought it had no contribution. These findings are also in agreement with other studies that have been conducted elsewhere in the world. Enríquez-de-Salamanca et al., (2015) in their study in Spain found out that consideration of climate change effects on transport projects was very low.

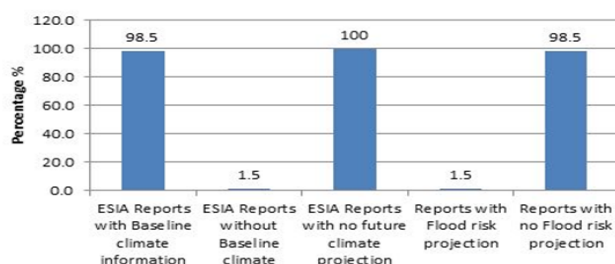


Figure 3: Consideration of baseline and future climate information on roads (Source: Author, 2018)

Despite the fact that the reports lacked climate change projections, 32.4% of the reports had recommendations for adaptation measures. The EIA consultants made recommendations that the proponent consider climate change related rainfall patterns in the project areas as basis for designing drainage structures. This effectively shifts the responsibility of incorporating climate change issues into infrastructural planning to the lead agencies. Whilst 48.5 % of the ESIA reports proposed for development of drainage infrastructure and storm water management plans to control increased runoff from catchment areas and impervious surfaces from newly constructed roads. The remaining 17.6 % of the ESIA reports did not have any recommendation for either managing the impact of extreme rains or run off on infrastructure.

In the context of airports, baseline temperature and rainfall were considered for the sampled airstrip infrastructure projects. However, the reports did not have temperature nor rainfall impact projections on infrastructure on the proposed airstrips.

Similarly, climate change scenarios for temperature and rainfall for the sampled Standard Gauge Railway ESIA report were discussed based on information from existing literature. The ESIA report had recommendation that the design of bridge and culvert adopt a flood frequency of 1/100 and large bridges adopt a flood frequency of 1/300 as indicated in the feasibility report.

3.3 Barriers to the Integration of Climate Change Impacts into Environmental Impact Assessments.

As background information to the online survey, 72.4% of the respondents had previous experience in conducting EIA for various transport infrastructures while 27.6% did not have any experience related to transport infrastructure. The experts gave different ratings of the contribution of current EIA practice in addressing climate change issues in Kenya whereby 38.1% rated it as low, 40% as moderate and 3.8% none. Only 4.8% of the experts thought that it was very high. Sampled ESIA reports for road infrastructure were geographically distributed over forty counties with the exception of Marsabit, Nyamira, Tana River, Makueni, Baringo, Trans Nzoia and Nandi Counties.

Results of the survey revealed a number of barriers to climate change integration into the Kenyan EIA system. Key among them is the weak monitoring and enforcement capability of institutions entrusted with climate change and environmental issues. Figure 4 shows that a majority (61%) rated it inadequate and 14.3% as absent. The inadequacy of institutional enforcement and monitoring capacity was reported at two levels, that is, NEMA as the focal institution for climate change in Kenya and Lead agencies in charge of transport infrastructure in Kenya. Weak institutions may retard any gains achieved in the advancement of climate change legislation and regulations. It is therefore critical that adequate funding be sought to strengthen the capabilities of these institutions. Strong institutions will enhance compliance to regulations by the developers and EIA consultants

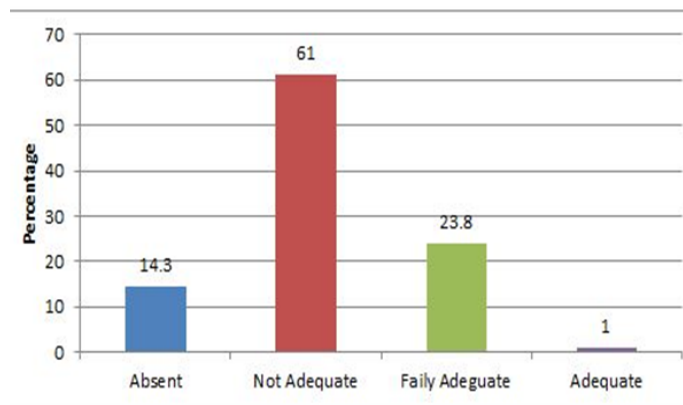


Figure 4: Adequacy of institutional enforcement and monitoring capacity (Source: Author, 2018)

Adequate knowledge and skills in climate change science are pertinent to the integration of climate change impacts into EIA practice. Results of the survey showed that climate change science knowledge among the EIA experts was inadequate. Figure 5 shows that only 24.8% of the experts thought that climate change science is a subject that is well understood while the rest rated it as poorly understood, fairly understood, complicated or very complicated. Climate change impacts projection, risks and vulnerability assessments need specialized knowledge and training. The results therefore show the need for proper training among the stakeholders concerned. Incorporating climate change specialists into EIA teams will be essential.

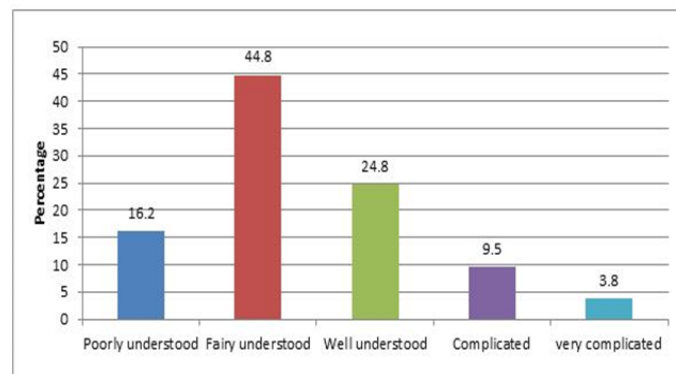


Figure 5: Perception on knowledge of climate change science by EIA Experts (Source: Author, 2018)

In terms of climate change related policy and legislation, most of the respondents noted that Kenya has made great progress. 43.8% of the respondents said that policy and legislation are fairly adequate in Kenya citing the existence of the various climate change Strategies, Plans, Acts and Policy. 9.5% of the respondents were satisfied that the laws and policies are adequate since the current EIA regulations 2003 gives room for international laws and conventions to bridge the gap where Kenyan laws do not address certain issues such as climate change. The rest (46.7%) of the respondents noted that that it was inadequate. Although Kenya has various climate change strategies, plans, legislation and draft policy in place there is an urgent need for EIA regulations that will make climate change integration into EIA mandatory. In an international survey conducted among EIA consultants, appropriate regulations and guidelines were cited as the key drivers to integration of climate change into the EIA process (Sok et al. 2011).

In 2018, Kenya had formulated draft Integrated Environmental Impact Assessment/Audit Regulations. These regulations need to be reviewed and adopted to facilitate the implementation process.

Availability of climate data and information is central to the assessment of climate change impacts and development of risk management strategies in EIA practice. Majority of the responses from the EIA experts indicated that climate data is scarce (50.5%), while others thought it is available (37.1%), not available (1.9%) and the rest said it was available to varying levels. In a study that was carried out in Austria and Germany, lack of data and climate uncertainty were perceived as the main barriers to the integration of climate change impact and adaptation into EIA practice (Jiricka et al., 2016). Climate change research requires a lot of funding. Local and international sources of funding should be explored in order to generate and avail data relevant to the Kenyan situation. Through the Kenya Meteorological Department, Kenya already has infrastructure for climate data collection which can be further improved.

The cost of integrating climate change issues into the EIA process was rated moderate by the majority of the experts (43.8%), while 31.4% and 11.4% rated it as high to very high. It was stated that developing countries have strained national budgets which will not be sufficient for climate change issues.

The respondents were also asked to state any other additional barriers they thought could hinder the integration process. They cited low level of awareness among EIA experts, general public and other stakeholders on the existence of the various climate change plans, strategies, and legislation (31.4%), lack of political commitment and support for climate change issues (14.3%), poor ethical and professional standards in the EIA practice (17.1%) and climate change uncertainties (10.5%). The rest (26.7%) did not give any additional barriers. Modeling climate change impacts is a difficult task due to uncertainties in the climate system. Failure of climate change models to precisely project future impacts may lead to confusion in relation to risk mitigation and adaptation. However, climate change modeling is a useful tool in the planning of projects and application of adaptation measures.

3.4 Suggested solutions to the integration of climate change impacts into EIA practice

In commensurate to the barriers identified, a number of solutions were suggested both by the EIA experts and key informants (Figure 6). It is worthy to note that emphasis was placed on training and capacity building of all stakeholders, strengthening of enforcement and monitoring capacity of institutions and review of existing policies and legislation.

3.5 Future suitability of EIA for climate change considerations

In spite of the aforementioned barriers, majority of the EIA experts (85.3%) and key informants (87.5%) highly rated EIA as a tool that has the potential to incorporate climate change issues into future EIA practice. While the rest felt that it was not appropriate and should be

used in tandem with other tools. In support of EIA as a tool to incorporate climate change issues into EIA practice, Chang and Wu (2013) notes that EIA provides opportunity for re-evaluating the assessment process, mitigation and monitoring measures. Enríquez-de-Salamanca et al., (2015) also points out that EIA provides a platform for comparing alternatives, adaptation measures and gives opportunity for considering compensation measures.

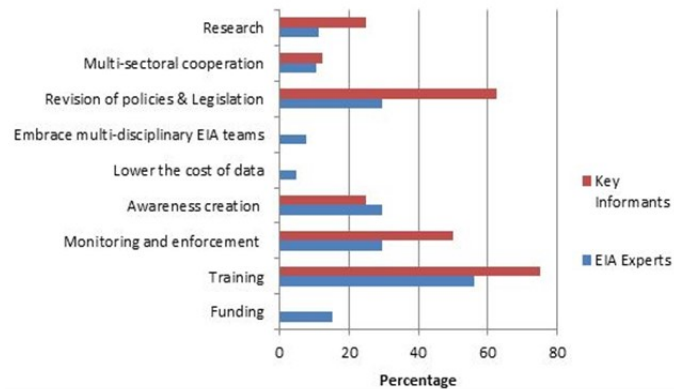


Figure 6: Suggested solutions to the integration of climate change into EIA practice (Source: Author, 2018)

4. Conclusions and Recommendations

This study has revealed that the contribution of Kenyan EIA system towards addressing impacts of climate change in the transport sector is low and is only limited to recommendations for adaptation. Results of this study have shown that extreme rainfall events resulting from climate change negatively impact on transport infrastructure, but they are not considered in the current EIA practice. Majority of the respondents attributed this situation to lack of appropriate EIA regulations, weak institutions for monitoring and enforcement, inadequate training among EIA experts and unavailability of reliable climate data. The effectiveness of EIA to address climate change impacts and adaptation will therefore depend on many factors including addressing the barriers identified in this study. Although Kenya is on the right path in the development of climate change strategies, legislation and plans, it is imperative that appropriate EIA regulations be formulated to fast track the integration process. Comprehensive EIA regulations with embedded climate change requirements would act as a trigger towards addressing the other barriers identified in this study. Cooperation among various experts and institutions both at the planning and design stages of infrastructure is critical since climate change impacts transcend many boundaries and sectors. It is also vital that planners, EIA experts and infrastructure design engineers, be exposed to practical experience and best practices from similar projects in other parts of the world. EIA alone will not solve problems of climate change integration into infrastructure development but should be backed up by other tools and implemented within the frameworks of strategic environmental assessments and regional developments plans.

In view of the findings of this research, the following recommendations have therefore been proposed:

- Lead agencies in the transport sector should map and develop databases to archive both the physical and economic impacts of extreme rain on infrastructure. This will form the basis for effective ESIA/EIA assessments and development of climate change resilient infrastructure.
- There is need for the development of region specific climate change models and gathering of data relevant to the Kenyan situation through continuous research
- EIA regulations should be revised to include standards and clear procedures for integrating climate change impacts into transport infrastructures
- The EIA training syllabus in Kenya should be revised to include climate change impacts, mitigation and adaptation.
- Adequate funding should be allocated to NEMA and transport lead agencies for training and improvement of monitoring and enforcement capabilities.
- NEMA in collaboration with EIK should regularly create awareness on climate change matters through newsletter publications and holding of stakeholder forums

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