ADDRESSING THE IMPACT OF CLIMATE CHANGE-INDUCED URBANIZATION ON MUSCULOSKELETAL INJURIES: A POLICY ANALYSIS

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ABSTRACT

Antoinette J. Charles: Addressing the Impact of Climate Change-Induced Urbanization on Musculoskeletal Injuries: A Policy Analysis (Under the direction of Ciara Zachary and Kiran Agarwal-Harding)

This paper explores the intersection of climate change-induced urbanization and its impact on musculoskeletal injuries. The migration of people from rural to urban areas in low-and middle-income countries like Ethiopia has led to increased motorization, higher traffic density, and a surge in road traffic injuries and fatalities. The objective of the paper is to conduct a comprehensive policy analysis addressing the implications of climate change-induced urbanization on musculoskeletal injuries. The policy options evaluated include maintaining the status quo, enforcing seat belt usage, developing pedestrian-friendly infrastructure, and implementing a fossil fuel export tax. The analysis considers factors such as costs, effectiveness in prevention of musculoskeletal injuries, addressing climate change, feasibility for implementation, and financial equity. After evaluation, the fossil fuel export tax was determined to be an equitable, cost-effective solution that tackles the broader impact of climate change on forced displacement and migration, while supporting sustainability initiatives and road accident funds for victims.

Keywords: climate change, traumatic musculoskeletal injuries, road safety, road traffic injuries
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## GLOSSARY

<table>
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<th>Term</th>
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<tr>
<td>Climate Change-Related Migration</td>
<td>The movement of people or communities that relocate due to environmental and socioeconomic changes caused by climate change, including rising sea levels, extreme weather events, and the loss of arable land.</td>
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<tr>
<td>Fuel Export Tax</td>
<td>A tax imposed by a country on the export of fossil fuels—coal, petroleum, and natural gas products.</td>
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<td>Fuel Levy</td>
<td>A surcharge imposed on the sale of petrol that's paid by citizens and businesses that purchase fuel in a country.</td>
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<tr>
<td>Greenhouse Gases</td>
<td>Gases that trap heat in the atmosphere and contribute to the warming of the planet. These gases include carbon dioxide, methane, nitrous oxide, and fluorinated gases.</td>
</tr>
<tr>
<td>High-Income Countries</td>
<td>Countries with a gross national income per capita of $13,846 or more (e.g. United States, China, and Sweden).</td>
</tr>
<tr>
<td>Low-and Middle-Income Countries</td>
<td>Countries with a gross national income per capita less than $13,846 (e.g. Ethiopia, Haiti, and Colombia).</td>
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<tr>
<td>Musculoskeletal Injury</td>
<td>Damage or trauma that affects muscles, bones, ligaments, tendons, joints, and soft tissues.</td>
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<tr>
<td>Urbanization</td>
<td>The process of an increase in population concentration in urban areas, accompanied by the growth and expansion of cities.</td>
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Overview of Climate Change

Climate change involves long-term alterations in temperature, precipitation, and other atmospheric conditions on Earth\(^3\). The primary drivers of climate change today are widely attributed to human activities, particularly the combustion of fossil fuels, deforestation, and industrial processes that release greenhouse gases into the atmosphere\(^4\). Greenhouse gases trap heat in the atmosphere and contribute to the warming of the planet. This warming leads to various environmental consequences, including rising sea levels, more frequent and severe extreme weather events, disruptions to ecosystems, and shifts in global climate patterns\(^5\). Vulnerable populations, particularly those in low-income countries, often bear the brunt of these impacts, exacerbating existing social and economic inequalities.

While Africa emits a lower amount of greenhouse gases than other continents, its countries face heightened susceptibility to the consequences of climate change due to a confluence of historical factors, socioeconomic vulnerabilities, and global carbon inequality\(^6,7\). Historically, many African nations endured exploitation and colonialism, resulting in weakened economies and insufficient infrastructure. The exploitation of minerals, fossil fuels, and agricultural products during colonial rule—from the late 19th to the mid-20th century—left many African nations economically impoverished\(^8\). Agriculture, constituting approximately 35% of the continent's GDP, is a pivotal economic sector; it serves as a primary source of employment for Africans, engaging around 70% of the workforce\(^9,10\). Climate change-induced extreme weather events pose a threat to agricultural productivity by directly impacting crop yields and livestock output, contributing to heightened food and job insecurity, particularly in Africa\(^11,12,13\).

Regarding global carbon inequality, high and upper-middle-income countries contribute to 80% of carbon emissions compared to low and low-middle-income countries (LMICs)\(^14\). Despite this, high and upper-middle-income countries have greater access to resources for investing in infrastructure, technology, and adaptive measures, affording them a heightened capacity to mitigate and respond to climate-related challenges\(^15\). Additionally, these nations often have more diversified economies, reducing
their vulnerability to climate-induced disruptions, particularly in the agricultural sector\textsuperscript{16,17}. The effects of climate change on vulnerable populations highlight the urgent need for equitable and collaborative solutions to tackle the challenges presented by the global climate crisis. In a positive step towards addressing climate equity, in November 2023, the European Union, United Kingdom, United States, and other high-income countries (HICs) have collectively agreed to contribute to a fund of about $400 million to assist low-income countries in dealing with the damages resulting from the outcomes of climate change\textsuperscript{18}. While this financial commitment falls considerably short, it signifies an acknowledgment of global responsibility and the need for collaborative efforts to mitigate the disproportionate impact of climate change on the most vulnerable regions.

**Impact of Climate Change on Musculoskeletal Injuries**

The consequences of climate change extend beyond its environmental impacts, directly affecting human health. It can create and influence conditions that increase the risk of musculoskeletal injuries for individuals in affected regions. In this section, various ways in which climate change can impact musculoskeletal health will be discussed.

Climate change disasters, such as hurricanes, tornadoes, and cyclones, have become increasingly frequent and severe\textsuperscript{19}. Numerous studies have established a strong correlation between extreme weather events and climate change due to elevated levels of carbon emissions and greenhouse gas concentrations\textsuperscript{20,21,22}. These events can lead to displacement of people and devastate communities, by rendering homes and infrastructure uninhabitable\textsuperscript{23}. Cyclone Freddy, which struck northern Mozambique and southern Malawi on March 11, 2023, serves as a recent example of the destructive consequences of extreme weather events\textsuperscript{24}. Its powerful winds, storm surges, and torrential rainfall inflicted widespread devastation in Mozambique and Malawi, causing houses and other buildings to collapse, killing and injuring people\textsuperscript{25}. The heightened frequency and severity of climate change-induced disasters,
exemplified by events like Cyclone Freddy, contribute to a higher incidence of injuries caused by collapsing structures and other storm-related accidents\textsuperscript{26}.

The loss of arable land is a growing concern worldwide and has also been attributed to climate change\textsuperscript{27}. Climate change results in increasingly frequent and severe droughts, heatwaves, and altered precipitation patterns, which degrade soil quality and reduce its agricultural productivity\textsuperscript{28}. This loss of fertile land exacerbates the competition for already scarce natural resources, impacting livelihoods and disrupting food sources in LMICs\textsuperscript{29}. As arable land diminishes, it intensifies the competition for the remaining fertile areas, sparking disputes and violence among communities, ethnic groups, and even nations over limited agricultural resources\textsuperscript{30}. Notably, countries like Nigeria, Sudan, and Ethiopia, already grappling with resource scarcity, are particularly susceptible to these interrelated issues\textsuperscript{31}. Interpersonal conflicts result in a large number of deaths and non-fatal injuries\textsuperscript{32}.

\textbf{Climate-Driven Mobilization and Population Displacement}

Population mobility has historically been closely linked to environmental and climatic conditions, as communities have adapted to changing landscapes and resource availability\textsuperscript{33}. In recent times, a multitude of climate-related factors have accelerated the movement of people from rural to urban areas\textsuperscript{34}. These factors encompass climate change disasters, the loss of arable land, and adverse impacts on ecosystems, each of which has profound implications for both human and environmental well-being\textsuperscript{35}. Consequently, individuals living in these challenging environments are often compelled to seek better opportunities for financial sustainability and

\begin{figure}[h]
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\includegraphics[width=\textwidth]{image.png}
\caption{The effects of climate change, factors influencing migration, and migration processes}
\end{figure}
improved living standards through migration and displacement\textsuperscript{36,37}. Figure 1 offers a visual representation of the primary effects of climate change, factors influencing migration, and migration processes\textsuperscript{33}.

Ecosystems have been adversely affected by climate change, which encompasses heat stress on vegetation, decreased soil fertility, nutrient loss in soils, declining vegetation cover, and erosion of natural waterways\textsuperscript{33,38,39}. Physical processes and land use practices also contribute to the land degradation\textsuperscript{40}. These ecological disturbances have repercussions that extend beyond the environment; they also affect the livelihoods of individuals reliant on these ecosystems for sustenance and income. For instance, farmers facing damage to their grazing lands and reduced crop yields may face higher livestock mortality rates, resulting in food scarcity and reduced profits\textsuperscript{41}. In these challenging circumstances, food insecurity may force people to resort to riskier activities, increasing the likelihood of injuries and musculoskeletal trauma, thereby perpetuating a vicious cycle of adversity\textsuperscript{30}. As individuals in poverty experience musculoskeletal trauma, it worsens their economic challenges by potentially affecting their functional abilities. Consequently, this increases the susceptibility of their family members to engage in riskier activities, contributing to an enduring cycle of poverty and injury across generations. A tragic example of this cycle's impact occurred in June 2019 when a report emerged of a man in Nigeria severing a child's hands in response to alleged fish theft. These kinds of acts of “mob justice” are unfortunately still practiced in many Sub-Saharan African countries as retaliation for theft\textsuperscript{42}.

Since 2008, approximately 20 million people have been uprooted from their homes due to climate- and weather-related disasters annually\textsuperscript{43}. In 2022, the global population of forcibly displaced individuals reached an unprecedented high, exceeding 100 million\textsuperscript{44}. Again, this movement is primarily a response driven by escalating temperatures, extreme weather events, sea-level rise, depleting water resources, and rampant deforestation. The World Bank predicts that Latin America, Sub-Saharan Africa, and Southeast Asia will witness the migration of 216 million people within their countries by 2050\textsuperscript{45}. 

The decision to migrate is influenced by a multifaceted interplay of political, social, economic, and demographic factors. Government policies and regulations can either facilitate or impede the movement of people, while social networks and community ties play pivotal roles in determining destinations. Economic factors, including access to financial resources, determine an individual or family's capacity to relocate. Considerations such as housing availability, household size, and language barriers add further complexity to the decision-making process.\(^{46}\)

**Urbanization and Road Traffic Injuries**

Climate change-related migration has significant implications for road traffic injuries, especially in urban areas experiencing an influx of rural migrants. As more people move from rural to urban settings, there is a parallel increase in motorization. There is greater traffic density, a growing number of vehicles, and a higher volume of bicyclists and pedestrians.\(^{47}\)

The surge in road traffic comes at a heavy cost in terms of human lives. Annually, road traffic injuries claim the lives of approximately 1.3 million people worldwide.\(^{48}\) It is one of the leading causes of death, particularly among children and young adults aged 5-29 years.\(^{49}\) However, the impact extends beyond mortality. For each person who tragically loses their life to a road traffic injury, there is a growing number of individuals who suffer non-fatal injuries. It is estimated that between 20-50 million people sustain injuries resulting in temporary or permanent disabilities due to road accidents.\(^{50}\) Furthermore, road traffic injuries accounted for a staggering 72.9 million years of disability-adjusted life years (DALYs) globally in 2019.\(^{49}\) These statistics highlight the long-term physical, emotional, and socioeconomic consequences of road traffic accidents, which have multigenerational impacts.

In addition to the direct impact of climate change-induced migration on road traffic injuries, other factors exacerbate this issue. The rapid urbanization resulting from increased migration can lead to inadequately planned road networks, insufficient public transportation systems, and limited pedestrian-friendly infrastructure. These shortcomings create a risky environment for both migrants and existing...
urban residents. Moreover, migrants from rural areas may have varying levels of experience and familiarity with urban traffic rules and norms, potentially contributing to road traffic accidents and injuries\textsuperscript{51}.

Road Traffic Injuries and Fractures

A substantial portion of road traffic injuries are non-fatal, the majority of which involve the extremities. Research has demonstrated that over 75% of non-fatal road traffic injuries sustained during road traffic collisions affect the limbs\textsuperscript{52}. Among these injuries, femoral shaft fractures (a broken thighbone) account for approximately 9% of all road traffic injuries\textsuperscript{53}. These injuries often lead to long-term physical disabilities, loss of productivity, and increased healthcare costs. Not to mention, the burden of these non-fatal musculoskeletal injuries disproportionally affects individuals residing in LMICs compared to those in HICs. The prevalence of such injuries is reported to be two to five times higher in LMICs\textsuperscript{52}. This emphasizes the need for targeted interventions and policies to address road traffic injuries, ultimately leading to a decreased prevalence of orthopedic traumatic injuries.

Problem Statement

The intersection of climate change-induced urbanization, its impact on traumatic musculoskeletal injuries, and the added challenges of extreme weather events, resource scarcity, and conflicts increase the risk of musculoskeletal injuries and influence mobilization. Climate change has driven a significant migration of people from rural to urban areas, especially in LMICs. This influx of rural migrants into urban settings has led to increased motorization, resulting in higher traffic density, more cars, and a surge in pedestrians and bicyclists. Consequently, road traffic injuries have become a pressing public health concern, with millions of people suffering non-fatal injuries annually, primarily affecting their extremities. These injuries may lead to long-term physical disabilities, reduced productivity, and elevated healthcare costs. This burden disproportionally impacts individuals residing in LMICs.
Objective

The objective of this paper is to conduct a comprehensive policy analysis that addresses the impact of climate change-induced urbanization on traumatic musculoskeletal injuries. It will evaluate existing policies related to promoting road safety and urban planning. Based on the analysis, the paper will propose an evidence-based policy recommendation aimed at reducing the incidence of musculoskeletal injuries in urban areas affected by climate change-induced migration.

Country of Interest: Ethiopia

Africa has the highest percentage of pedestrian and cyclist fatalities, accounting for 44% of such deaths, surpassing the rates in the Americas, Eastern Mediterranean, Europe, Southeast Asia, and the Western Pacific region\(^4\). This problem is compounded by the insufficient reporting of road injury deaths in numerous sub-Saharan countries. The issue becomes even more significant when focusing on Nigeria, Ethiopia, South Africa, and Sudan, which collectively contribute to half of the road injury fatalities in sub-Saharan Africa\(^5\).

Ethiopia, in particular, grapples with complex road safety challenges marked by rapid urbanization, inadequate road and pedestrian infrastructure, and limited enforcement of traffic laws\(^6\).

Ethiopia, located in East Africa, shares its borders with Sudan, South Sudan, Kenya, Somalia, Eritrea, and Djibouti, as illustrated in Figure 2\(^7\). The population of Ethiopia is estimated at 126 million people, making it the second most populous country in Africa after Nigeria\(^8, 9\). In terms of gender distribution, the population comprises 50.2% females and 49.8% males. Regarding age, 39% of the
population falls within the 0-14 age bracket, 58% between 15 and 64, and 3% are 65 and older\textsuperscript{57}. In 2022, Ethiopia's GDP was estimated to be $126.78 billion\textsuperscript{60}. The country's primary industrial sectors encompass agriculture, food processing, construction, tourism, and resources and energy.

About 75% of the Ethiopian population resides in rural areas\textsuperscript{61}. Addis Ababa, the capital of the country, is its largest city, with a population of approximately 5 million people\textsuperscript{56,58}. The annual rate of urbanization for individuals moving from rural areas to Addis Ababa is rapidly increasing at 4.4%, driven by the pursuit of employment opportunities and an improved quality of life\textsuperscript{62,63}. Efforts to accommodate this urbanization include initiatives to increase the number of cars, such as enhanced road paving. However, the city faces a deficiency in pedestrian infrastructure, particularly walkways, crosswalks, and cycling facilities\textsuperscript{64}. At present, around 85% of commuting involves walking, cycling, and public transportation, with car usage making up roughly 15%\textsuperscript{64}. Addis Ababa has recorded a road traffic accident fatality rate of 16.1%\textsuperscript{65}. Nationally, the estimated road traffic fatality stands at around 114 deaths per 10,000 vehicles per year, with pedestrian fatalities contributing to 33% of road traffic deaths\textsuperscript{66,67}.

In light of these challenges, addressing the aftermath of road traffic injuries becomes increasingly crucial. Ethiopia's healthcare system operates on a three-tiered structure, comprising primary, secondary, and tertiary levels of care\textsuperscript{68}. The primary level includes primary hospitals, health centers, and health posts, providing emergency, inpatient, and ambulatory services and serving as referral points for higher levels of care. General hospitals at the secondary level serve as referral centers for patients from primary hospitals, while specialized hospitals at the tertiary level play a crucial role as referral centers for general hospitals. In the country, there are only three tertiary-level hospitals designated as trauma centers, and they are all situated in Addis Ababa\textsuperscript{67}. The hospitals providing trauma care include AaBET Hospital, Tikur Anbessa Specialized Hospital (TASH), and All African Leprosy and Tuberculosis Rehabilitation and Training (ALERT) Hospital.

Despite having an established health system, there are limited robust emergency medical services, a shortage of health professionals, a shortage of medications, medical supplies, and equipment, and
limitations in the infrastructure\textsuperscript{69,70,71}. Pre-hospital care can involve critical lifesaving and limb-saving measures, especially when provided at the scene of the injury. Outside of Addis Ababa, there is limited access to pre-hospital services\textsuperscript{67}. These challenges can make it difficult to adequately address and treat injuries from road traffic accidents for people who do seek care. The continuous rise in musculoskeletal injuries and economic losses from road traffic accidents highlights the pressing need for the Ethiopian Government to improve road safety.

**Existing Evidence Based Strategies**

The consequences of climate change-induced urbanization pose a significant challenge to public health, especially in the context of traumatic musculoskeletal injuries resulting from road traffic accidents. To address this multifaceted issue, evidence-based strategies are imperative in urban planning, transportation, and injury prevention. Within this framework, four strategies exemplify approaches utilized in various countries, serving as solutions to address road traffic injuries—the development of pedestrian-friendly infrastructure, promotion of public transportation, implementation of road safety initiatives, and the creation of a fuel levy.

**Pedestrian-Friendly Infrastructure**

Pedestrian-friendly infrastructure represents a fundamental component of urban planning strategies aimed at reducing the risk of road traffic injuries. This approach involves designing cities with a focus on creating pedestrian-friendly environments, which include well-maintained sidewalks and designated crosswalks\textsuperscript{72}. Bogotá, a city in Colombia that successfully reduced the number of traffic deaths by 50\% between 1996 and 2006, serves as a compelling example of the effectiveness of an integrated approach to road safety and urban mobility\textsuperscript{48}. One of the key initiatives within this approach involved investing $2 billion over a 10-year period to enhance bikeways, public transportation, and pedestrian infrastructure in the city. Notably, it was one of the first cities in the world to create bicycle lanes\textsuperscript{73}. Research findings indicate that cities with well-planned, walkable infrastructure can effectively
decrease the occurrence of accidents and associated injuries\textsuperscript{74,75}. By prioritizing the safety and accessibility of pedestrians, this strategy not only facilitates more sustainable urban development but also directly addresses the impact of climate change-induced urbanization on musculoskeletal injuries from road traffic accidents.

\textit{Public Transportation}

Encouraging the use of public transportation systems represents another crucial strategy. Through investments in efficient and accessible public transportation networks, the number of vehicles on the road is reduced, ultimately leading to a decrease in traffic accidents\textsuperscript{76}. The American Public Transportation Association presented a compelling case in 2016, demonstrating that cities with robust public transportation systems experienced fewer traffic-related deaths\textsuperscript{77}. Similarly, in Israel, the introduction of night buses in metropolitan areas resulted in a remarkable 24\% reduction in road traffic injuries\textsuperscript{78}. The presence of effective public transportation systems can significantly contribute to mitigating the adverse effects of urbanization driven by climate change because the use of public transportation reduces carbon emissions\textsuperscript{79}. In 2018, the United States achieved a 63 million ton reduction in carbon emissions through the use of public transportation\textsuperscript{80}. There is limited literature on public transportation strategies to mitigate the consequences of climate change-induced urbanization in LMICs, except for gray literature. It is imperative to prioritize research in these settings related to the use of public transportation to ensure equitable strategies and address the unique challenges faced in LMICs. A well-developed public transportation infrastructure can reduce the need for private car ownership, aligning with the broader sustainability goals.

\textit{Road Safety Initiatives}

Road safety initiatives constitute another evidence-based strategy for reducing traffic-related injuries. These initiatives encompass a range of approaches, from enforcing speed limits to punishing drunk driving\textsuperscript{81}. Sweden's successful implementation of Vision Zero, an internationally recognized
strategic framework for enhancing road safety, serves as an exemplary model. Between 1990 and 2015, Sweden achieved a 66% reduction in road traffic deaths\textsuperscript{48,82}. This success can be attributed to a combination of measures, including lowering speed limits, promoting sober driving, increasing seat-belt and helmet usage, and adopting higher car safety ratings. Because of the marked success in Sweden, Vision Zero has expanded to several other countries such as the Netherlands, the United Kingdom, India, and the United States\textsuperscript{83,84,85}.

In Brazil, the enforcement of the 1998 Brazilian Traffic Code classified offenses such as not using safety helmets, driving without a license, or being under the influence of alcohol as serious\textsuperscript{86}. This was achieved through increased fines and the removal of driver licenses, resulting in a reduction in road traffic injuries. Furthermore, a study demonstrated that the traffic code led to a 24.7% decrease in immediate road traffic fatalities and a 21.3% reduction in crash incidence. In Uganda, the implementation of traffic enforcement measures by law officers, including speed cameras, checks on dangerous driving, overloaded vehicles, and driver license possession, led to a significant 17% reduction in mortality related to road traffic accidents\textsuperscript{87}. The use of these road safety programs has demonstrated the potential to significantly decrease the incidence of traffic accidents and resulting orthopedic injuries.

\textit{Fuel Levy}

Pedestrian-friendly infrastructure, public transportation, and road safety initiatives are evidence-based strategies that address the downstream effects of climate change-induced urbanization on traumatic musculoskeletal injuries. To alleviate the socioeconomic and environmental impact of climate change on rural communities and provide support for victims of road traffic injuries, a solution that has demonstrated success in achieving both goals is a fuel levy. A fuel levy is a surcharge imposed on the sale of petrol that's paid by citizens and businesses that purchase fuel in a country. A government can use a fuel levy to generate revenue for a country and contribute to supporting infrastructure development, environmental initiatives, and funds to aid road traffic victims.
This approach has been successfully implemented in various African countries, including South Africa, Botswana, Namibia, and Swaziland. In South Africa, a general fuel levy and a road accident fund levy are applied to gasoline, diesel, and kerosene. However, there is an exception for sectors in agriculture, manufacturing, fishing, and mining, in which companies in these sectors qualify for a refund for the general fuel levy. The road accident fund levy serves to support victims of road traffic injuries. Additionally, it allocates funds to enhance traffic law enforcement, promote pedestrian safety education, and improve overall road infrastructure. In 2020, there were 41.2 billion South African Rands—equivalent to $2.18 billion USD—generated in revenue from the road accident fund levy, and 80 billion South African Rands—equivalent to $4.2 billion USD—generated from the general fuel levy. This accounts for about 6% of the total revenue for the South African Government.

In Namibia, a fuel levy is imposed on on-road users purchasing petrol or diesel, contributing to the Motor Vehicle Accident Fund and the National Energy Fund. Similar to South Africa, there is an exception for sectors in agriculture, construction, fishing, mining, and railroad transport, where companies in these sectors qualify for a refund. The Motor Vehicle Accident Fund supports people with road traffic injuries by compensating medical costs, physical rehabilitation, assistive devices (e.g., wheelchairs), and caregiver allowances for people with severe injuries. The fuel levy also serves as the primary source of income for the Road Fund Administration, which provides financial support for building and maintaining road infrastructure in Namibia. The National Energy Fund is used to finance renewable energy projects, subsidize electricity for low-income communities, improve the quality of energy supply and services, and support energy research and development. The renewable energy projects focus on solar and wind energy—solar water heaters, solar home systems, and wind power plants.

Although fuel levies can positively influence the economic growth of a country, they may have a disproportionate impact on low-income individuals and marginalized communities. Since the tax burden is placed on citizens in the country, it can further exacerbate existing economic inequalities.
because people will have to allocate additional financial resources to transportation costs\textsuperscript{102,103}. Furthermore, fuel levies may contribute to inflation because they increase the prices of food, goods, and services due to higher transportation costs for manufacturers and retailers\textsuperscript{104}. It may lead to an impact on employment as businesses, reliant on transportation or fuel-intensive operations, may have to cut employees and reduce work expansion to compensate for operational costs\textsuperscript{101}. Although countries like South Africa and Namibia have an exception for sectors in agriculture, manufacturing, fishing, and mining, in which companies in these sectors qualify for a refund, it is not adequate to address the inflation affecting goods and services\textsuperscript{105,106}. While a fuel levy is a promising solution for revenue generation to fund infrastructure development, sustainability initiatives, and support for victims of road traffic injuries, it is crucial to carefully consider its potential adverse effects on economic inequalities, inflation, and employment.

**Policy Goal**

The goal of this analysis is to identify a feasible, cost-effective solution to address the implications of climate change-induced urbanization on traumatic musculoskeletal injuries in LMICs like Ethiopia. The urgency of this goal stems from the increasing vulnerability of urban populations to musculoskeletal injuries resulting from the complex interplay between environmental changes, migration patterns, and urban infrastructure. The existing evidence-based strategies were taken into consideration during the process of selecting policy options to propose for Ethiopia. The next section will delve into a range of legislative strategies, including enhancing seat belt safety regulations, investing in the development of pedestrian infrastructure, and implementing a fossil fuel export tax.
Policy Options

Status Quo

The current state of road safety and transportation infrastructure in Ethiopia reflects the status quo\textsuperscript{48}. With a Ministry of Transport funded by the national budget, there are currently no mandatory audits for assessing new road infrastructure. With pedestrian fatalities accounting for 37\% of road traffic injuries in the country, there is also a clear deficiency in safety measures for pedestrians and cyclists\textsuperscript{67}.

The efficacy of national regulations on speed limits, drinking and driving, and seat belt laws is hindered by minimal local enforcement, exacerbating road safety challenges\textsuperscript{67}. Several factors, such as local authorities prioritizing other law enforcement activities, a shortage of staff, and limited effective technology, contribute to the challenges in monitoring and enforcing road safety\textsuperscript{67}. Despite these challenges, the implementation of these policies has shown positive outcomes. In the inaugural year of implementation in Addis Ababa, when enforcement was more stringent, motor vehicle accidents decreased by 19\%, and fatalities reduced by 12\%\textsuperscript{107}. Ethiopia's National Road Safety Strategy (2021-2030) sets an ambitious goal to reduce traffic fatalities by 50\% by 2030\textsuperscript{108}.

Ethiopia has recently developed new policies and investments in public transport. In 2020, the government unveiled a 10-year plan to invest approximately $58 billion in transportation infrastructure development. This comprehensive plan encompasses the expansion and enhancement of railways, cross-country transportation services, expressways, buses, and cable car systems\textsuperscript{109}. Additionally, an extra $2 billion has been allocated to the National Logistics Development strategy, focusing on expanding road coverage, improving road quality, increasing train network coverage, and constructing long-distance bus stations. These proposals rely on financial investments from both domestic and international entities. The enforcement of laws can also generate revenue through fines, which can be allocated to road infrastructure or health system development. While the current state of infrastructure and its enforcement of laws pose challenges, the government's significant investments in transportation development signal a promising path forward for the country's infrastructure improvement.
Seat Belt Enforcement

Seat belts are designed to minimize driver and passenger accelerations, distribute forces effectively across the body's strongest areas, and prevent the ejection of individuals from the vehicle\textsuperscript{110}. Recognized globally as the singular standard for vehicle seat belts, UN Regulation No. 16 establishes essential criteria and enforces rigorous testing to ensure the safety of all occupants\textsuperscript{111}. The enforcement of seat belts has the potential to be a vital step towards improving road safety globally.

Numerous studies have consistently demonstrated that the use of seat belts reduces the risk of injuries and death in motor vehicle accidents\textsuperscript{110,112,113,114}. According to research conducted by the National Highway Traffic Safety Administration (NHTSA), seatbelts saved an estimated 14,955 lives in the United States in 2017\textsuperscript{115}. Nonetheless, comparing measures between HICs and LMICs presents its challenges. In Nigeria, a lower middle-income country, research demonstrated that the mortality rate of individuals who did not use their seatbelts was 79\%, while those who did use seatbelts had a significantly lower rate of 14\%\textsuperscript{113,116}. Seatbelts significantly reduced the severity of injuries.

Ethiopia could adopt a multifaceted approach, encompassing public awareness campaigns and law enforcement efforts. Public awareness campaigns could educate the population on the importance of seatbelt use, targeting both urban and rural areas. Utilizing a variety of platforms such as television, radio, social media, and community outreach programs can aid in disseminating information about the significance of seatbelt usage. Law enforcement efforts should involve training officers on the importance of enforcement and how to effectively conduct visible checks to ensure compliance with seatbelt laws. Ensuring sufficient funding will be vital to support law enforcement initiatives, improving seat belt compliance and overall road safety.

Development of Pedestrian-Friendly Infrastructure

In low-income countries, 45-75\% of road traffic fatalities are pedestrians\textsuperscript{117}. In the capital of Ethiopia, Addis Ababa, 79.8\% of road traffic fatalities were pedestrians during 2018-2020\textsuperscript{118}. Several
studies have investigated the impact of various pedestrian infrastructure developments on the reduction of road traffic injuries and fatalities, demonstrating the effectiveness of enhanced pedestrian infrastructure, such as well-maintained sidewalks, pedestrian crossings, dedicated walkways, pavement markings, and traffic signs.\(^{74,119,120}\)

Sidewalks and walkways provide pedestrians with safe and designated paths, promoting mobility and minimizing the risk of accidents, which enhances overall safety\(^{121}\). These paths should be designed with proper signage, crosswalks, and ramps to ensure ease of use for everyone, including those with disabilities. Pavement markings play a role in enhancing road safety by providing visual cues to guide drivers and delineate traffic lanes, contributing to smoother and more organized traffic flow\(^{122}\). Traffic signs are communication tools on roadways, conveying important information and regulatory instructions to drivers, pedestrians, and other road users\(^{123}\). Ethiopia has the potential to enhance road safety by increasing the development of areas designated for walking, cycling, and other non-motorized modes of transportation.

*Implementation of Fuel Export Tax*

A fuel export tax functions much like a fuel levy, but there's a key difference in its application. A fuel export tax is imposed by a country for the exportation of fossil fuels—coal, petroleum, and natural gas products. In contrast to a fuel levy, which places the responsibility on citizens and businesses buying fuel within the country, a fossil fuel export tax shifts the burden to corporations exporting fuels outside the country. Ethiopia currently lacks a fossil fuel export tax\(^{124}\). A fossil fuel export tax for the context of Ethiopia could be a tax on petroleum and natural gas products exported out of the country. The revenue generated from the fuel tax can contribute to prevention and management of traumatic musculoskeletal injuries.

In 2019, the governments of Ethiopia and Djibouti signed an agreement to construct a 767-km natural gas pipeline, projected to generate a minimum annual revenue of $1 billion from natural gas and
The infrastructure development is currently progressing in the Ogaden Basin, located in southeast Ethiopia. Notably, the Kalub and Hilala fields in this area reportedly possess substantial reserves, estimated at 6-8 trillion cubic meters of natural gas and oil. The project's anticipated outcome involves significant annual revenue, projected to be at least $1 billion, through the extraction and export of these valuable resources. Commercial production of natural gas is expected to begin in 2027, highlighting the timeliness of this policy option.

The funds generated by a fuel export tax would provide additional revenue for the Ethiopian government. It could be directed towards projects like renewable energy initiatives and reforestation programs, especially for rural areas to help offset the impact of carbon emissions generated in the country. In 2021, oil emissions in Ethiopia alone reached 12.61 million tonnes of carbon dioxide, compared to the United States, which reached 5 billion tonnes of carbon dioxide. Addressing the socio-economic impact of climate change through sustainable efforts is crucial, as improving living conditions in rural areas could potentially mitigate musculoskeletal injuries resulting from forced urban migration due to economically barren rural regions.

Revenue generated from a fuel export tax holds the potential to establish an Ethiopian Road Accident Fund, similar to those in Namibia and South Africa. This fund aims to support individuals affected by road traffic injuries by addressing various medical needs for victims and their families. A portion of the Road Accident Fund can be allocated to enhance overall road safety, thereby preventing road traffic injuries and fatalities. This includes continuous improvements to road infrastructure, implementing driver training programs, conducting educational advertisements on driver safety, and enforcing traffic regulations. The Road Accident Fund not only eases the financial burden resulting from musculoskeletal injuries for victims and their families through comprehensive health services but also contributes to ongoing road safety initiatives, working to prevent road traffic injuries and fatalities.

The fuel export tax can catalyze the development of a Trauma Care Capacity Building Fund to better equip healthcare systems for providing trauma care, especially for musculoskeletal injuries. It can...
contribute to the expansion of healthcare infrastructure in the country, particularly by scaling up hospitals to create more trauma centers in different regions in Ethiopia. As of 2022, there were 367 hospitals available in Ethiopia, yet only three tertiary-level hospitals were designated as trauma centers, all located in the capital—Addis Ababa\textsuperscript{67,131}. There could be an investment in specialized training programs for individuals to grow the workforce of health professionals, such as surgeons, nurses, pharmacists, physiotherapists, and laboratory technologists. In 2020, there were 0.1059 physicians per 1000 people, and an even smaller number of orthopedic surgeons\textsuperscript{132}. Workforce disparities lead to a strain on the healthcare system, resulting in longer wait times for patients and longer distances traveled to access high levels of care\textsuperscript{133}. The Trauma Care Capacity Building Fund could improve accessibility to resources for providing surgical care for the management of musculoskeletal injuries. Providers in Ethiopia face challenges with resource scarcity, impacting diagnostic and treatment capabilities due to a lack of equipment, laboratory tests, medications, hospital beds, operating rooms, and resulting in the rationing of resources\textsuperscript{134,135}. Implementing a fuel export tax will generate revenue that can contribute to the prevention and treatment of road traffic-induced musculoskeletal injuries through supporting sustainability initiatives, a Road Accident Fund, and the Trauma Care Capacity Building Fund.

Assessment Criteria

<table>
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<tr>
<th>Option</th>
<th>Costs to the Government</th>
<th>Effectiveness in Prevention of Musculoskeletal Injuries</th>
<th>Addresses Climate Change</th>
<th>Feasibility for Implementation</th>
<th>Financial Equity</th>
<th>Total</th>
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<td>x2</td>
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<td>4</td>
<td>2</td>
<td>4</td>
<td>34</td>
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</table>
In evaluation of policy options, each proposed policy is systematically assessed using a set of criteria, with rankings on a scale of 1 (lowest score) to 4 (best score) for each of the five key components: costs, effectiveness in prevention of musculoskeletal injuries, addressing climate change, feasibility for implementation, and equity. Costs to the government carries a weight of 1x, focusing on the financial implications and budgetary considerations associated with each policy option. Effectiveness in prevention of musculoskeletal injuries is weighted at 2x, assessing each policy's capacity to reduce such injuries resulting from climate change-induced urbanization. The criterion for addressing climate change is assigned a weight of 2x, considering options that actively contribute to improving climate change conditions and promoting sustainability, particularly in rural areas. The criterion with the highest weight, 3x, is the feasibility for implementation, examining the practicality and ease of putting the policy into practice while accounting for factors such as skilled workers, infrastructure, and resource availability. Financial equity is also weighted at 3x, considering the suitability of the policy options that do not exacerbate economic hardships or further disadvantage impoverished populations. By employing this assessment framework, the proposed policy options will be evaluated holistically. This ensures that the selected policy not only addresses the issue effectively but is also cost-efficient, feasible to implement, supported by stakeholders, and tailored to the specific needs of Ethiopia.

Costs to the Government

The fossil fuel export tax has the potential to generate millions of dollars in government revenue through taxes on the exports of natural gas and oil from the Ogaden Basin. This option was ranked as the most cost-effective (4) for the government, as it can contribute revenue rather than incur expenses.\textsuperscript{127,128} The associated costs for this policy may include personnel, administrative infrastructure, and information systems to monitor sales from the exportation of natural gas and oil. Seat belt enforcement is the second-best option (3) in this category, leveraging existing resources such as law enforcement officers and media platforms through quality improvement measures. The costs associated with implementing this policy
may involve expenses for law enforcement training programs and workshops, along with compensation for officer participation. The costs of hiring new officers should also be considered. Although existing media platforms could be leveraged, there would be costs associated with promoting educational materials through various media channels, including social media, community outreach programs, radio stations, and television. The development of pedestrian-friendly infrastructure was ranked as the second lowest (2) due to costs related to designing, constructing, and maintaining sidewalks, crossings, street signs, and similar measures. In Bogotá, Colombia, over $2 billion was invested over 10 years to build pedestrian-friendly infrastructure. A comparable or higher amount would be needed to develop such infrastructure in Ethiopia. The status quo was ranked as the least favorable option (1) because Ethiopia's 10-year plan to expand transportation infrastructure and road safety is estimated to cost over $60 billion. This amount is substantial, relying on investments from domestic and international entities. Furthermore, the greatest amount of government funds would be needed to implement all the proposed development plans for the status quo compared to the other policy options.

**Effectiveness in Prevention of Musculoskeletal Injuries**

Pedestrian-friendly infrastructure was the highest-ranked option (4) because the creation of safer pathways and walkways with proper signage and crosswalks directly mitigates the risks faced by pedestrians. This approach reduces pedestrian fatalities and injuries, constituting a significant portion of road traffic injuries, especially in urban centers such as Addis Ababa. There is also enhanced road safety for drivers with pavement markings and traffic lanes. The seat belt enforcement policy is globally recognized for its impact on reducing injuries and fatalities in motor vehicle accidents. However, seat belts may increase the risk of injury to the spine, especially in the thoracic to coccyx region; therefore, it is the second-best option (3). A study found that spine injuries, particularly vertebral fractures, occurred in 35.5% of seat belt users compared to 17.9% of non-seat belt users, yet the severity of the injuries was reduced in seat belt users. The fuel export tax is ranked as the second-lowest option (2) because its potential to foster stability in rural areas could gradually reduce forced urban
migration, thereby preventing musculoskeletal injuries\textsuperscript{67}. The revenue generated by the export tax would support a road accident fund, providing financial assistance to victims of road accidents. Furthermore, the trauma care capacity-building fund would enhance musculoskeletal care capacity, ultimately reducing the overall burden of injuries. Although measures are in place that have led to some reductions in road traffic injuries and fatalities, Ethiopia currently faces challenges with the enforcement of road safety laws and significant safety measures for pedestrians and cyclists, which may contribute to challenges in the effectiveness of preventing musculoskeletal injuries. This places the status quo as the lowest option (1).

\textit{Addresses Climate Change}

In evaluating policy options based on their implications for addressing climate change, it is evident that the fuel export tax is ranked highest (4) compared to the other options. The funds generated by the fuel export tax could lead to substantial efforts to promote sustainability, particularly in rural areas. These efforts could include supporting the maintenance and expansion of the Grand Ethiopian Renaissance Dam, transitioning to the use of solar lanterns, increasing tree-planting initiatives, and enhancing water sources\textsuperscript{138,139,140}. The development of pedestrian infrastructure can potentially contribute to mitigating the impact of climate change, so it was ranked as the second-best option (3) in this category. As the population of urban areas, including the capital of Addis Ababa, increases, there is an escalating reliance on motorized transportation, resulting in carbon emissions that exceed global air quality guidelines\textsuperscript{130,141}. In Addis Ababa, emissions are 2-4 times higher than the WHO-recommended limit of 5 µg/m\textsuperscript{3}, and vehicle emissions were the greatest contributor to poor air quality\textsuperscript{141}. Well-maintained sidewalks, walkways, and bicycle lanes can encourage non-motorized modes of transportation, reducing the reliance on carbon-intensive vehicles, subsequently curbing emissions, and fostering a more sustainable urban environment. The status quo in Ethiopia, in the context of climate change, revolves around the expansion of public transportation, which can reduce the environmental impact of individual vehicle emissions by increasing the availability of shared modes of transport\textsuperscript{109}. Nevertheless, it is ranked as the second-lowest option (2) due to the 10-year timeline for the expansion of public transportation.
infrastructure, so it will take a while to see the impact of this effort on climate change. While the seat belt enforcement policy is crucial for road safety, it does not directly address climate change, so it was ranked the lowest (1).

**Feasibility for Implementation**

The status quo is the highest ranked (4) because it represents the current state of road safety and infrastructure, along with the plans that the government is currently implementing. The seat belt enforcement policy would be the second highest option (3) because it could leverage existing resources such as law enforcement officers and media platforms. Given the fact that there are existing seatbelt safety laws in place and there have been countless studies to demonstrate the benefits of seatbelt safety, it would be a policy option that would gain the support of stakeholders, such as the members of the Ethiopian Parliament, Ministry of Transport and Logistics, and Ministry of Health, public health researchers, and physicians. The infrastructure is already in place for enforcing seat belt safety, yet law enforcement officers could undergo additional training to be more effective. The fuel export tax is the second lowest-ranked option (2). Although the natural gas and crude oil plan is in place, the Ethiopia-Djibouti operations are expected to begin in 2024. The benefits of revenue generated by the exportation of crude oil and natural gas would only be realized after the development of the natural gas pipeline. This option is likely to gain support from the Ministry of Mines and Petroleum, the Ethiopian Parliament, and the Ministry of Transport and Logistics due to its potential to generate revenue for the government. The Ministry of Water and Energy would also support the fuel export tax because the funds generated would contribute to sustainability efforts. Implementing the fuel export tax would require skilled personnel and adequate technological resources, and it may be overseen by the Ministry of Transport and Logistics. The government might need to carefully navigate international dynamics and potentially adjust the tax rate to maintain competitiveness and prevent a loss of business. The development of pedestrian infrastructure would be the least favorable option (1) due to several factors. It would require adequate financial resources, skilled workforce, materials, and equipment to execute infrastructural overhauls, from
constructing well-maintained sidewalks to installing dedicated walkways, pavement markings, and traffic signs. Additionally, ongoing maintenance requirements for sustained infrastructure quality add another layer of complexity. Considering the extensive nature of these changes, it's important to note that this policy option would take a long time to yield results, potentially impacting public support.

Financial Equity

The fuel export tax emerges as the most favorable option (4) due to the potential sustainability initiatives it can fund. These initiatives aim to assist communities affected by climate change, particularly those in rural areas. Additionally, a minimum of 10% of the revenue generated from the resources will be specifically allocated to the area where the resource was obtained, providing essential support to the local community. The development of pedestrian-friendly infrastructure follows as the second-highest-ranked policy (3) due to its acknowledgment and targeted approach to reducing the disproportionately high pedestrian fatalities and injuries. This policy significantly benefits economically disadvantaged groups by enhancing safety for those without access to vehicles. On the other hand, maintaining the status quo ranks as the second-lowest option (2) in terms of equity, given the current deficiencies in road safety and transportation infrastructure that disproportionately affect communities. Although the proposed $60 billion transportation infrastructure plan is noteworthy, it prompts discussions on resource allocation, diverting attention from pressing societal needs like healthcare, education, and sustainability initiatives.

Seat belt enforcement ranks as the least favorable policy (1) due to concerns about fines for non-compliance. Fines for seat belt violations fall on drivers or passengers not wearing seat belts. This can have a disproportionate impact on individuals with lower incomes, potentially worsening their existing economic hardships.

Final Recommendation

The implementation of a fuel export tax stands out as the most robust, cost-effective, and equitable policy option for Ethiopia. While measures such as maintaining the status quo, enforcing seat
belt regulations, and enhancing pedestrian infrastructure address the downstream effects of climate change-induced urbanization on traumatic musculoskeletal injuries, the fuel export tax uniquely tackles the upstream impact of climate change. The revenue generated through this tax can be strategically channeled into various rural sustainability initiatives, development of a Road Accident Fund, and support Ethiopia’s health care infrastructure through a Trauma Care Capacity Building Fund. Additionally, a proposed multi-year budget and budget justification for the implementation of the fuel export tax are detailed in the appendix (see Appendix A and B).

In Ethiopia, sustainability initiatives would include– the maintenance and expansion of hydropower plants, the transition to solar lanterns for energy, extensive tree-planting programs, and improvements in water sources. In Ethiopia, hydropower stands as the primary source of renewable energy, followed by wind and thermal sources, respectively. The Grand Ethiopian Renaissance Dam (GERD), situated on the Nile River, is the largest hydropower plant in Africa. Utilizing the proposed export tax as a funding source could play a crucial role in supporting and sustaining the GERD. Despite a national effort since 2016 to transition to off-grid renewable energy sources, particularly through solar lanterns, challenges persist due to a reliance on international aid. Thus far, 25,844 solar panels have been installed for rural farmers in Ethiopia. Establishing a fuel export tax could provide funding to facilitate the transition to sustainable energy, especially for rural communities. Regarding reforestation, Ethiopia initiated the National Green Development Program in 2019 to combat environmental degradation. The government aims to reforest 7.4 million acres of land by 2030. Implementing a fuel export tax could offer crucial funding to support tree-planting initiatives and enhance water sources, especially in rural areas impacted by deforestation.

Investments on sustainable practices contribute to enhanced land quality, improved water source availability, and the use of alternative energy sources in rural areas. As rural communities adopt sustainable practices, they become less susceptible to environmental degradation and resource depletion. This approach also has the potential to reduce forced displacement and migration resulting from climate change.
change-related challenges. As a ripple effect, the goal is to decrease forced displacement and migration, thereby reducing the influx of rural migrants into urban areas. Consequently, fewer individuals are exposed to the risks of climate change-induced urbanization, specifically traumatic musculoskeletal injuries from road traffic incidents.

The fuel export tax can be a source to establish a Road Accident Fund, specifically designed to support individuals with injuries resulting from road traffic accidents. The financial assistance could cover medical expenses such as hospitalization, surgery, medications, diagnostic exams, radiographic imaging, and follow-up medical appointments. Furthermore, the fund could extend support to cover the costs of psychological counseling, rehabilitation services, assistive devices, and compensation for road accident victims and their families. Ethiopia's healthcare system relies predominantly on international donations and loans, constituting 46.8%, followed by out-of-pocket expenses at 35.8%, the Ethiopian government at 16.5%, and other sources at 0.9%. By designating a portion of funds from the fuel export tax into a Road Accident Fund, the country can significantly alleviate the financial burdens of out-of-pocket expenses for individuals and serve as a safety net.

By allocating a portion of the Road Accident Fund towards road safety initiatives, it is possible to reduce the frequency and severity of accidents. This contribution can enhance road infrastructure to meet growing traffic demands, directing resources towards necessary expansions and improvements. Additionally, there can be financial support for increased enforcement of traffic regulations, ensuring greater compliance and adherence to safety measures. Financial investments can also be designated for a multimedia approach to awareness campaigns, educating the public about the dangers of speeding, emphasizing the importance of seatbelt usage, discouraging driving under the influence of drugs and alcohol, and raising awareness about the risks of texting and driving. The integration of these initiatives into the Road Accident Fund will ultimately result in enhanced road safety, leading to a significant reduction in both the frequency and severity of road accidents.

A Trauma Care Capacity Building Fund would be another strategic initiative, funded through the fuel levy, aimed at improving Ethiopia’s health care infrastructure, particularly for the treatment of
musculoskeletal injuries. Notably, all existing trauma centers are concentrated in Addis Ababa, the capital, highlighting the pressing need for geographical expansion and equitable distribution across different regions. The establishment of trauma centers in various regions stands as a critical goal, necessitating an expansion in operating rooms, inpatient hospital beds, and the recruitment of highly skilled healthcare personnel. A component of this fund allocation involves comprehensive training programs for healthcare professionals, including surgeons, nurses, and pharmacists, aimed at enhancing proficiency in providing trauma care. These programs could encompass emergency response protocols, trauma evaluation and management, and wound management for all healthcare professionals involved. Furthermore, it is imperative to provide financial support for orthopedic surgical training to increase the number of surgeons available to treat musculoskeletal injuries in Ethiopia. Lastly, the Trauma Care Capacity Building Fund can contribute to the availability of resources for providing surgical care for the management of musculoskeletal injuries, such as diagnostic imaging technology, antibiotics, surgical equipment, implants, negative pressure wound therapy. By utilizing fuel export tax revenue for rural sustainability, a Road Accident Fund, and a Trauma Care Capacity Building Fund, Ethiopia can address both upstream and downstream implications of climate change-induced urbanization on traumatic musculoskeletal injuries.

Key Stakeholders

In conducting a comprehensive policy analysis aimed at addressing the multifaceted issue of climate change-induced urbanization and its impact on traumatic musculoskeletal injuries in Ethiopia, it is imperative to consider various key stakeholders. The Ethiopian Ministry of Health plays a central role in policy development and implementation, overseeing healthcare provision, injury prevention, and trauma management. Dr. Lia Tadesse currently serves as the Minister of Health for Ethiopia. Additionally, the Ministry of Transport and Logistics, with its focus on urban development, infrastructure, and transportation policies, wields significant influence over road safety and urban planning. Dagmawit
Moges Bekele currently serves as the Minister of Transport, and she is also the chair of the Ethiopian Roads Authority\textsuperscript{152}. The Ministry of Mines and Petroleum is responsible for the mining, geothermal, and petroleum sectors in the country, with Habtamu Tegene currently serving as the Minister\textsuperscript{125,153}. Habtamu Tegene would provide valuable insight into the development plans of the natural gas pipeline and the current state of petroleum and natural gas exportation. The Ministry of Water and Energy in Ethiopia plays a role in advancing and sustaining the country's water resources and energy infrastructure. The current Minister, Dr. Habtamu Itefa Geleta, would help inform, facilitate, and implement sustainability efforts using the revenue generated from the fuel export tax\textsuperscript{145}.

Professionals from institutions such as Addis Ababa University, the Ethiopian Public Health Institute, and Tikur Anbessa Specialized Hospital offer a distinctive perspective that yields valuable insights. These experts, including orthopedic surgeons, data scientists, trauma care specialists, and public health researchers, are well-equipped to provide invaluable data on road traffic injury prevalence and root causes. They can also offer comprehensive views on patient outcomes and contribute their specialized expertise. It is imperative to incorporate the perspectives of local community leaders, urban planners, and community members directly impacted by climate change-induced migration. Additionally, when considering potential stakeholders who may oppose the fuel levy tax, it is anticipated that resistance may arise from representatives of fossil fuel corporations. They may express concerns about the potential impact on their industry and market competitiveness. This collective representation of stakeholders will yield invaluable insights for shaping policies that align with the needs of the population.

**Policy-Making in Ethiopia**

According to the Ethiopian constitution, the country operates under a federal parliamentary system\textsuperscript{154}. This system involves a multi-step process for policy-making. The Ethiopian Parliament comprises two chambers: the House of Peoples' Representatives and the House of Federation. Proposals for policies can originate from government officials, legislators, or the public. These proposals are
introduced in the House of Peoples' Representatives, where policies and laws are enacted. In this chamber, policies undergo scrutiny and debates that can lead to amendments or rejection. Upon approval, the policy is signed by the president. After this stage, the council of ministers, equivalent to leaders of government agencies, ensures the implementation of these laws and decisions made by the House of Peoples' Representatives. The Prime Minister oversees the implementation of policies, regulations, and directives, and holds the council of ministers accountable. To secure approval and implementation, the proposed policy for a fuel export tax needs to undergo the outlined procedural steps.

Conclusion

In summary, the paper explores the intricate relationship between climate change-induced urbanization and traumatic musculoskeletal injuries, particularly in Ethiopia. Several policy options were evaluated to assess their effectiveness in addressing the implications of climate change-induced migration on road traffic injuries. These policy options include maintaining the status quo, enforcing seat belt usage, developing pedestrian-friendly infrastructure, and implementing a fuel export tax. Through comprehensive policy analysis, the fossil fuel export tax is the most compelling and robust choice. By generating revenue from natural gas and oil exports, this levy has the potential to finance sustainability initiatives, enhance rural living conditions, and establish a Road Accident Fund. This approach addresses the upstream influences of climate change and the downstream challenges associated with traumatic musculoskeletal injuries, presenting a holistic and impactful strategy for Ethiopia.
### Appendix A: Ethiopia Fuel Export Tax Multi-Year Budget

<table>
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<th>Revenue</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>YEAR 4</th>
<th>YEAR 5</th>
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<td><strong>1,299,600,000.00</strong></td>
<td><strong>1,481,544,000.00</strong></td>
<td><strong>1,688,960,160.00</strong></td>
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<tr>
<td>Fuel Export Tax</td>
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<td>259,920,000.00</td>
<td>296,308,800.00</td>
<td>337,792,032.00</td>
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<td><strong>Fuel Export Tax Revenue</strong></td>
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<td><strong>Total Personnel Costs in ETB</strong></td>
<td>203,040.00</td>
<td>207,982.80</td>
<td>212,147.22</td>
<td>216,434.56</td>
<td>220,722.47</td>
<td>936,712.64</td>
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<tr>
<td><strong>Total Personnel Costs in USD</strong></td>
<td><strong>36,634.32</strong></td>
<td><strong>37,367.01</strong></td>
<td><strong>38,114.35</strong></td>
<td><strong>38,876.64</strong></td>
<td><strong>39,654.17</strong></td>
<td><strong>168,294.05</strong></td>
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<tr>
<td>Operating Expenses</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rent</td>
<td>60,000.00</td>
<td>76,800.00</td>
<td>82,360.00</td>
<td>87,820.12</td>
<td>93,280.24</td>
<td>379,400.64</td>
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<td>Utilities</td>
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<td>19,200.00</td>
<td>24,576.00</td>
<td>31,457.28</td>
<td>40,265.32</td>
<td>150,300.08</td>
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<td>1,000.00</td>
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<td>30,000.00</td>
<td>30,000.00</td>
<td>30,000.00</td>
<td>30,000.00</td>
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<td>2,000,000.00</td>
<td>2,000,000.00</td>
<td>2,000,000.00</td>
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<tr>
<td><strong>Total Operating Costs</strong></td>
<td><strong>2,215,000.00</strong></td>
<td><strong>2,236,000.00</strong></td>
<td><strong>2,262,880.00</strong></td>
<td><strong>2,297,286.40</strong></td>
<td><strong>2,341,326.59</strong></td>
<td><strong>11,312,492.99</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability Initiatives</td>
<td>30,000.00</td>
<td>34,200.00</td>
<td>38,988.00</td>
<td>44,446.32</td>
<td>50,668.84</td>
<td>198,303.12</td>
</tr>
<tr>
<td>Road Accident Fund</td>
<td>30,000.00</td>
<td>34,200.00</td>
<td>38,988.00</td>
<td>44,446.32</td>
<td>50,668.84</td>
<td>198,303.12</td>
</tr>
<tr>
<td>Trauma Care Capacity Building Fund</td>
<td>30,000.00</td>
<td>34,200.00</td>
<td>38,988.00</td>
<td>44,446.32</td>
<td>50,668.84</td>
<td>198,303.12</td>
</tr>
<tr>
<td><strong>Total Reallocation Costs</strong></td>
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<td><strong>106,836,000.00</strong></td>
<td><strong>121,226,800.00</strong></td>
<td><strong>137,636,246.00</strong></td>
<td><strong>156,347,740.99</strong></td>
<td><strong>616,221,867.39</strong></td>
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<td>Overall Expenses</td>
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<td>Personnel Costs</td>
<td>36,634.32</td>
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<td>Operating Costs</td>
<td>2,215,000.00</td>
<td>2,236,000.00</td>
<td>2,262,880.00</td>
<td>2,297,286.40</td>
<td>2,341,326.59</td>
<td>11,312,492.99</td>
</tr>
<tr>
<td>Reallocation Costs</td>
<td>90,000,000.00</td>
<td>106,836,000.00</td>
<td>121,226,800.00</td>
<td>137,636,246.00</td>
<td>156,347,740.99</td>
<td>612,046,867.39</td>
</tr>
<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>92,251,634.32</strong></td>
<td><strong>109,109,634.39</strong></td>
<td><strong>125,225,878.55</strong></td>
<td><strong>145,922,105.46</strong></td>
<td><strong>158,224,217.25</strong></td>
<td><strong>623,590,208.87</strong></td>
</tr>
<tr>
<td>Surplus (Deficit)</td>
<td><strong>10,754,365.68</strong></td>
<td><strong>11,890,636.31</strong></td>
<td><strong>15,804,021.25</strong></td>
<td><strong>16,477,698.74</strong></td>
<td><strong>18,145,482.75</strong></td>
<td><strong>658,830,399.23</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Salaries are provided in Ethiopian Birr
2. 1.00 Ethiopian Birr is equivalent to 0.017966554 USD
Appendix B: Budget Justification

<table>
<thead>
<tr>
<th>Revenue/Expenditure</th>
<th>Methodology</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Export Tax</td>
<td>Extrapolation: constant percentage at 20% per year</td>
<td>A fuel export tax is proposed as a tax on the exportation of crude oil and natural gas. The prediction of a 20% share of the revenue generated from annual resource extraction is considered a rough estimate.</td>
</tr>
<tr>
<td>Chief Executive Officer</td>
<td>Simple time series: constant percentage at 2% increase per year</td>
<td>The chief executive officer would play a role in providing strategic direction and overseeing the successful implementation of the fuel export tax. The range for the annual gross salary for a chief executive officer is 68,664 to 532,884 ETB. The average annual salary increase in Ethiopia is 2%.</td>
</tr>
<tr>
<td>Managing Director</td>
<td>Simple time series: constant percentage at 2% increase per year</td>
<td>The managing director would be responsible for managing the day-to-day operations. The range for the annual gross salary for a managing director is 37,440 to 395,532 ETB. The average annual salary increase in Ethiopia is 2%.</td>
</tr>
<tr>
<td>Financial Analyst</td>
<td>Simple time series: constant percentage at 2% increase per year</td>
<td>A financial analyst would be responsible for fiscal management, overseeing revenue collection, budget planning, and financial reporting for the fuel export tax. The range for the annual gross salary for a financial analyst is 67,380 to 188,328 ETB. The average annual salary increase in Ethiopia is 2%.</td>
</tr>
<tr>
<td>Legal Advisor</td>
<td>Simple time series: constant percentage at 2% increase per year</td>
<td>A legal advisor would help ensure the fuel export tax's compliance with Ethiopian laws and regulations and advise on legal aspects of fund allocations and disbursement. The range for the annual gross salary for a legal advisor is 61,896 to 183,348 ETB. The average annual salary increase in Ethiopia is 2%.</td>
</tr>
<tr>
<td>Statistician</td>
<td>Simple time series: constant percentage at 2% increase per year</td>
<td>A communication specialist would help with engaging stakeholders, managing a website for the fuel export tax, and handling media relations to ensure transparency and public understanding of the fuel export tax's objectives and impacts. The range for the annual gross salary for a public relations specialist is 48,728 to 171,168 ETB. The average annual salary increase in Ethiopia is 2%.</td>
</tr>
<tr>
<td>Payroll Taxes</td>
<td>Extrapolation: constant percentage at 18% per year</td>
<td>The current payroll tax percentage in Ethiopia is 18%. The employer contributes 11%, and the employee contributes 7%.</td>
</tr>
<tr>
<td>Rent</td>
<td>Simple time series: constant percentage at 28% increase per year</td>
<td>The rent would be designated to the fees for an office complex for workers. The average inflation rate for housing has been highly variable between 7-35% over the past several years. The average inflation rate is currently 28%.</td>
</tr>
<tr>
<td>Utilities</td>
<td>Simple time series: constant percentage at 28% increase per year</td>
<td>The utilities include essential services such as electricity, water, gas, and sewage. The average inflation rate for utilities has been highly variable, ranging between 7% and 35% over the past several years. The average inflation rate for utilities is currently 28%.</td>
</tr>
<tr>
<td>Training</td>
<td>Extrapolation: $10,000 per year</td>
<td>Training programs are essential to keep the staff updated on the latest financial management, project evaluation, and technology, ensuring that the fuel export tax is managed effectively and efficiently.</td>
</tr>
<tr>
<td>Technological Infrastructure</td>
<td>Extrapolation: $100,000 per year</td>
<td>Technological infrastructure is necessary for streamlining processes related to revenue collection, financial management, and data analysis. This includes devices, hardware, software, and digital platforms. It facilitates efficient fund utilization, enabling real-time monitoring and reporting to enhance the overall effectiveness of the system.</td>
</tr>
<tr>
<td>Cybersecurity</td>
<td>Extrapolation: $30,000 per year</td>
<td>Cybersecurity is important to protect sensitive financial and operational data. It ensures safeguarding against potential breaches, unauthorized access, and the maintenance of the integrity and confidentiality of critical information.</td>
</tr>
<tr>
<td>Contingency Fund</td>
<td>Extrapolation: $2,000,000 per year</td>
<td>The Contingency Fund serves as a financial safety net, providing resources to address unforeseen challenges and emergencies.</td>
</tr>
<tr>
<td>Sustainability Initiatives</td>
<td>Extrapolation: constant percentage at 15% per year</td>
<td>Fifteen percent of the annual funds generated from the fuel export tax will be allocated to sustainability initiatives. These include supporting the maintenance and expansion of the Grand Ethiopian Renaissance Dam, transitioning to the use of solar lanterns, intensifying tree-planting efforts, and improving water sources.</td>
</tr>
<tr>
<td>Road Accident Fund</td>
<td>Extrapolation: constant percentage at 15% per year</td>
<td>Fifteen percent of the annual funds generated from the fuel export tax will be allocated to a Road Accident Fund, specifically designed to support individuals with injuries resulting from road traffic accidents.</td>
</tr>
<tr>
<td>Trauma Care Capacity Building Fund</td>
<td>Extrapolation: constant percentage at 15% per year</td>
<td>Fifteen percent of the annual funds generated from the fuel export tax will be allocated to a Trauma Care Capacity Building Fund. The fund will support scaling up trauma centers, training orthopedic surgeons, and contributing to supplies and equipment needed to manage musculoskeletal injuries.</td>
</tr>
</tbody>
</table>
Appendix C: Budget References


REFERENCES


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