# Large Scale infrastructural Projects and Climate Change in Kenya: An Assessment of Key Drivers of Climate Change in LAPSSET Project Area in Lamu

**Mwangi Kamau[1] & Zack Maritim[2]**

[1]*University of Nairobi, Kenya*

[2]*World Wide Fund for nature (WWF), Kenya*

https://doi.org/10.62049/jkncu.v4i1.75

## Abstract

*The paper argues that climate change has become a threat to human survival and life sustaining ecosystems. It argues that Large-scale infrastural projects' activities accelerates drivers of climate change. Three major objectives were pursued; to identify drivers of climate change at LAPSSET project area; to assess how LAPSSET activities impact on critical ecologically significant Areas (CESA) and to determine possible adoption options by people affected by climate changes in LAPSSET areas. Both qualitative and quantitative frameworks are applied to assess the climatic risks and vulnerabilities. The paper finds that: 63% of the respondents cited high population increase and infrastural development at LAPSSET area as key drivers of climate change. Second ,70% of respondents thought that LAPSSET project was magnet of activities that had serious consequences on the environment and CESAs. While 80% of the respondents identified coral bleaching, clogging of creeks, shifting of fishing sites, changes in weather patterns, increased shoreline and draught as major climate related footprints. The paper recommends funding of environmental mitigating agenda pegged on law and on pre-determined percent of the resources allocated to any large-scale project. It recommends establishing a pool of climate change mitigation green army funded through a multi-agency approach. It also recommended that, all large-scale infrastructural projects operating in the Kenya should, by law be forced to re-green their area of operation and fight threats associated with climate change via legislation.*

**Keywords**: Climate Change, Environmental Degradation, Large Scale Infrastructural Projects

## Introduction

Climate change has created a new normal in sub-Saharan Africa. The horn of African has experienced serious drought in the last four continuous decades. Indeed, at the start of year 2023 UNICEF has warned that 20 million children are at risk of severe hunger, thirst and disease (Ruto, Adesina and Verkooijen (2023)[1]. Similarly, the rising global temperature are playing havoc with rainfall patterns that hundreds of millions of small holder farmers in Africa and elsewhere rely on. Tellingly, climate change is a major challenge that humanity has to deal with this century (Jafari, 2013). Indeed, The Inter-Governmental Panel on Climate Change (IPCC) estimates that 20-30% of the plant and animal species evaluated so far in climate change studies are at risk of extinction. The IPCC report (2022) adds that climate change is already causing more frequent and more severe storms, floods, droughts wildfires and other extreme weather events. The report says that in the next decade climate change will lead into extreme poverty, global warming and food in-security. The report projects that 350 million people will experience water scarcity by 2030 and about 3.6 billion people will be vulnerable to climate impacts in South Asia, Central and South America and much of Sub-Saharan Africa.

Anthropogenic activities and their related emissions is a carbon-footprint of human beings. Indeed, infrastructural projects like Lamu Port-South Sudan-Ethiopian Corridor (LAPSSET), do not occur naturally but are made to occur by human beings. These development activities generate emissions which contribute to global warming potentially influencing climate change vulnerability and viability (Lwasa, 2014). Seen this way, humans bear the greatest responsibility in engaging in activities that accelerate climate change. Indeed, a lot of greenhouse gas (GHGs) emanates from agricultural activities (Loboguerrero 2019), transport related activities (Marsden & Rye, 2010), manufacturing activities (Worrell 2009,) and energy generation (Wuebbles & Jain, 2001). Climate change therefore is a consequence of anthropogenic activities (Halsnæs & Verhagen, 2007).

For instance, the usage of heavy machineries like evacuators which use fossil fuel, the destruction of biodiversity and the ecosystem to create sites and source of raw materials for the LAPSSET Project, the axillary roads, and the dredging of the sea all had direct impact on the factors accused of accelerating climate change. Emissions from the heavy machineries that use fossil fuel at the LAPSSET directly impacted on greenhouse emission. The destroyed vegetation surfaces led to non-sequestration of carbon dioxide (CO2) because trees are not there to feed on this gas (Photosynthesis). As a consequence, there is concentration of CO2 blanket which in turns increases temperature. Temperature increases on land surface affects and distort the wind cycles and rain pattern -when the land boils, it rains in the ocean, and when the ocean boils it rains in the land. Distorted rain patterns are directly linked to draught and food in-security (Ruto, et al. 2023).

The Kenyan Lamu Port is part of the seven key infrastructural projects that form what is generally called; the Lamu Port - South Sudan - Ethiopia Transport Corridor Project (LAPSSET) estimated to cost a total of 2.5 trillion Kenya shillings. It incorporates a new 32 berths port at Lamu Port Project and Interregional Highways, a crude oil pipeline, an interregional standard gauge railway line, international airports, three Resort Cities and the construction of a multipurpose High Grand Falls Dam along the Tana River. (GoK,

[1] Ruto William, Akinwiumi, & Verkoojen (2023). Time to Scale up African Solutions for Continent's Food, Climate Crises, in The Standard Newspaper, March 15,2023, pp18.

2017). The project is 'Mega' by any standards and Its impacts on the environment will vibrates in many sectors. The project is part of the Government of Kenya Vision 2030 long-term development blueprint aimed at transforming Kenya into a newly industrializing middle-income country. The 32 berths Lamu Port is the corner stone of the project. Indeed, an address to a workshop titled 'Stakeholders workshop on review and dissemination of research findings on the impact of LAPSSET's programmes in Lamu, held on 2/12/2021, Irungu Macharia, the County Commissioner of Lamu, argued that, without the Lamu-port there would be no LAPSSET. He described the LAPSSET programme as:

'*The project of opportunity, transformation and immense development for Kenya in particular and Africa and other continents in general'*.

Against the above observation, the Kenyan 2010 constitution protects climate change explicitly and implicitly. For instance, Article 42 of the Kenya constitution states that every person has the right to a clean and healthy environment. Similarly, Kenya is a signatory to various international conventions linked to climate change for instance; the Kyoto Protocol ( 2005), and Cites Protocol (1963), Kyoto limits and reduce greenhouse gases (GHG) emissions and lists the sources of pollution related activities: energy/industrial, manufacturing, transport (vehicles, ships, trains and airplanes etc.) agriculture and solid waste) the protocol advocates for countries to adopt policies and measures on mitigation of emissions (Kyoto 2005). In Kenya, all All-large-scale infrastructure development projects are required by law to conduct an Environmental Impact Assessment (EIA) as prescribed by the Environmental Management and Coordination Act (EMCA) 1999. Clearly, The LAPSSET project has become a fertile site for peoples' contestations, conflicts and environmental degradations.

The risks associated with climate change are grave and adaptation options to reduce them urgently needed. Climate change is a threat to human survival and a threat to life sustaining ecosystems. It is the right time to understood what the key drivers of climate change are in the many large-scale projects like LAPSSET in order to chart a path of a viable mitigation process and minimize climate change related hazards.

**Objectives**

- To identify drivers of climate change at LAPSSET project area
- To assess how LAPSSET activities impact on critical ecologically significant Areas (CESA)
- To determine possible adoption options by people affected by climate changes in LAPSSET areas.

## Literature Review

Research on climate change discourse are rapidly increasing in recent years because of increased climatic risks, vulnerabilities and impacts climate change has in all sectors at all levels of human and environmental survival (Lwasa, 2014). Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil and gas), which produces heat-trapping gases.

Climate change can alter where species live, how they interact, and the timing of biological events, which could fundamentally transform current ecosystems and food webs. For instance, in a study by Environmental Protection Agency,2007, it was reported that, earlier springs led to earlier nesting for 28 migratory bird species on the East Coast of the United States and in a California study, 16 out of 23 butterfly species shifted their migration timing and arrived earlier. Climate change leads to either expansion and reduction of hospitable habitats. It also leads to increased competition, range reduction and limits opportunities for survival. Indeed, Lake Kenyatta, the only freshwater lake in Lamu County in Kenya, had dried up. The drying up of the lake has led to the death of hippos, birds, water snails and other wildlife that depended on the lake for survival. Climate change and human modification may restrict ecosystems' ability to temper the impacts of extreme conditions, and thus may increase vulnerability to damage. Apart from the above, climate change and shifts in ecological conditions could support the spread of pathogens, parasites, and diseases.

LAPSSET is in the transport sector. This sector is documented as the largest producer of greenhouse gases in the last 30 years (Aminzadegan (2022), (Ong et al., 2011; and Dzokoto et al., 2022). Similarly, Agriculture and food-value-chains are significant emitters of greenhouse gases hence very important in fuelling climate change (Loboguerrero et al., 2019). Agriculture account for 24% of total global emissions (IPCC, 2015; Niles et al.,2018) while agricultural food systems contribute about 35% of GHGs global emissions (Foley et al., 2011). It needs to be noted that, the presence of LAPPSSET has led to increase in agricultural activities.

## Methodology

Both qualitative and quantitative frameworks were applied to evaluate the climatic risks, vulnerabilities, impacts and also evaluate adaptations mechanism. This approach was intended to fuse top-down and bottom-up approaches with scientific data, information and local knowledge and practices for detail assessment of the climate change related activities at LAPSSET area.

### The Methods

*a) Desktop Reviews and Climate Screening of the project areas using WWF Climate screening toolkit*

To understand the context of climate change in the project area, the WWF screening tool was deployed to a panel of experts drawn from institutions dealing with environment and climate related activities in Lamu County. The panel consisted of 11 experts selected on basis of their knowledge on the issues under investigation and study's objectives. They were distributed as indicated in the table 1 below:

***Table 1: Panel Experts Selected For FGD***

| Item | Institution | No Expert Selected |
|---|---|---|
| 1 | Kenya Ports Authority | 2 |
| 2 | Kenya Wildlife Service | 1 |
| 3 | National Museum | 1 |
| 4 | Lapsset Corridor Dev., Authority | 2 |
| 5 | Indian Ocean Water board | 1 |
| 6 | Kenya fisheries | 1 |

| | | |
|---|---|---|
| 7 | Lamu County Government | 3 |
| Total | | 11 |

*Source: Authors data.*

The WWF climate screening too was also deployed to a sample of 237 respondents living within the LAPSSET ecosystems areas in Lamu county. The respondents were purposively selected based on the length of residence in the area (for at least 10 years) and their willingness to participate in the study. The WWF crowd screening tool is a survey instrument that helps researchers define their climate change study parameters. It is a detailed questionnaire aimed at gathering data from the community and integrating the same into scientific synthesis. It is designed to help in identifying climate related hazards, effects of the hazards and peoples' adoption responses to the climate change hazard. The tool broadens understanding of climate related hazards as well as help in crafting of solutions that can help people and nature adapt to changing climate. It is a community driven approach to climate studies. Data was analyzed quantitatively and qualitatively and presented in graphs and tables.

## Results and Discussion

### Respondents Bio data

237 respondents were selected purposely based on number of years lived in the area and language competence (Swahili or English). The link attached here shows the map and the specific geographical locations of each respondents courtesy of WWF crowd screening tool, **https://wwfclimatecrowd.org/#report-3187.** 80 % were male and the rest female. In terms of age, almost 5 in ten of the respondents were between the ages 35 and 53 years and therefore constituted what is generally considered as the active segment of the Kenyan population (see Figure 1 below).

*Respondents' Age categories*

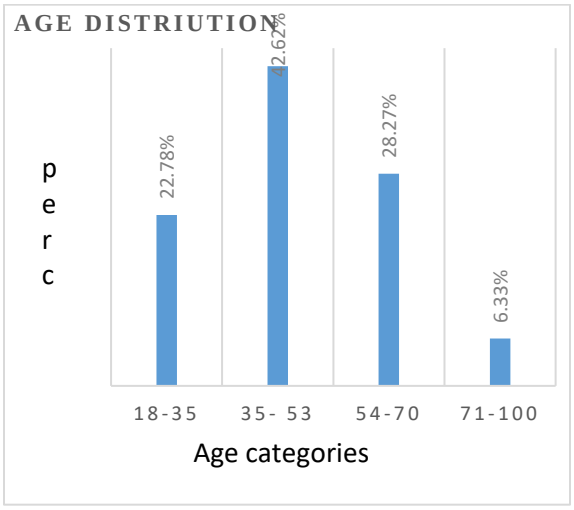


***Figure 1: Respondents Age Categories.***

*Source: Author's data*

*Respondents' Livelihood*

Fishing and farming were the main source of livelihoods for the respondents, they constituted 65%. About one in ten of the respondents claimed to be mangrove cutter. And a similar number claimed to be boat operators (Figure 2 captures the respondents' Livelihoods).

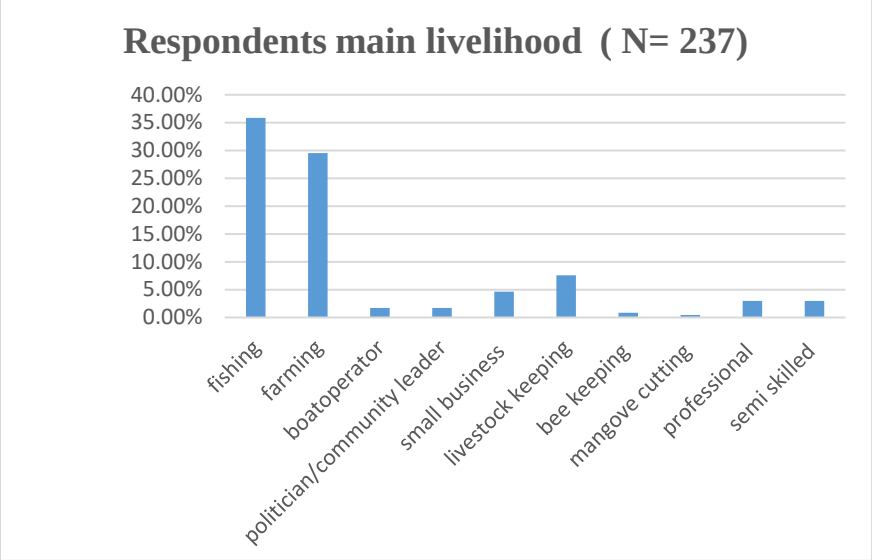


***Figure 2: Respondents livelihoods***

From figure 2, the respondents engage in various activities that are directly linked to climate change acceleration; Farming, fishing, livestock keeping, boat operator and mangrove cutting. Indeed, one expert in the FGD expressed the issue as follows:

*'Mangrove cutting was a traditional economic activity that the coastal people were engaged in since time immemorial. But the difference between then (old days) and now is that, then it was done in in rotational methods which gave the mangrove forest time for rejuvenations and regeneration, this practice is no more, the appetite for mangrove is unlimited due to population increase and large inflow of people to the LAMU towns and its surrounding area"* (Respondent (A)

It was also noted that, a portion of mangrove forest was also cut to pave way for the construction of the 32 berths platform. Another expert respondent argued that '*due to increased farming activities, there was significant bush clearing activities near and along the LAPSSET corridor. The LAPSSET projects acted like magnet for they drew people to their sites in search for employment and business opportunities. Increased urbanization along the LAPSSET corridor put pressure on farming activities* (Respondent K)

**Major Changes in the LAMU Port Neighbourhoods in the Recent Past**

About 74% of respondents indicated that they had noticed major climatic changes in their neighbourhood in the past few years. Infrastural development was listed as the most significant change in the environment with a score of 25% followed by high cost of living and third was improved high standard of living, (See figure 3 below).

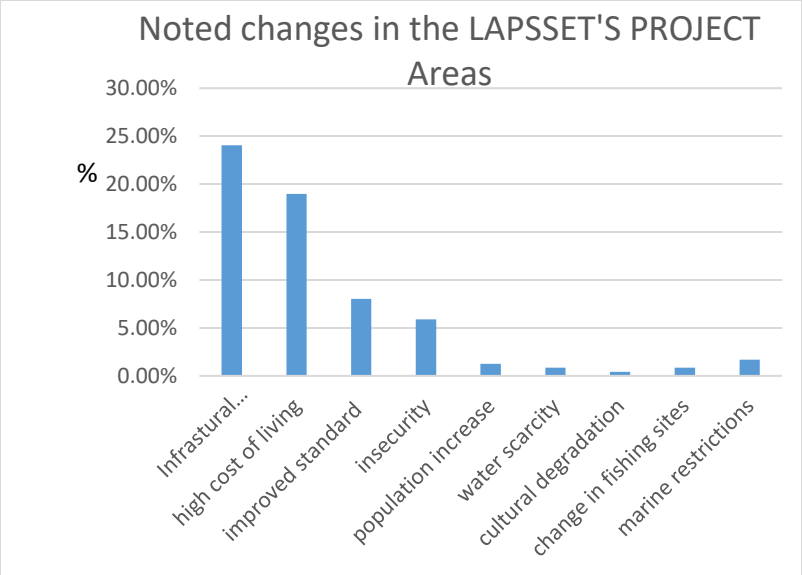


***Figure 3: Changes in the LAPSSET Project area of Lamu county***

*Source: Author's Data*

From figure 3, almost four in ten respondents said that, they have noted remarkable infrastructural development and another one in ten respondents said they have noted; high population increase, water scarcity and shifting of fishing sites. Infrastural development and population increase are major causes of climate change. The other two (water scarcity and shifting of fishing sites) are footprints indicators of climate change. Indeed, from one of the FGD, two experts captured the impact of climatic footprints as follows:

*'In area known as Kirirana in Lamu county, there is noticeable coral bleaching which have resulted in death of some fish species like clowns, in other areas the fish have migrated deeper into the sea and fishermen are no longer able to catch them where they used to catch them. Marine mammals like Cow of the Sea has become very uncommon. Another noticeable issue is that Tuna fish is now common but in earlier times (ten years ago) fishermen used to go deeper into the sea to catch them, now they are near the shore. Again spices like dolphins used to be cited near a place known as Pate Creek, they are no longer cited.'* (Respondent E)

Another respondent said; *Sand beaches are important habitat for crabs and other sea creatures and in the last ten years there is noticeable sea rise in Mkokoni area of the Lamu county where 50 to 60 metres of land has been swallowed by sea water. Indeed, a physical wall that was built there is now completely submerged at a distance of about 50 metres inside the sea. With these kind of change the crabs habitats were seriously affected.* (Respondent K)

*Noticeable Changes in Climatic Conditions in LAPSSET Area, Lamu County*

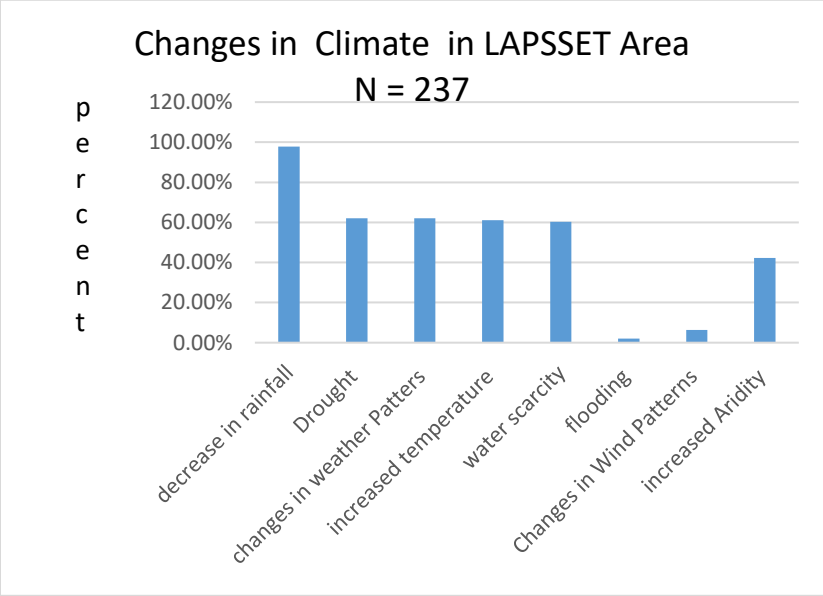


***Figure 4: Changes in Climate in Lamu County***

From Figure 4, almost all the respondents (96%) agreed that rainfall decrease has become more profound in LAPSSET area in the recent past. As a result, drought was cited as a major issue that has arisen at (63%), other major climatic changes in the area includes changes in weather patterns and increased temperature. Similarly, water scarcity and increased aridity were cited as significant. All these issues are footprints of climatic changes. Indeed, the experts had these to say:

*A big climatic-change bomb at Lamu county is, the drying up of Lake Kenyatta, it is a dreadful ecosystem loss which has gone with it life supporting systems for flora and fauna. One need not go further than the dried lake to understand the effects of climate change*. (Respondent H)

*There is a direct link between part of dried-up mangrove forest and rain scarcity, mangrove flourish at certain alkalinity levels, and whenever these levels are interfered with then there is death of mangrove, rainfall scarcity is the surest and the fastest way of affecting alkalinity levels in the sea. It needs to be known that rainwater is good for both the sea and land for it increases productivity in both ecosystems.* (Respondent C)

*With reduced rainfall there is degradation of forest cover and acceleration of drought. As a result, important ecosystems like shrubs and herbs in Lamu county are becoming scarce and disappearing fast. Similarly, range ecosystem in Lamu county is vanishing quickly and in alarming rate*. (Respondent U). Reduced rainfall leads to water scarcity and increased temperature.

The consequences of increased temperature are quite dire and the drying up of Lake Kenyatta is cited as an example. Indeed, increase in temperature make the range land and forest very prone to bushfire, for instance in Witu forest. It also led to drying up of well, rivers and wetlands leading to loss of wildlife. Animals like giraffes, antelopes, lions, hippos, buffalo and zebra were common in Kenyatta Lake ecosystem but they are

now vanished. Increase in temperature also interfere with reproduction of some species. Indeed, one expert respondent stated it as follow:

*With increased temperature only the female gender of the turtle flourish thus accelerating the rate of their (turtle) extinction. Similarly, increased temperature destabilizes the ability of climate agents to balance the climate*. (Respondent F)

**Ecosystems Present in LAPSSET Area in Lamu County**

Lamu County is generally a pristine environment with a rich and diverse ecosystem that supports her economy. From both the panel of experts and survey respondents, the following were identified as the most common ecosystems within Lamu county: Coral reefs, mangroves, sea grass, water bodies (Lake-Kenyatta, seasonal rivers, and Indian oceans, wetlands, sandy beaches, creeks, forests and sand dunes. Most of the habitats are found both within key protected areas Kiunga marine protected areas, Boni-Dodori National Reserve, Witu forest reserve, and non-gazetted areas and community conservancies. In these ecosystems, there is diverse wildlife species that span marine and terrestrial ecosystems. Key terrestrial species include Hyenas, giraffes, buffalo, lion, hippopotamus, zebras, various bird species. Dolphins, Dugong, Sea turtles, fish, crustacean -such as prawns, crabs, and fish are the key marine species.

**Climate Related Hazards in LAPSSET Area of Lamu**

The respondents observed the following key climate change related hazards in the LAPSSET area:

*Timings of Seasons and Change in Frequency and/or Severity of Rainfall:*

Both the panel of experts and the survey respondents were unanimous that, the rainfall patterns have been affected. The long rain season is no longer predictable. Traditionally the long rains used to fall from March to July every year. It was observed that, the long rain duration is reducing to two months on average around May/June. Previously short rains occurred from October to December. Now, they are highly unpredictable. Over the past two years, Lamu county has had low rains and this has worsened droughts, caused boreholes/water wells and lakes to dry up, and disappearance of seasonal rivers. The effect of diminished rainfall has culminated into longer drought periods which brought about increased aridity in the region. With aridity there is increased wildfires, degradation of land and water sources, poor agricultural productivity, death of livestock & wildlife and conflict over limited resources.

*Frequency and Severity of Winds:*

It was reported that, the winds seasonality has also been impacted. The Southern Monsoon winds *(Kusi)* which were traditionally experienced in June are now longer there. The Northern Monsoon winds *(Kaskazi)* wind season has also changed. The respondents insinuated that there has been a relative shift in wind patterns and intensity with recent observations revealing stronger winds near shore than in deep sea.

*Sea Level rise*

80% of respondents observed gradual sea level rise in some parts of Lamu Coastline. For instance, in *Mkokoni* area, some of the forested areas near the shore are not accessible due to water intrusion. They

reported that, sea water invaded the land by 60-80 metres. As a result, some species of fish that were found in the deeper sea were now easily accessible in the area.

**Biodiversity impacts**

Over 70% of the respondents listed the following as biodiversity impacts: A general increase in frequency of drought, floods, fires, heat, etc; Range shift (wildlife moving into an area they previously did not occupy or out of an area they previously occupied), emergence of new diseases affecting plant/animal species; and Mortality/decline of plants/animal species caused by extreme weather events; There was also reported increase in beach erosion, high sea temperature and increased and stronger force of sea waves in the area. For instance, it was reported that in Kiwani area the coral there had died and as a result more sand had entered into mangroves ecosystems.

*Species Migration:*

It was reported that, some of the marine mammals that were present in the area such as Dugong have migrated, and they were no longer cited.

*Terrestrial Ecosystem Impacts*

Both the panel of experts and the respondents reported that there has been increased incidents of Forests and rangelands wildfires. As a result, there is noticeable biodiversity loss. It was noted that, honey harvesters are nowadays unable to control fires they set during the honey harvesting process. Respondents reported that, pollinators such s bees and birds have become scarce and rare. Respondents reported that, there has been notable increase in human wildlife conflict because wild animals have moved to residential areas in search of water and pasture. It was also reported that due to the drying up of Lake Kenyatta a lot of animals like the hippos died. Similarly, new pests such as locusts are emerging and noticeable and other pests such as tsetse flies are now found in areas they never used to be.

*Marine-Terrestrial Ecosystem Impacts*

Sedimentation caused by anthropogenic activities and exacerbated by changes in climate was observed as a key problem in coastal fringes (low intertidal zones along the shoreline) leading to habitat changes. The changes include conversion from mud flats to sand flats. Another problem is clogging of creeks leading to mangroves degradation and loss of species that depend on a healthy mangrove ecosystem. According to the respondents, major contributors to sedimentation included: i) sea erosion due to erratic floods washing out exposed soils and agricultural lands upstream and along the lagas. ii) Dredging (sea reclamation) by LAPSSET and other developments in the area resulted in high tonnage of sand dusts released to the atmosphere, this combined with strong wind patterns near shore resulted in high volumes of sand deposits along the creeks. Other changes observed by the respondents were: New animals such as whale sharks being sighted, Fish migrating that impacting fishers, overfishing in the nearshore and some fishers moving to the Economic Processing Zones (EPZ) area or adopting alternative income opportunities such as tourism

**Community Response to Climate Change and their Impacts Proposed Adaptation Options**

The respondents highlighted the following as Some of the adaptation/coping interventions that are being implemented/adopted: Shifting forms of livelihoods intervention e.g. from fishing to farming, Adoption of agricultural innovations such as greenhouses, growing drought resistant crops, adoption of irrigation, use

of pesticides and fertilisers, use of Early Warning Systems/weather forecasting, sinking of boreholes, and people migrating to areas with available pasture. Other adoption measures included; community conversion of areas from farming to conservation, settling of communities in one area and communities not practising shifting cultivation.

*Perceptions on LAPSSET's Contributions to Climate Change*

The respondents were of the view that, the LAPSSET projects has led to the rising of the cost of living. As a result, this high cost of living has inhibiting people's ability to cope with climate change impacts. Similarly, the respondents perceived LAPSSET activities as limiting access to traditional fishing grounds that were near the lamu Port which resulted in conflicts between the locals and the LAPSSET project. 73 % of the respondents argued that dredging by LAPSSET directly affected mangroves and eventually led to their habitat loss. Majority of the respondents 85% were of the view that. high population influx due to LAPSSET's pull factor (employment, business investments opportunities etc) have resulted to demand for housing and overall expansion of the built environment which has resulted in high biodiversity loss. 8 in 10 respondents accuse the LAPSSET project of causing increased emissions from the construction activities.

*Respondents Perception About Climatic Change Effects on Livelihoods*

The respondents pointed out that food shortage has become more pronounced and that more people were now prone to hunger and poverty as a result of the harsh climatic conditions (See figure 6 below).

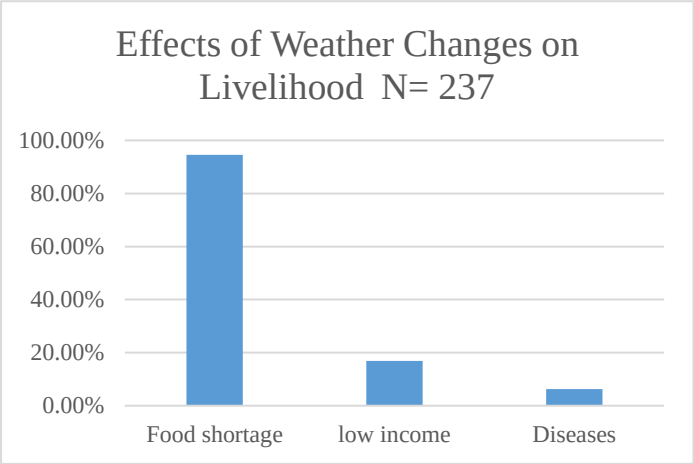


***Figure 5 Effects on Livelihood***

*Climatic Hazards Identified by Respondents.*

The respondent's identified the following as the hazards associated with climate changes in LAPSSET project area of Lamu county; Severe droughts, Desertification, Destruction of ecosystem, Scarcity of fresh water, Death of livestock, Sea level rise, Severe hate waves, drying up of well,Well water becoming saline, Drying up of water bodies and reduction of certain species such as prawns, crabs , turtles

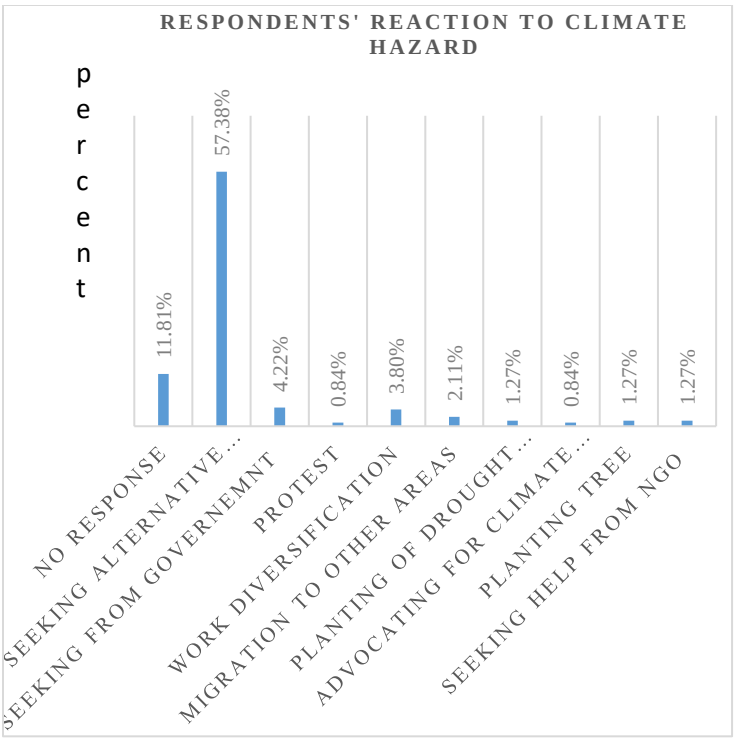


***Figure 6: Response to Climate Change***

The impacts of climate changes on people and their livelihood are real. Respondents said that they would consider protest as a mechanism of expressing their voice on matters of climate changes and their related impacts. 60 % of the Respondents also said that they would migrate from the area if the problem of climate change persisted and indeed, they said they knew people who had relocated to other more habitable areas. Other adaptation mechanisms by respondents were rainwater harvesting, borehole drilling, use of saline well water, relying on government for water, purchase of clean water and factoring more money for water budget. They cited the following as coping mechanism: water export from neighbouring villages, purifying saline water and Recycling Sea water.

## Conclusion and Recommendation

Although large scale Infrastructural projects like LAPSSET open doors for immense human empowerment via economic and social transformation in their area of operation, they also have significant negative impact on the global common. Their operations and activities provide 'the dilemma of the balance between desired development goal of a country and a country's physical environmental preservation'. The respondents accused the LAPSSET's projects of engaging in activities that accelerate climate change. For instance, it was projected as magnetic force pulling people toward it and in essence increasing the population influx in its area of operation. With increased population variegated climate change activities kick in; increased agricultural activities, urbanisation and human settlement (indeed, the county government of Lamu with conjunction with the National Government of Kenya has created a new human settlement scheme known as *Swahili scheme* just adjacent to the Lamu Port), increased electricity consumption, increased use of fossil fuels, increased demands for mangrove in construction and housing sectors, and increased uptake of water all led to the degradation of the forest cover among other issues. Indeed, 84% of the respondents

listed Mangrove clearing to make room for ship Berths and sea dredging as activities that had direct impact on the climate and productivity of the sea in the LAPSSET neighbourhood. Dredging, clogged creeks and other sea ecosystems as well as interfered with wind patterns.

In conclusion it is argued that the activities of LAPSSET projects are not without environmental consequences and mitigating mechanism need to be put in place. And although Kenya as a country has elaborate laws to safeguard the environment activities and is party to many international environmental protocols, adverse effects associated with environmental degradation and climate change related hazards are present at the LAPSSET operation area.

## Recommendations

The study makes the following recommendations based on its objectives and findings. For objective one, the study recommends that, because climate change and biodiversity are complex, both the local communities and the implementers of large scale infrastructural projects should be empowered on issues of climate change and diversity loss. Various environmental syllabuses and training manuals should be developed and be mandated via both County government and National government legislative agenda on environment. The funding of such training programmes should be pegged on law and on pre-determined percent of the resources allocated to these (such) projects. They should also be custom suited for various stakeholders. Let everyone be knowledgeable on the role they can play in climate change mitigating agenda. Specifically, the training should aim at producing a pool of climate change mitigation green army capable of identifying environmental damages associated with large scale infrastructural projects and take active role in stopping them or advocating for their stoppage. The operation of the green army should be funded through multi-agency approach, from the development projects, the county government, national government, and environmental organisations.

For the second objective, the findings are alarming and dreadful, one CESA lake *Kenyatta* has dried up, and in another area (Mkokoni) the sea has swallowed up 80 mitres of land, bringing deep sea into the coastline of Lamu. There is also conversion of mad flats into sand flats and clogging of creeks. It is recommended that, there should be acceleration of development and deployment of technology to monitor climate change related activities. Technological applications that can monitor disturbance of both flora and fauna of terrestrial and marine ecosystems should be deployed. Such technological interventions can be achieved via legislations that would require large scale projects as well as local governments and other stakeholders to deploy them. We have in mind technologies to monitor air quality, forest cover, ocean rise, and wind patterns among others. Such technologies would aid in decision making and promote prompt actions by stakeholders.

For objective three, it was noted that, many people at the LAPSSET area are still heavily dependent on natural sources of water such as rivers and wells. They also depended on traditional fishing methods, traditional animal husbandry and small-scale business enterprises. The study recommends that, there is need to develop technological applications aimed at bringing amenities such as water to where the people are and to develop smart solution for preserving and for harvesting rainwater. Solar powered technologies to irrigate land and to convert sea water into fresh water should be funded by infrastructural projects, local, national government, environmental stakeholders and rich nations. Swift action is needed because as UNFPA report 2020 states; severe draughts in sub-Saharan Africa has increased malnutrition, opportunistic

diseases and deaths at alarming levels. Rich nations should cancel debts owed to the sub-Saharan countries so that they can be able to deploy such funding to mitigates and fight climate change related hazards. It is recommended that, showcasing of successful best climate adaptation- projects should be done and their adoption funded. Further it is recommended that, all large-scale infrastructural projects operating in the Kenya should, by law be forced to re-green their area of operation and fight threats associated with climate change, global warming, draughts, and loss of biodiversity. To achieve this, the government of Kenya should legislate carbon sequestration bill to guide the domestication of carbon credit markets locally and internationally. Large scale companies operating in Kenya should be forced to calculate their carbon footprint and demonstrate how they off-set them. Safaricom company in Kenya has set a voluntary path on this approach. This approach should be made mandatory for all large-scale infrastructural projects. We call for collective positive action by all stakeholders to make our planet a better place for human sustenance and enjoyment. The battle for climate hazard mitigation shouldn't be lost. After all, both the Kenyan constitution and the many International Environmental Protocols guarantee every citizen of the world the right to clean and healthy environment.

## References

Aminzadegan, S., Shahriari, M., Mehranfar, F., & Abramović, B. (2022). Factors affecting the emission of pollutants in different types of transportation: A literature review. *Energy Reports, 8,* 2508-2529. https://doi.org/10.1016/j.egyr.2022.01.161

Colvile, R., Hutchinson, E., Mindell, J., & Warren, R. (2001). The transport sector as a source of air pollution. Atmospheric *Environment, 35*(9), 1537-1565. https://doi.org/10.1016/s1352-2310(00)00551-3

Cooper, R. N., Houghton, J. T., McCarthy, J. J., & Metz, B. (2002). Climate change 2001: The scientific basis. *Foreign Affairs, 81*(1), 208. https://doi.org/10.2307/20033020

Cooper, R. N., Houghton, J. T., McCarthy, J. J., & Metz, B. (2002). Climate change 2001: The scientific basis. *Foreign Affairs, 81*(1), 208. https://doi.org/10.2307/20033020

Dzokoto, S. T., Atomb, C., Braimah, M. M., & Issahaku, A. (2022). Study on factors influencingexhaust emission levels in five major cities in Ghana. *International Journal of Environment and Pollution Research, 10*(1), 28-44. https://doi.org/10.37745/ijepr.13/vol10n1pp2844

Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy (2011). Solutions for a cultivated planet. *Nature, 478*(7369),337-342. https://doi.org/10.1038/nature10452

Halsnæs, K., & Verhagen, J. (2007). Development based climate change adaptation and mitigation—conceptual issues and lessons learned in studies in developing countries. *Mitigation and Adaptation Strategies for Global Change, 12*(5), 665-684.https://doi.org/10.1007/s11027-007-9093-6

Intergovernmental Panel on Climate Change. (2015). *Climate change 2014: Mitigation of climate change*. https://doi.org/10.1017/cbo9781107415416

Jafari., R. (2013) *Quantitative Mapping and Assessment of Environmentally Sensitive Areas to Desertification in Central Iran*. https://doi.org/10.1002/ldr.2227

Kopelias, P., Demiridi, E., Vogiatzis, K., Skabardonis, A., & Zafiropoulou, V. (2020). Connected & amp; autonomous vehicles – Environmental impacts – A review. *Science of The Total Environment, 712*, 135237. https://doi.org/10.1016/j.scitotenv.2019.135237

Loboguerrero, A., Campbell, B., Cooper, P., Hansen, J., Rosenstock, T., & Wollenberg, E. (2019). Food and earth systems: Priorities for climate change adaptation and mitigations for agriculture and food systems. *Sustainability, 11*(1372), 1-26. https://doi.org/10.3390/su11051372

Marsden, G., & Rye, T. (2010). The governance of transport and climate change. *Journal of Transport Geography, 18*(6), 669-678. https://doi.org/10.1016/j.jtrangeo.2009.09.014

Niles, M. T., Ahuja, R., Barker, T., Esquivel, J., Gutterman, S., Heller, M. C., Mango, N. Portner, D., Raimond, R., Tirado, C., & Vermeulen, S. (2018). Climate change mitigation beyond agriculture: A review of food system opportunities and implications. *Renewable Agriculture and Food Systems, 33*(3), 297-308.https://doi.org/10.1017/s1742170518000029

Ong, H., Mahlia, T., & Masjuki, H. (2011). A review on emissions and mitigation strategies for road transport in Malaysia. *Renewable and Sustainable Energy Reviews, 15*(8), 3516-3522. https://doi.org/10.1016/j.rser.2011.05.006

Ruto W, Akinwiumi, & Verkoojen (2023). Time to Scale up African Solutions for Continent's Food, Climate Crises. *Standard Newspaper*, March 15,2023, pp18.

Worrell, E., Bernstein, L., Roy, J., Price, L., De la Rue du Can, S., & Harnisch, J. (2009). Industrial energy efficiency and climate change mitigation. *Energy Efficiency, 2*, 109-123. https://doi.org/10.2172/957331

Wuebbles, D. J., & Jain, A. K. (2001). Concerns about climate change and the role of fossil fuel use. *Fuel Processing Technology, 71*(1-3), 99-119. https://doi.org/10.1016/s0378-3820(01)00139-4