

Impact of Road Transportation Network on Socio- Economic Well-Being : An Overview of Global Perspective

Nuhu Honney Tini^{*1}, Muhammad Zaly Shah², Zahid Sultan³

^{*1}Department of Urban & Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor Bahru, Malaysia

¹Department of Geography, Faculty of Science, Adamawa State University, PMB 25 Mubi, Nigeria.

²Department of Urban & Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor Bahru, Malaysia

³Civil Engineering Department, PNG University of Technology, Private Mail Bag Lae 411, Morobe Province, PNG

ABSTRACT

Road transportation serves as a base for socio-economic development which is imperative for the survival of humanity. Such vital role played by transport led to the ever-increasing expansion of road network worldwide. The multidimensional significance of road network to societal welfare is insufficiently uncovered and less understood. This paper analyses the interplay between growth of road network and socio-economic well-being of humanity. The growth and density of road network has been investigated and it is established that disparity exist generally across continents of the world. In specific cases, while some countries have dense road network most countries of the world have less dense road network. Facts about the social and economic impact of road network is as well discovered to be multi-faceted. Economically, road transport network ensures job opportunities, income, resource exploitation, exchange of goods and poverty alleviation. Socially, roads guarantee accessibility, mobility, liveability, activity location, safety, social interaction, dispersal of idea and services, land-use efficiency and reduce vehicle emissions. Conversely, road facilitates transportation activities which directly or indirectly inflict diverse societal costs. The major challenges militating against the growth of road network worldwide includes social, economic, cultural, political and environmental factors. The mitigation measures of such challenges identified among others are improvement in road network planning and design, investment in road development and maintenance, standardization of road network, traffic safety regulations, traffic management legislation and skills. This study contributes to gaining more insight into the social and economic influence of road network to societal quality living.

Keywords : Road Development, Socio-Economic Impact, Challenges, Mitigation Measures

I. INTRODUCTION

Transportation is an important and necessary sector from which most people earn their living. It is essential for human survival and serves as a base for social and economic development of the society.

People and goods move from one place to another by different modes such as air, rail, road, water, and space. Road as a mode of transportation serves as a conduit linking places, regions, and economy together. Thereby facilitating movement of people, goods, and services. Hence, it has an edge over other modes of

transportation due to flexibility and door-to-door service rendered. Road transport conveys 42% of global mobility and constitutes 75% (Europe) and 85 - 90% (Asia) of freight traffic ¹.

Systematic connection, linkage or intersection of the road network in a place is significant ². This satisfies mobility needs, allows unlimited and unrestricted interaction and provides access to services in an area. A well connected road network promotes socio-economic well-being by ensuring movement of people to and from work, business, shopping, schools and recreational locations and transportation of freight which comprise raw material and finished goods ³.

Road transportation transcends the history of humankind and has been the backbone of social and economic growth of nations from the dawn of ages ³. Over the years, urge to enhance the social and economic well-being of people generated interest and concern for improvement of road network globally, regionally, nationally and locally. This paper is aimed at providing a global overview of how road network affects the well-being of humanity. Thereby contributes to literature and enhance perception of the influence of transport system on quality of life. The article focuses on road network growth, its socio-economic achievement, challenges facing the system and mitigation measures for the challenges.

II. Methodology

Network density analysis was used to assess the extent of road network expansion in each of the six continents. The road length and land area estimated for countries of the world by CIA⁴ and Auto travelers ⁵ were summed up for every continent. Then the results were used to calculate road network density of all the continents. The review aspect draws on the literature published in scholarly journals, conference proceedings, government articles, online articles, and reports. Relevant scholarly journals and conference

proceedings were explored using Science Direct and Google Scholar database. Furthermore, Google search was conducted for government articles, reports, and online articles. The keywords used for the search includes road network and socio-economic impact, social impact, economic impact; road/street network and well-being, living standard, challenges. In turn, 84 articles published between 1994 and 2016 were sorted for this assessment.

III. Global Road Transportation Network

Road facilitates travel either by motorized or non-motorized vehicles. Globally, road has been on rapid expansion since the 1900's. As a result, road network has become a distinctive feature on the earth's surface. Its enormous contribution to societal welfare mandated most European Union (EU) countries to reserve 1% to 2% of their land surface for roads (ERF, 2001). Recently, the tropical region experiences the highest rate of road expansion, due to great priority bestowed on road development in order to ensure socio-economic progress through enhancing spatial connectivity, aiding travel, helping to establish land claims and facilitating resource extraction ⁶. Expansion of road network over the globe goes concurrently with increase in service it renders. In this regard, Papi, Hellman ³ note that road transport carries the highest inland freight which kept on growing at 47% between 2001 and 2010. In industrialized countries, heavy vehicles account for 80% every inhabitant freight. Almost 44% of all freights delivered in European countries are by roads. Such significant role played by road in promoting social and economic well-being of the society makes it to attract special attention which in turn leads to its continuous expansion worldwide.

Road network is a framework of functional relations of road pattern in a territory ⁷. Network connectivity denotes multiple linkages of roads over a place which create interconnection yielding a web-like system ⁸. Road density is the ratio of total length of the road

network to land area, estimated in kilometres per square kilometre (km/km²)^{9, 10}. The entire world is virtually connected as road network continuously keeps on expanding in every continent. The estimate of road length and network density of continents globally is shown in Table 1.

Table 1: Road Length and Network Density of World Continents

Continent	Land Area (Km ²)	Road Length (Km)	Road Density (Km/Km ²)
Europe	9,938,000	8,255,366	0.83
North America	24,256,000	7,884,599	0.33
Asia/Middle East	44,579,000	10,971,051	0.25
South America	17,819,000	2,721,739	0.15
Australia/Oceania	7,687,000	927,724	0.12
Africa	30,065,000	2,396,954	0.08
Total	134,344,000	33,157,433	1.76

Source: CIA⁴ and Autotraveler.ru⁵

Europe over many years have experienced consistent amendments of road policy and immense commitment by the public authorities. This resulted to the development of Trans-European road network which currently has a total road length of about 8,255,366 Km as indicated in Table 1 connecting the entire region⁵.

North American with a total road length of 24,256,000 Km while South America has 17,819,000 Km length of the road network as shown in Table 1. Pan-American Highway is the most popular and major route traversing these two continents. It is the

world's longest motorable road with a total road length of about 48,000 kilometres connecting almost the entire nations of North and South America continents. The missing link 'Darién Gap' is the main setback of the highway. Road construction through the Gap has been proven abortive due to difficult terrain and cost of road building. Anxiety to guard the rainforest, concerns to maintain the native culture, and fear of disease penetration into North America¹¹ are additional constraining factors.

The entire Asia including the Middle East has almost 10,971,051 Km road length and road density of 0.25 Km/Km²⁴. Asian Highway with the length of 143,000 km connecting 32 countries is the longest route in the region. South Asia has denser road network in the continent linking major cities in India, Pakistan and South-East Asian Peninsula¹². Most Asian countries currently experience rapid expansion of domestic road network. For example, road grows annually at the rate of 6.2% in China, 3.1% in Korea, 2% in India while it is 1.2% in the Russian Republic¹³.

Australia and Oceania have total road length of about 927,724 Km and road density of 0.12 Km/Km²⁴. The prominent Australian Highway 1 with a total length of 14,500 Km is the longest national highway worldwide⁴. Africa with a total road length of barely 2,396,954 Km and road density of 0.08 Km/Km²⁴ remains the least connected continent. Trans-African Highway with a total length of 541,120 km is the most eminent regional route in the continent. However, its missing links which concentrate in central Africa coupled with inadequate maintenance of road system are two major factors limiting the role of Trans-African Highway in promoting socio-economic development of African continent¹⁴.

In view of individual countries as represented in Table 2, United States of America tops the ranking of 10 countries with highest (6,586,610 Km) road network worldwide. This is followed by India (4,689,842 Km) and China (4,106,387 Km)¹⁰. China

leads the ranking of top 5 countries with highest (43.0 Km/100 Km²) road density. This is followed by San Marino and Bahrain as shown in Figure 1. Conversely in Figure 2, Mauritania has the least (1.1 Km/100 Km²) road density worldwide ¹⁰. This outcome implies that there is disparity in road length and road density across countries globally.

Table 2: Top 10 Countries in the World with Highest Road Network

Country	Road Network (KM)	Ranking
USA	6,586,610	1
India	4,689,842	2
China	4,106,387	3
Brazil	1,580,964	4
Russia	1,283,387	5
Japan	1,210,251	6
Canada	1,042,200	7
France	1,028,446	8
Australia	823,217	9
South Africa	747,014	10

Source: Adida, ¹⁵

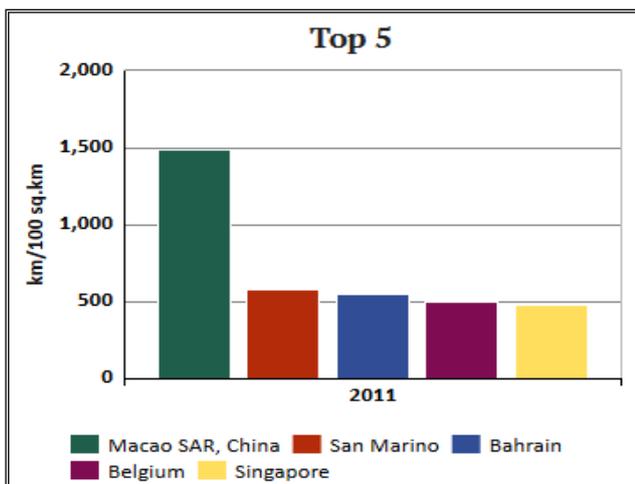


Figure 1: Top 5 Countries in the World with Highest Road Density. Source: WDI, ¹⁰

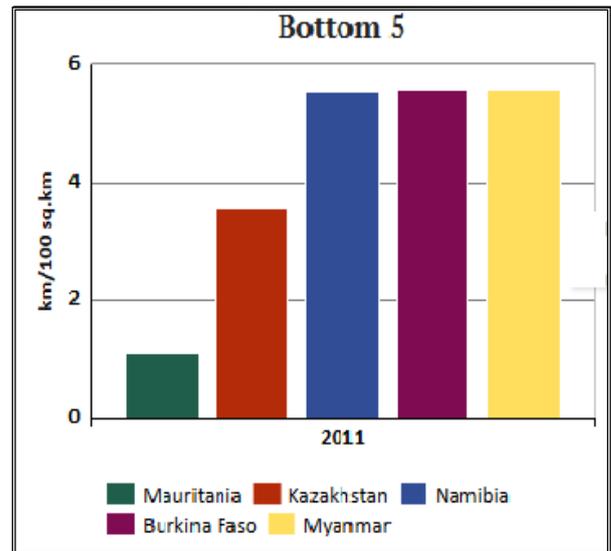


Figure 2: Bottom 5 Countries in the World with Least Road Density. Source: WDI, ¹⁰

IV. Socio-Economic Benefits of Road Transport Network

The concept of socio-economic well-being is established on two principles. These are first, the ability to access diverse economic opportunities; and secondly, providing privilege for people to access such opportunities easily ¹⁵. This makes road network and socio-economic well-being intertwined. On one hand, social and economic activities generate movement and networking. On the other hand, the road does not only facilitate mobility but also provides attractive and favorable locations for social and economic activities. Thus, road draws people closer to information, jobs, services, and markets; thereby improving people’s quality of life in the society ¹⁴. The role of road network in promoting the social and economic prosperity of people are numerous outlined as follows.

A. Economic Impact

Road network is an impulse of development within a city or region. This is because it leads to optimum exploitation of natural endowment; which makes labor force to shift from primary and secondary to tertiary economic activities. Thus attracting

additional infrastructure and social amenities to deprived and isolated areas. This enhance people's earnings and eventually curtail regional disparities in socio-economic development within a country or community¹⁶.

Road network contributes greatly in shaping the economy of the society. Sarkar and Ghosh¹⁷ adduce that access to road network has positive correlation with national per capita income. The contribution of road sector to economy is estimated between 3% - 5% of Gross Domestic Product (GDP) Worldwide^{18, 19}. Road transport share in European inland freight transport markets in tonne-kilometres of freight amounted to 78% in 2004. The overall freight volume rose by 43% between 1992 and 2005²⁰. Between 1952 and 1989, about one-quarter of United States of America's productivity growth was from the road transport sector¹⁸. The contribution of transport sector to GDP amounted to 4.07% in Vietnam and 10.13% in Thailand in 2008 (ESCAP 2009). Road transport share of GDP in India is 3.19%²¹, China 2.10%²² and Nigeria 1.10%²³. A typical example of income impact of road network improvement is seen in the case of American State of Kansas. An estimate of FRF 845.16 million (EUR128, 843811377) was invested on Highway Networks between 1991 and 1994; this, in turn, yielded an impact of FRF 2,201.43 million in Kansas.

Road transport sector contributes significantly to public finances via taxes, fuel subsidies or insurance premiums. Taxes on vehicles amount to 10.2% of annual total income in some European Union States²⁴. Generally, road user taxation accounts for 1.6% to 4.6% of GDP in the USA and in EU respectively. Road usage tax is estimated at 4.9% of total annual revenue in U.S.A, 11.7% in Asia and 12.9% in EU states. In 1995, the total income generated through different road transport taxes by France amounted to FRF 31.25 billion¹⁸. In 2005, revenues of road sector in EU 25 states was estimated at EUR 2,290.4

billion, which was equivalent to 22% of the EU 25 GDP³.

Road transport significantly promotes growth and new jobs in both rural and urban communities^{25, 26}. Specifically, road network development creates both direct and indirect employment opportunities²⁷. Direct jobs are created by investment in road sectors such as construction and operations comprising maintenance, supervision or exploitation. Indirect jobs are generated as a result of productivity by road activities. Road sector accounts for 3% to 5% of wage earning jobs in each European Union country¹⁸. Almost 15 million people in EU states work indirectly or directly with road sector, constituting about 5% of EU 25 workforce³. In the United States of America, a \$1 billion investment in road construction creates a total of 34,437 employments to citizens. About 18,144 of such jobs are induced into the economy as direct while indirectly workers spend their additional wages and earnings on local commodities and services. A \$1 billion investment in highway management and maintenance generates a total of 44,709 full-time jobs in U.S.A. About 8,390 of such jobs are related to road construction, 20,924 in support industries, while 15,935 are directly or indirectly employed in service sectors³.

In France, exploitation of Poitiers-Bordeaux highway (282 km) generates threefold to fourfold new permanent jobs per kilometer in immediate communities. In Brittany (France), road construction between 1968 and 1982 generated 30% growth in non-agricultural jobs¹⁸. Moreover, in 2000, a joint investment of ERU 1.82 billion by 18 European cities in road development resulted to 0.3% to 1.8% growth in employment within a period of years. Investment in construction of A92 motorway in Spain led to an increase in job opportunities, creating about 48,938 employments; of these, 81% as wage earnings and the rest as indirect jobs²⁸.

Road transport network contributes significantly to poverty reduction^{25, 29}. In turn, this indirectly supports economic growth and directly improves the personal welfare of the poor³. In Vietnam, improvement in rural access from 76% to 84% at the provincial level in 2002 and 2004 respectively led to drop in poverty level from 41% (1999) to 24% (2004) at the same provincial level. Similarly, in Lao PDR between 1997 and 2003, poverty rates declined by 9.5% of the rural population; almost 13% of the downfall was due to improvement in road access³⁰.

Road network improves economic system by allowing territorial transformation which generates efficiency and interchange of goods, services and people³¹. It also supports other economic sectors which result in structural change. Good road network saves time, enables the industrial sector to acquire technological developments and allows the use of modern process of production such as 'just in time' delivery and change in consumer's expectation like product differentiation¹⁸.

B. *Social Impact*

Road transport network ensures flexible and door-to-door service. Whereby routes and timings can be modified to personal interest without much difficulty. This enhances free movement of people, freight, and service. With the use of car, motorcycle, and bicycle, road allows direct and simple access to all destinations, which offer relief particularly to travelers with handicapped, elderly or children³.

Road network is a major determinant of activity location. Hence improvement in road system enlarges individuals' and enterprises' location choice. In agglomerated areas, adequate road network serves as a means to check congestion of activity in the inner-city. It also enables suburb dwellers to acquire enough space for housing,

working space and other services¹⁸.

Road network also improves accessibility, travel options and accelerates the movement of people and goods. This creates employment opportunities resulting to economic prosperity and enhanced quality of life³¹⁻³³. Good road networks provide access for effective social interaction, not only in terms of social context but also in their location over a greater geographical area. This is crucial for the growth of society. Because it enables people to easily organize for progress and plan safety strategies for risk management³⁴.

Road transport system offers accessibility to various destinations within a short period of time and facilitate walking, cycling and access to social facilities³⁵. It minimize vehicle operating cost, accident cost, travel expense, travel time and improve services in trade, education and health sectors^{3, 35-37}. For instance, the overall benefit of A92 motorway in Spain was estimated at EUR 39.9 billion within 30 years. This amount comprised mainly of time saved during shorter travels, decrease in traffic overcrowding and reduction in road accidents and deaths'. Likewise, the socio-economic benefit of A7 motorway in Valence region of Spain amounted to EUR 251 million in 2000. This was realized from real-time cost savings on travel time³.

Road network promotes well-being by ensuring easy access to health care and medical facilities³⁷ at all levels – nationally, regionally and locally. In Germany, Government Survey indicates that about 94% of people aged above 64 years having access to car reach hospital in 30 minutes time. About 69% arrive at the hospital in 30 minutes with public transport, whereas about 8.26% require over 60 minutes to reach hospital^{38, 39}.

Efficient road network provides access for traveling to leisure locations. In Sweden, about 80% of

visitors to Aletsch, Bietschhorn and Jungfrau glaciers for leisure travel to the area by roads, even with the existence of good rail links. Similarly, construction of 2nd Mekong Bridge attracted about 8% increase in tourist visiting Lao PDR in first two months of its opening in 2007 ¹⁹.

In an urban setting, road network serves as an instrument for land use policy ⁴⁰. By providing access to territory and dense network, road prevents natural tendency of concentration of housing, employments and other activities. In this respect, good density of road network is maintained by European Union members; ranging from 1.62 km/km² in Netherlands to 0.71 km/km² in France and 0.12 km/km² in Finland ¹⁸.

Recently, good road networks are constructed in cities with the aim of reducing emissions. Papi, Halleman ⁴¹ found that rearrangement and improvement of roads lessen automobile emission. In three different scenes of single lane road, two lane roads and motorway, it was found that emissions of CO₂ dropped by 11%, 61% and 38% correspondingly, NO_x and NO rates also reduced. Likewise, an increase in capacity of road network controls vehicular traffic volume ⁴².

V. The Challenges of Road Transport Network

Road network plays a vital role in promoting the socio-economic well-being of the society. However, numerous factors impede its optimum performance. In spite of the foremost contribution of road transport to public finance, drastic reduction of investment in road development has become a universal syndrome. Attane, Jose ¹⁸ adduce that between `1976 and 1988, investment in land transportation dropped in all EU States. Specifically, it fell from 1.5% of GDP in the 1980s to less than 1% in 2004. Likewise, investment in road development decreased from 1.8% - 1.0% in

Germany and from 1% - 0.5% of Gross Domestic Product (GDP) in the United Kingdom between the year 1976 and 1988.

Most public authorities expend less than the huge benefits they derive from road sector. For instance, France in 1995 invested FRF 18.75 billion on roads. In turn, road transportation contributed FRF 31.25 billion to the economy. Similarly, in 2000, France Government budgeted EUR 8 billion for transport infrastructure, 60% was allocated to rail sector with only 25% invested in the development of road network ^{3, 18}. In view of the foregoing facts, Shahi ⁴³ rightly express that 'policy makers who are responsible for development plans never consider it a necessity to invest in roads as it requires huge investments and human resources'.

Equally, the budgets earmarked by public authorities for road maintenance are insufficient. In some EU countries, the government allocates only 76% of the required expenditures on road maintenance. Consequently, lack of investment in road maintenance cost road authorities and road users extra money. In France, for each EUR 1 not spend in road maintenance, road-users ravage EUR 3 on additional transport costs while road authorities invest EUR 4 on asset construction costs ³.

Poor and inadequate maintenance of road network retards effective performance of transport system especially in developing countries ⁴⁴. This jeopardize lifespan of various road transport infrastructure particularly in rural areas. In cities, road transport system faces challenges as a result of growing urban population, private vehicle ownership, traffic congestion, and deficiency in public transport systems ²⁶.

Resource constraint has adverse effect on road network expansion. Specifically, it retards development of new road projects and regular

maintenance of existing ones. In 2013, France government suspended implementation of big projects on road development and construction of 3-kilometre bridge from Lena to Yakutsk worth 80 billion rubles (pounds 2 billion) due to shortage of funds ⁴⁵. Such challenge is more pronounced in developing countries where resource constraint results to in-affordability of advanced technologies. As a result, sub-standard roads are often developed which are neither durable nor reliable, thereby do not meet the demand of road users. Thus, poor road condition results to a high traffic accident, loss of life and property.

Road network facilitates transportation activities which in turn impose diverse societal costs (externalities) or effects such as traffic congestion, road accident, local air pollution, noise pollution, carbon dioxide emissions and climate change ⁴⁶. Traffic congestion generates serious concern in modern cities. In several cities, traffic congestion is no longer restricted to rush hours in the morning and evening; but has extended to various spots and hours of the clock. The effect of such overcrowding is not limited to social costs such as delay, stress and fewer time families spend together but also reduce fuel efficiency of vehicles, work productivity and places enormous cost on freight, businesses and consumers ³⁹. Almost one-third of vehicle travels are undertaken in congested condition of which speeds are limited to half of the free flow value ⁴⁷. For example, in London city, road traffic has become much slower than in some few decades ago, with a continuous decline in speed rate ⁴⁸.

Congestion results to slower speeds and longer travel time, which imposes cost on economy and generate multiple impacts on urban regions and their inhabitants ⁴¹. This is ascertained by Didier, Prud'homme ⁴⁹ who estimated true congestion cost at EUR 500 million in the Greater Paris Region; a figure equivalent to 0.5% GDP of the same region.

The study also reveals that a 7.5 km drive in the area takes 25 minutes by car and 36 minutes by public transportation, while with low traffic flow, car journey time diminishes to 15 minutes.

The rise in motor vehicle ownership has led to increased energy consumption by road transport congestion. This resulted to dependence on petroleum. Cities differ in transport energy consumption. For instance, 'an average U.S. urban dweller uses 24 times more energy annually for private transport than a Chinese urban resident, and almost four times as much as a European urban dweller'⁵⁰. The report also shows that in the United States, about 2.9 billion gallons of gas are burned in traffic and over \$ 121 billion in time and fuel is wasted due to gridlock ⁵¹. In consequence, more traffic emissions are generated along with its effects on the economy, human health, and ecology.

Modern urban roads are increasingly becoming more congested due to rise in car ownership. Table 3 shows the top 25 cities in the world with worst traffic congestion. Such traffic jam generate air and noise pollution which negatively affect comfort and health of the urbanite. Road transportation accounts for over one-fifth of global carbon dioxide emissions from fossil fuels⁴⁶. It is rated as the major (25%) air polluter. Vehicle emissions are the main source of nitrogen oxide (*NOx*) carbon mono oxide (*CO*), hydrocarbon and lead which are harmful to human health. These cause diseases such as asthma and bronchitis. Fine particles such as *PM* 10 and *PM* 2.5 emitted by vehicles also cause breathing diseases and loss of vision. Air pollution caused about 3.2 million deaths worldwide in 2010. This makes it rank seventh of world's top 10 killer diseases ⁵². In Europe, cars and lorries have been identified as the main contributor of *NOx*, *CO* and non-methane volatile organic compounds (*NM VOC*) ⁵³. In the UK, road transportation accounted for 339 kilo tonnes of nitrogen oxide and 17 kilo tonnes of fine particles in 2011. This makes it the leading

donor to poor air quality in the UK⁵⁴. In developing nation cities, ignorance and the way inhabitants carry out their economic activities expose most people to road traffic emissions and its health hazard⁵⁵. Air pollution is not only dangerous to health but also reduces life satisfaction of people⁵⁶

Noise pollution which results from road traffic is not only a nuisance but greatly affect health and quality of life of inhabitants particularly in agglomerated areas. For instance, about 67 million inhabitants of EU states and about 55% of over 250,000 people living in agglomerated areas are daily exposed to road noise⁵⁷. Another research reveals that over 44% of the EU25 populace were commonly bare to more than 55 *dB* of road traffic in 2000, a level possibly harmful to human health⁵⁸. Consequently, about 24 million people are exceedingly angry with road traffic noise in the EU states⁵⁸.

Fatality emanating from traffic accidents is one of the serious consequences of the growing number of motor vehicles on our modern roads. Figure 3 shows top 25 countries with highest fatal vehicle accidents Worldwide in 2017. This has become a great tragedy and a big challenge experienced globally. Road fatality ranks third on the list of the most serious health problems today and is rated much higher in developing countries than in developed world⁵⁵. Almost 1.2 million people die in road accident yearly, while about 50 million sustain injury; accounting for 30% to 70% of orthopedic cases in developing nations⁵⁹. Developing nations have the largest share of casualties, with 85% deaths annually and 90% of lifespan deformity resulting from road traffic crash⁶⁰. Africa records the highest number of people killed in traffic accidents per 100,000 populations; occupying almost 11% of world road fatalities^{61, 62}. The United States of America, in 2006 recorded almost 42,642 deaths in a road accident, 2,575,000 injured, with a ratio of 1: 60

deaths to injuries⁶³. On daily basis, over 16,000 accidents are experienced and yearly about 43,300 deaths are recorded on U.S Highways. Almost 100,000 crashes (2% of all accidents) are estimated every year in the United States⁶⁴. Each year, road traffic accident renders over 150,000 people disabled in the EU states⁶⁵.

Globally, road crashes claim almost 1.25 million lives of people while 20 to 50 million are injured every year⁶⁶. Although the impact of road accidents are less understood due to inadequate data, it is a fact that 'losing a loved one is enormous, both in terms of emotional distress, loss of income and caused disability'⁶⁷. Countries have experienced remarkable declines in road fatalities over the last decades. However, the figure of serious injuries is reducing at a slower rate and most survivors of stern crash scarcely get well fully⁶⁸.

Road crime is another big challenge experienced today. Roads are increasingly becoming 'lawless and a commonplace for drug pushing, rape, prostitution, shooting, knifing, murder, and robbery'. For instance, Hampton road in the USA recorded 7,506 serious criminal incidents per 100,000 people in 2009. The figure increased to 7,582 in 2010. Similarly, In Britain, Stapleton road is known as the worst streets with a crime rate of about 250 offenses for every 1000 people in a year^{69, 70}. Hence, Miller³⁹ rightly observed that 'transport system is a popular terrorist goal since it congregates a huge number of commuters into little space, raising the likelihood of harm and attracting psychological impact'.

Ecological effect is also an impressive challenge of the road network. The negative effect of road on ecology are diverse and range from mortality, loss of habitat, formation of barrier to animal dispersal and gene flow, to alteration of habitat structure, creation of edges, introduction of pollutants,

change in hydrological processes and increase in susceptibility to alien invasion ⁶.

Road network also has great environmental footprint, especially in relation to air quality and worldwide climate change. This is because road transportation is the biggest promoter of warming. Road transport releases significant amounts of black carbon, carbon dioxide, and ozone. These substances generate huge amounts of pollutants which cause warm climate ⁷¹. Roads equally have indirect footprint through stirring up other systems, such as cities, to manifest environmentally untenable structure like sprawl ³⁹.

Top 25 Cities with the Worst Traffic Congestion Worldwide

City/Country	Hours Spent In Congestion	Ranking
Los Angeles, CA, USA	102	1
Moscow, Russia	91	2
New York, USA	91	2
Sao Paulo, Brazil	86	4
San Francisco CA, USA	79	5
Bogota, Colombia	75	6
London, United Kingdom	74	7
Magnitogorsk, Russia	73	8
Yurga, Russia	71	9
Atlanta, GA, USA	70	10
Aerodromnyy, Russia	69	11
Paris, France	69	11
Caracas, Venezuela	67	13
Miami, FL, USA	64	14
Kansk, Russia	64	14
Bangkok, Thailand	64	14
Jakarta, Indonesia	63	17

Washington, DC, USA	63	17
Boston, MA, USA	60	19
Istanbul, Turkey	59	20
Mexico City, Mexico	58	21
Chicago, IL, USA	57	22
Medellin, Colombia	57	22
Krasnodar, Russia	57	22
Belem, Brazil	55	25

Source: <http://ceoworld.biz/07/02/2018>

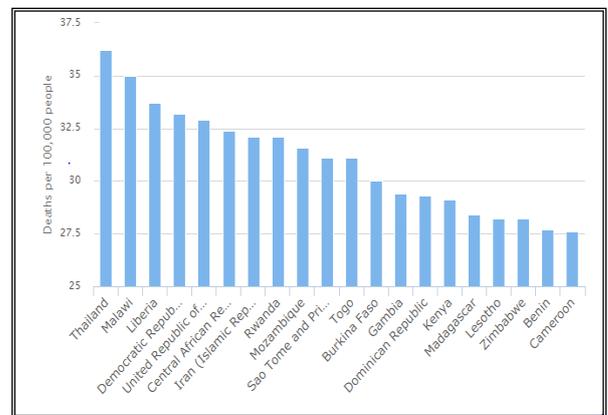


Figure 3: Countries with Highest Fatal Vehicle Accidents Worldwide

Source: WWW.Worldatlas.com, 25/11 /2017

VI. Mitigation Measures For Road Transport Network Challenges

The need to increase mobility and minimize the effect of transportation system has become a common agenda universally. This is driven by desire to achieve efficient and sustainable transport system that could support economy and welfare of the society. Thus mitigating the aforementioned challenges is a basic step towards realizing sustainable road transport which might enhance social and economic well-being in the society.

In view of the declining rate of investment in roads, policy-makers, particularly in developing countries need to increase road budgetary

allocation in order to ensure adequate, safe and quality road network at both local and regional level. In developed countries, effort should be intensified towards expanding regional road network so as to achieve universal development which would result to the overall quality environment and socio-economic well-being of people across regions.

Reducing the rate of fatalities and serious injuries caused by road transport accident should be a worldwide agenda. One sure means of curtailing road fatality and injury is by preventing road accidents from occurring. This could be achieved by conducting efficient road safety assessments and inspections at design, planning, construction and operational phase of roads. This is to be done by experts to curtail recurrent accident hazards.

Road safety could also be achieved through harmonization and standardization of road network by traffic laws, vehicle rules, and traffic skills. Other measures include dealing with driver behavior, motor vehicle safety and steady improvement of road network¹². This can as well be attained through 'investments in institutions and governance, infrastructure, vehicle fleets and allied ventures in health and well-being of citizens to address their vulnerability to catastrophic death and injury'³⁴

Traffic safety could also be ensured through 'Avoid-Shift-Improve framework'. This entails avoiding irrelevant travels, shift from car usage to transit transport model and improve transportation by implementing people-oriented urban design^{72, 73}. Similarly, policy formulation on transportation taking into cognisance the importance of aligning road safety priorities and high precedence to sustainable development goal in urban areas; capturing the associated co-benefits of integrated initiatives will go a long way in reducing accidents and fatality on our roads⁷⁴.

Encouraging and providing walking and cycling facilities in cities and enhancing the role of public transport through use of electric rail, electric or hybrid vehicle and fuel efficient and safer cars will go a long way in achieving a cleaner, healthy and friendly environments in modern cities⁷⁵. Policy-makers and planners need to give priority to the terms of safer transport amenities to encourage more cycling and walking. Policies should also be initiated to reduce unsafe vehicle speeds and generate minimum greenhouse gas releases and local air pollution, energy security, and better physical well-being⁷⁴.

Promoting car sharing; a less car intensive mode of urban transportation is a significant approach to reduce car ownership. This strategy is becoming popular and should be encouraged in both developed and developing countries. In Europe and North America, car sharing lessen car ownership at the ratio of one hired car to 15 personal vehicles⁷⁶. Countries like India, China, Mexico, have introduced car-sharing in an effort to minimize vehicle-related pollution, improve traffic, and increase people's accessibility to car⁷⁷.

Emissions of transport-related conventional pollutants require key consideration so as to curtail its effects on public health. The recent initiative of replacing high emitter vehicles with new effective pollution control technology vehicles is an impressive effort towards achieving healthy and eco-friendly environment. Hence, the use of emission reduction technologies and fuel efficiency vehicles need to be encouraged in order to curtail vehicle-related Green House Gas (GHG) emission.

Significant reduction of noise from road transport-related sources can be achieved through technical benchmark on sound taxonomy. Noteworthy progress is being made to optimize vehicle composition such as the design of tires, wheels, and engines. In the same fashion, road construction

sector is making effort to develop energy proficient measures and skills to improve road surface which abates the level of noise by smoothing road tire interaction.

Addressing the impact of road transport noise can also be through implementing traffic management strategies such as legislation of traffic volumes, speed limits, day-night traffic, central noise barrier, noise reducing pavement, noise barrier with photovoltaic or interactive speed signs on motorway^{78, 79}.

VII. Conclusion

This paper has revealed that road network expansion is globally marred by diverse social, economic, political, cultural and environmental factors. Furthermore, the article shows that road network has twofold-causal (positive and negative) impact on socio-economic well-being. The positive impacts are those factors that considerably enhance economic growth and social well-being. The negative impacts are the driven challenges which retard economic development and advancement in living standards.

Although road network facilitates socio-economic development, imbalances are often introduced. Such imbalances occur at local, national, intraregional or interregional level between the advantaged metropolitan regions or cities and their peripheral or surrounding hinterlands. Metropolitan regions and cities dominate in terms of structural network and growth process. This implies that other regions or parts of regions fall short of social and economic development⁸⁰. Since socio-economic well-being is founded on the ability to access a variety of economic opportunities, plan for road network expansion need to be directed towards bridging the gap between regions. This will ensure equity and optimize opportunities to the rest of society.

Improvement in road network promotes regional resource exploitation and increases agricultural yield. However, its expansion process initiates diverse social costs (e.g. air pollution, noise) and environmental implications such as land-use changes and habitat loss. These, in turn, affect the social and economic well-being of people. Hence, there is need for more research that will develop working models with proactive strategies towards reducing social cost and environmental damages in planning and implementation of road network expansion^{81, 82}.

Commonly, the existing socio-economic evaluation procedures are untenable due to ethical, methodological and practical challenges. Hence, further research is needed to develop better quantitative methods for appraisal, modelling and prediction of road network impact on social and economic well-being⁸³.

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