Road development and its impacts in Ethiopia

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Abstract

Among basic modes, road transport plays a paramount role in socioeconomic development in both developing and developed countries. The main objective of this study was to assess temporal and spatial road infrastructure development during three political regimes in Ethiopia and its impacts. The methodology employed mainly secondary data supported by limited primary data. The results showed that the road density of Ethiopia per 1,000 people has increased for more than four folds from 1951 to 2018). The mean distance of the network also showed decreasing trends. The empirical analysis shows that there are significant positive socioeconomic impacts upon households. However, the road traffic accident, as one of the main direct negative impacts, has been increasing from time to time. Compared to population trend since 1951, the correlation between the density of the total and asphalt roads is 0.87 and 0.38, respectively. This shows that the emphasis given to the expansion of paved roads in Ethiopia particularly in recent years is rather weak and needs attention.

Key words: *Density, development, impacts, regime, road.*

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Background and introduction

Like many other economic and social activities that are intensive in infrastructure, the transport sector is an important component of the economy impacting on development and the welfare of the people (Rodrigue and Notteboom, 2017). When transport infrastructure is well-organized, it provides various economic and social opportunities and benefits that result in positive multiplier effects such as better accessibility to overall services and additional investments (Oosterhaven and Knaap, 2000).

Growth theories have been used to look at regional economic theories as they relate to transportation investment and its impacts on population change and economic development. For instance, Aschauer (1989) and Akhmetzhanov and Lustoy (2013) concluded by stating that positive impacts on private sector productivity occurs when public capital was invested in transportation infrastructure. Moonmaw et al. (1995) also found positive relationships between transportation infrastructure and per capita income.

Particularly rural roads are somewhat typical in terms of their capacity to literally pave the way for various investments in social infrastructure sectors such as schools, health services, and security services. In case of the agriculture sector, better roads can significantly reduce the cost of inputs such as fertilizers, seeds, and extension services (Dercon *et al,* 2008). On the output side, better roads increase the scope of profitable trade, which in turn encourages on-farm investments to raising agricultural production (Binswanger *et al,* 1993). This in turn raises rural incomes, lowers food prices (and hence raises disposable income in urban areas), reduces spatial inequality in food prices, and reduces dependence on food imports.

The ideas mentioned in these cases are said to be about direct and indirect impacts which are proved by impact theories. In

these stances, impact evaluation of road development in this study is mainly guided by program theory and change theory. Programme theory is the issue of intervention by actors such as the government, private companies, etc... for the project formulation and implementation, whereas, change theory is about the direct and indirect impacts created due to the interventions in policy formulations and implementations.

Based on these theories, Patarasuk (2013) elaborates that despite the social and economic benefits, road infrastructures are also perceived as cultural artefacts that lead to negative ecological effects such as traffic accident and congestion which are most of the time direct impacts. However, their outcomes are of indirect impacts in nature. Generally, if hard (road infrastructures such as fixed facilities like tracks and nodes) and soft (overall management of flow entities what we call traffic) are well managed by the support of innovative technologies, then the outputs will transform the quality of life of citizens through dynamic externalities that the development often generates (Sengupta *et al,* 2007: 3). But when the system is deficient in terms of capacity or reliability, it can have an economic cost such as reduced or missed opportunities.

When we come to the historical development of roads from global perspectives, the first roads in various parts of the world were those that developed following trails and paths made by animals that helped people for hunting and gathering activities. Early roads were built in the Near East soon after the invention of wheels about 3000 B.C. The Romans were known for their ingenuity in road construction. Historical development of transportation and the socioeconomic role it played is also well documented by Papi *etal* (2007: 4) as quoted below.

> *Throughout history it is important discoveries and technological developments which have allowed mankind to leap forward,ameliorating its status and improving its standards of living. Reaching back thousands of years, the invention of the wheel generated a revolution comparable only to the invention of the steam engine which sparked the industrial revolution. In a similar fashion, it was the engineering feats of the Roman Empire, which allowed them to reach the furthest corners of Europe. Their roads, originally built for the fast deployment of legions, allowed citizens from all over Western Europe to have a better access to economic centres, thus enlarging the potential market for goods and services. It is significant to note, in light of the examples mentioned above, that road infrastructure has always played a key role in the progress and economic growth of a nation, both through the direct effects of a higher mobility for citizens and goods and also via the indirect benefits derived from the process of building infrastructure.*

Understanding the importance of roads, the most improved type of its construction was started in 1810, when two Scottish, engineers, Thomas Telford and John Macdam demonstrated that a sheet of broken stones two or three centimetres in thickness became consolidated with the passing of traffic in to a hard water proof mass (Cain, 1975 cited by Shiferaw, 2008). Many authors have also documented that the highway transportation has been expanded rapidly since the end of World War II.

Nowadays, road transport is a dominant and popular mode in both developed and developing countries. In Ethiopia it accounts for 90 and 95 percent of motorised inter-urban freight and passenger movements respectively (MoT, 2018). Road in Ethiopia has paramount role in terms of: supporting growth in agriculture and industry, in opening corridors, port links and tourism areas, and connects each region to the rest of the country. Even though multi-directional development is ongoing in Ethiopia, the pace of the movement in density/ accessibility of road infrastructure is very low as compared to cross countries. Due to this, among others, Ethiopia is still suffering from low socioeconomic development. Therefore, one of the major causes for such low socioeconomic impacts in this respect is low development trends of road

infrastructure in terms of quantity and quality as well as poor management on the hard and soft sector of transport industry. This study therefore deals with the assessment of road infrastructure development trends, and its major positive and negative impacts generated in Ethiopia.

Problem statement

Roads are important to provide the opportunity to realize the productive potentials of agricultural land, to facilitate schooling, health services and marketing and satisfy other social and economic needs. If rural roads are not maintained properly, access will deteriorate and these activities will be negatively affected. It is usual that high peak of benefits occur when a region receives first time access of road whether paved or unpaved. The first roads open up the area to markets, health facilities, schools, government services etc. This can bring about substantial economic and social impacts. Goods, services and facilities become increasingly accessible. Communities enjoy the benefits from access but can become increasingly frustrated if access deteriorates and improvements in their living standards are compromised.

The road infrastructure has a high potential payoff in terms of poverty alleviation and economic growth. Some cross national studies of economic growth and public infrastructure notably one using public investment in transport and communication, and other using capital stocks in roads, railways and telephones, show that infrastructures variables are positively and significantly correlated with growth in developing countries.

This study was conducted to increase knowledge about the relationship between road transportation infrastructure investments and the economic development of Ethiopia. The theoretical framework is derived from Frischmann's theory of infrastructure and commons management which provides a theoretical foundation for analyzing the contribution of a country's road network to economic growth and development and the resulting social implications in developing economies. Frischmann (2005) argues that a network of roads, would create an economic return for the society and lead to social change. Many researchers have hypothesized that such an analysis must encompass lots of components including GDP, population size, degree of urbanization, traffic density, and level of economic development.

Regarding impact of road infrastructure, valid theories for this study are programme theory and change theory. Programme theory is the issue of intervention by actors such as the government, private companies etc for the project formulation and implementation, whereas, change theory is about the impact created due to the interventions. Under the theory of change, the most important objective is to check temporal and spatial changes (impacts). Spatial change can also be analyzed using concepts from the Central Place theory and Graph Theory, which are dominant theories in transport geography.

There are direct and indirect links between economic growth and the reduction of various social ills, and the road provision. The direct effects are registered in the impact zone by reduced cost: travel time to school, work, hospitals, markets and the savings in fuel and other direct transport costs. On the other side, the indirect effects consist of increase in income and other dimensions of well-being such as health, education, social interaction and political participation. The benefits of road include the access they provide to other goods and services especially in cities, where the poor are concentrated on the periphery of urban areas, as in many developing countries. The cost and availability of public transport become key factors to the poor in their ability to obtain employment (Porter, 2005). For example, "a household survey

in Ecuador identified the access to secure and reliable public transport as an influential factor in determining the ability of low-income girls and women to participate in evening training classes (The World Development Report, 1994).

In China, the investment in road infrastructure was directly linked to rural poverty reduction as well as the economic growth of that country. From 1985 to 2002, the GDP grew by more than 9% per year, making China's economy one of the most dynamic in the world. The absolute poverty in rural China declined from 250 million people in 1978 to 29 million in 2001. A reduction in poverty of such scale and within such a short time unprecedented in history and is seen by many to be one of the greatest achievements in human development in the 20th century (Zhana and Xiaolong, 2002 as cited in Matebie, 2009).

To reduce negative impacts of roads many countries are performing standardised road safety audit (RSA). For instance India has applicable two basic categories of RSA, ie, during new roads and existing roads. Research on RSA is a huge gap in most of developing countries including in Ethiopia. It is obvious that they are characterized by increasing motorization on a limited motor-able roads within ill management conditions. Few of the critical problems characterizing these countries are poor road infrastructure density and quality, traffic congestion, poor public transport service, higher rate of traffic accidents, and costly operation of transport services.

Ethiopia, the second populous country in Africa (110.million in 2018), is facing the above mentioned challenges. Its density of road infrastructure is very low as compared to cross countries which World Bank puts its status among the least countries in the world. Structurally its economy is also based on agriculture and it is suffering from poverty. These basic problems among others, are always forcing the country to rely on foreign aids and debts. Therefore, one of the major causes in this respect is poor development trend of road infrastructure particularly during the last regimes. For instance, a primate city, Addis Ababa had been without ring road and now it has a minimum alternative networks to fulfil the mobility needs. Its road density at present is 18% which is lower than global standard (25-30%) of cities of developing countries. It is also suffering from congestion due to insufficient network density and motor-able roads. Even though good strategies were formulated in GTP II, the development of the road infrastructure in the Country could not cope with the rate of urbanization, population growth, and the rapidly growing technology and thereby missing of the advantages that can be gained from globalization. Due to mismatched road transport managements in Ethiopia irritating negative impacts are common among which the road traffic accident is the dominant one.

According to Federal Transport Authority (FTA) 2018 report, there are recorded 935,888 vehicles in all over the country. Parallel to road developments, a rapid increase in the number of vehicles (more than the rate of road growth), and an increase in the number of population accompanied with poor traffic accident reduction management as well as overlooked road safety audits have significant negative impacts in the country. In this research, given the capital-intensive nature of road transportation infrastructure and the increasing scarcity of resources for capital-intensive road projects, it is important to investigate the positive and negative impacts of road transportation infrastructure investment in Ethiopia. Based on these, the objectives of this research were:

1. to analyse and compare road infrastructure development trends during the past and present government regimes;
2. to discuss impacts related to road accessibility in Ethiopia;
3. to overview level of satisfaction of end users by road development; and
4. to investigate impacts related to traffic accidents.

Materials and methods

This study used mixed approaches. The nature of the research follows positivist paradigm which supports quantitative and qualitative approaches. To investigate the road network development, the analysis dominantly employed secondary data sources and documentary reviews. The documentary review was made from empirical study of three highways of Amhara, Afar and Oromia regions. The respective study corridors are: Gendewuha – Gelago (gravel type with distance of 125 kms), Mile – Weldiya (paved with distance of 165 kms) and Ginchi – Kachisi (gravel type with distance of 105 kms). The spatial scope of each study area refers 20kms diameter (10 kilometres on both sides of the roads). By using quasi-experimental research design the direct and indirect socioeconomic impacts were compared with before five years of intervention and during study time of road development. The degree of impact was also compared with changes spatially occurring within 5kms and above five kms from each study road.

In addition to vast secondary time-series data of more than 60 years, and documentary review, qualitative data from 77 key informants had been considered. Furthermore, seven end-user persons with disabilities, mainly from Addis Ababa participated in the study. Trend analysis from outputs of GIS utilizing satellite imageries, and traffic counts was also included.

Data analysis was also based on quantitative and qualitative data. Out puts of random method approaches and paired sample t test were used to analyse secondary and primary data, respectively. Qualitative data was analysed using thematic analysis approach. Generally, analysis methods varied from simple summations and percentages to advanced techniques such as trend analysis, and measurement indicators of transport performance, graphs and other methods.

Results and discussion

Historical development and planning trends of roads in Ethiopia

The Ethiopian experience in road transport development, planning and expansion performance can be discussed under the different regimes as briefed below.

Pre-1973 (Imperial Regime):

Historic chronicles of the 17th and 18th centuries show that there were a number of small roads trails and foot paths, in addition to the traditional shoulder porterage, animals like mules, donkeys and horses and camels were used as a means of transportation in Ethiopia. In the 18th century, especially during the reign of Emperor Tewodros, although the technology was primitive it was believed that planned road construction efforts were made. It is also believed that Emperor Yohannnes IV, who succeeded Tewodros, was engaged in road building. However due to the danger of invasion by Egyptians, Derbush and Turkish the Emperor was not able to achieve his desires (Bogale, 2016).

The construction of modern highways and transport service in Ethiopia started during the regime of Emperor Menilik (1889-1913), the founder of modern Ethiopia. In 1902, he undertook the construction of the roads from Addis Ababa to Addis Alem and from the palace (presently located in the area known as Arat Kilo) to the British Embassy and to many different directions in the city (Meron, 2007). The construction of these roads was soon followed by the import of the first automobile to the country in 1908. The vehicle was brought from Britain by a foreigner caller Mr. Bentley. During his importing, Bentley was convinced that he needed a very

strong kind of vehicle that can withstand the long trip and unfavourable road conditions since there was no paved road in the country at that time (Eskinder 2007). In 1912, Emperor Menilik received a present from the King of Austria, a roller (stone crushers) for paving roads, which operated with steam energy. Then the road pavement was undertaken from the palace to 'Entoto Genet' and Addis Alem into modern standards. The rest roads were doomed to be dry and wet season types (Meron 2007). In 1915 other motor vehicles were imported to Ethiopia from Germany and Britain (Eskinder 2007). However, up to the end of his reign in 1920, road pavement was not successful as expected and the transportation within the country was limited to the use of mules, donkeys and horses as well as camels in low land regions with most of the roads being nothing more than trails. Furthermore, it was during the reign of next successor, Emperor Haileselasie I (1930-1974) that road construction began to be undertaken in a better modern and extensive manner.

Regarding the road network expansion in Ethiopia, time series data of Ethiopian Roads Authority (ERA) has been summarised and computed since 1950s. Accordingly, when the Imperial Highway Authority was established in 1951(renamed Ethiopian Road Authority in 1974), the total road stock was 6,400 kms (0.30 per 1000 people) which was built during the Italian invasion (1931-1936). The mean distance of the network had decreased from 95.31 kms in 1951 to 70.93 km in 1970. The road network in this Era was characterized by radial patterns centring the capital city, Addis Ababa to different resource areas, and administratively important towns and historical sites. It is following these radial roads that the major towns in Ethiopia emerged. The 40-towns master plan project in the mid-1960s that was undertaken by Italian consultant firms was an important opportunity in the consideration of road network. But these town masters plans did not deal adequately with transport facilities like bus and truck terminals, parking, junctions, and traffic control points as an integral part of the transport infrastructure. Moreover, they paid little attention to integrate urban transport with regional transport system (NUPI 2006).

At the end of the Imperial political power (in the early 1970s), the road stock reached to 9,160 km. In this period, the average annual growth rate of road network expansion was 4.6 percent. The road length per 1000 people and per 1000km^2 was also 0.30 and 5.2km in 1951, respectively. The respective figures were 0.29 (this decline is caused by low rate of road growth may be due to political instabilities during the transition period than population growth rate) and 7.7 km in 1973 (Table 4.1).

1974-1991 (Derg Regime)

A major breakthrough in urban transport planning was observed in 1986 by Addis Ababa Master Plan (AAMP). It had considered the regional metropolitan transport system; the road network; public transport services and basic infrastructures; future urban mobility scenarios; integration of road infrastructure with public utilities; mass transit consisting of metropolitan railway system; a trolley bus service and the main bus system. AAMP also considered priorities and implementation programmes for key projects though it failed to provide detail action plans for its implementation. Following the AAMP, many urban plans were prepared by the National Urban Planning Institute (NUPI) particularly after 1987 and next Regional Works and Urban Development Bureaus since the early 2000s. However, the attention they gave for road and transport planning was mainly focusing on the city level road networks and not supra-urban level (NUPI 2006).

In terms of the network expansion status (Table 1), when the Derg assumed power (at the end of 1974), the road network had grown to 9,260 km, of which 3,360 km (36.7%) was paved. By 1991, the network had increased to 19,017 km of which 4,109 (21.6%) was paved. The increase over these years was mainly due to the expansion of the rural network most of which was unpaved. Average annual road growth rate was 4.2% which was lower than both Imperial and, as we shall see later, with the EPRDF period. At the end of its political power (after17 years), the road density per 1000 people and per 1000km^2 reached to 0.36 and 15.6kms respectively.

1992- Present (EPRDF Regime)

In the first quarter of 1990s, the Government of Ethiopia gave more emphasis to expand road network to meet its development goals. These goals are: (a) upgrade and expand essential infrastructure; (b) advance the private sector; and (c) conserve the environment. To implement these strategies, the Government formulated the 10-year Road Sector Development Programme (RSDP 1997–2007), a two-phased integrated package of investments, reforms, and institutional reorganization. The programme was later extended to include a third phase up to the end of June 2010. In 2015, ERA completed the 4th RSDP (ERA , 2018)

Analysis on road network expansion and pavement in Ethiopia

After the ousting of the Derg by EPRDF, and due to the formation of Eritrea as a new state in 1992, the road network in the remaining part of Ethiopia was 18,081 kms, of which 3,542 kms (19.9%) was paved. By 2002, the road network had reached 33,297 km of which 4, 053 km (12 .2%) was paved and the remaining 29, 244 km (87.8 %) was gravel. As a result of huge investments under RSDP I, II, III, IV and V, theand the remaining huge proportion is unpaved (1). The figures show that the proportion of paved roads is very week in the EPRDF period (Bogale, 2016).

As shown in the trend line of 67 years data (Table 4.1), both total road, and rural road growth were generally increasing upward almost keeping parallel pace until 2011. But after 2011, a new campaign at *wereda* level contributed to significant increases in the amount and average annual growth rate that reached 7.5%. The average growth rate of asphalt roads almost remained flat up to 2009 .

Table 1 Road Length (kms), Road Density and Population Growth in Ethiopia (1951-2018)

Regime	Year	Asphalt	Gravel	Rural	Wereda Road			Total	Average Annual Growth Rate of Road[1]	Population (000,000)	Road Density /1000 people[2]	Road Density /1000 Sq.km
Imperial Period	1951	3400	3000					6400	4.60%	21.5	0.30	5.2
	1973	3360	5800					9160		31.3	0.29	7.7
Derg Period	1974	3360	5900					9260	4.20%	32.1	0.29	7.6
	1991	4109	9298	5610				19017		53.0	0.36	15.6
EPRDF Period	1992	3542	8968	5573				18081	7.5%	53.3	0.34	14.8
	2018	15886	12813	35985	56732	1693	3864	126773		100.0	1.27	115.2

Source: Computed by the author based on ERA Data

1 The mathematical model of average annual growth rate of road is ***AAGR = [∑[(X$_2$-X$_1$)/X$_1$]*100]/T****; Where AAGR is Average Annual Growth Rate of Road; X$_2$ is the next or the end value of road performance; X$_1$ is the beginning value of road performance; and T is defined here as number of years.*

2. Area of Ethiopia before 1992 was 1.22 million km^2; after the separation of Eritrea the density is computed by 1.11 million km^2

Figure 1 below also depicts that the rate of pavement is 42, 27 and 14% in Imperial, Derg and EPRDF periods, respectively. According to a World Bank study (2014), the density of paved roads per 1,000km^2 in Ethiopia was 8 kms which is below the average of low income countries.

The selected low-income and less populated countries with the share of paved road in this study are Nigeria (31kms), Cameroon (9kms), Vietnam (423kms), Madagascar (10kms), Kenya (19 kms), Cambodia (13 kms), and Algeria (36 kms)(World Bank, 2014).

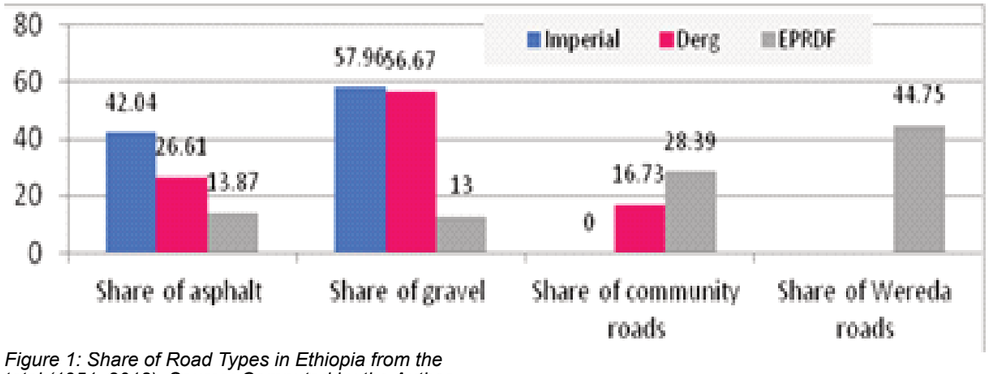

Figure 1: Share of Road Types in Ethiopia from the total (1951–2018) Source: Computed by the Author based on the raw data of ERA

Comparing road density status of Ethiopia with low and middle income countries

In spite of recent increases in the density, the road network of Ethiopia is one of the least developed in Africa. For instance, in 1997 Ethiopia had 0.5km per 1000 people as opposed to Sudan (0.8), Kenya (2.3), Tanzania (2.0), Angola (6.0), DR. Congo (2.8), and South Africa (12.6) (ERA, 2007). By 2010, the figure for Ethiopia had increased to 0.59 km per 1,000 people and 44.4 km per 1000 km^2 (the change which is lower than the Africa region average of over 54 km per 1000 sq. km) (ERA, 2011).

On the other hand, Ethiopia's road development status can also be compared with low and middle income countries using comparable data for 2012. Accordingly, the average road density for the low-income countries is 39.5km per 1000 km^2, whereas Ethiopia's road density at 49km per 1000 km^2 is greater than the average of low income countries. The average road density for the middle-income countries is 104.7km per 1,000 km^2, which is twice higher than that of Ethiopia. The average density in high-income countries is 167.6km per 1,000 km^2, which is about 3.4 times higher than that of Ethiopia. However, the road density in very high-income countries (315.8km per 1000 km^2) is about 6 times higher than that of Ethiopia. Finally, the ERA, 2014a document suggests that Ethiopia should reach a road density of about 120km per 1000km^2 to arrive at middle per capita income countries by the year 2025.

Road infrastructure growth index

Road growth index is commonly used to evaluate and compare the changes by taking into consideration the base line in the given time. The model developed in this study is indicated as follows:

$$Rgi=(k/x_1)*x_2,x_3,x_4,\ldots\ldots x_n \quad \ldots\ldots(1)$$

$$ARgi = \sum[(k/x_1)* x_2, x_3, x_4,\ldots\ldots x_n] / T \quad \ldots\ldots(2)$$

- *Where Rgi is the value of road growth index*
- *K is the constant and here is 100*
- $x_1, x_2 \ldots x_n$ *are the consecutive figures according to the given time* x_1 *considered as base line*
- *ARgi is the value of average road growth index*
- *T is time*

As illustrated in Figure 2A, by taking 1951 as the base line *(index = 100),* growth of total road, paved road, Ethiopian population and road density indexes per population could reach to 1981, 517, 465, and 510 in 2018 respectively. The growth rate of the road network is very fast particularly after 1992 (Figure 2B). However, the figure illustrates that pavement and the impact on density is not rapid, though improvements have been observed particularly since 2011 under GTP-1 implementation.

Regional comparisons of road growth and induced density changes

Data on changes in road density depicted in Figure 4.3 shows significant differences across the various regions. The comparison is made excluding urban centred regions like Addis Ababa, Dire Dawa and Harari National Regional states. As illustrated in the Figure, Amhara Region is found to have very low road density as compared to other regions during the last seven years. It performed the road density of 0.15, 0.2 and 0.38 in 2007, 2010 and 2013, respectively.Whereas sparsely populated regions like Gambella and Afar have high road density. In terms of total road length, comparison can be viewed among the three highest populated regions. Oromia with 8354 km is the first (31.33% of the total road stock in the country) followed by SNNP region that has 7482 km (28.06%) in 2013.

Comparing road network growth with motorized vehicle growth in Ethiopia

The low level of road provision in Ethiopia is accompanied by a very low level of motorization. The total vehicle fleet has been growing at an annual average rate of 6.7% as it increased from 96,502 vehicles in 1996/97 to 190,367 in 2006/07 of which, 69% are passenger vehicles, 28% are cargo vehicles while the remaining refer to other types such as motor cycles.

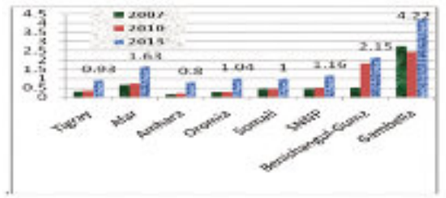

Figure 3: Road Density Changes in Ethiopian Regions in Selected Years 2007 -2013) (km per 1000 inhabitants)
Source, Computed by the Author based on data of ERA

Furthermore, in 2013, the total number could reach to 474,143 vehicles which is 5.5per 1,000 people in the country. When we compute and compare the density of low and middle income countries with the available data for 2012 that is obtained from ERA, Ethiopia has 3.3 vehicles per 1000 people which is 2.8 and 19 times lower, respectively. With regard to Ethiopian regions, excluding urban areas (outliers like Addis Ababa, Dire Dawa and Harari), average vehicle ownership is 1.59 per 1,000 people. The figure

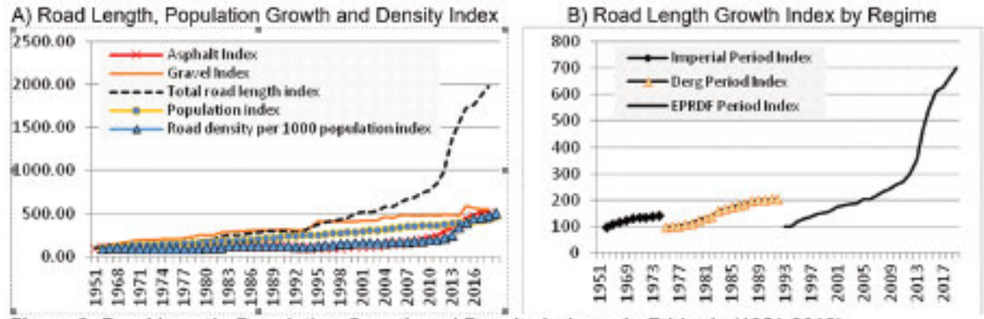

Figure 2: Road Length, Population Growth and Density Indexes in Ethiopia (1951-2018)
Source: Computed by the Author based on ERA Data, 2018

In this perspective, Oromia, has performed 2.3 times greater. than Amhara, which is expected to have better implications in terms of socioeconomic impacts

for Tigray (4.82 per 1000 people) is 5.54 times higher than that of Amhara (0.87 per 1000 people) in 2013.

Analysis of impacts of road network development on accessibility by using random model approach

In the preceding sections, explanations was given how the implementation of road development strategies brought about gradual changes in the total stock of roads as well as in the overall densities per inhabitant and per area. In particular, the empirical results that are based on time series data show disparities among the last three regimes. This can be attributed to the fact that different regimes accord different priorities to the road sector. In the following sections, it is also important to analyze the extent of impacts due to policy interventions on accessibility, road conditions and mobility.

The change of accessibility can be demonstrated by employing the commonly used parameter, *Random Model Approach*. The word *random* is to explain that if all pieces of road tracks are distributed equally in a given area, keeping many other barriers constant. Of course, in reality, it is impossible to distribute all road tracks equally in a given area because of natural and man-made factors. The random model approach, therefore, is a model which measures road accessibility scientifically (ERA, 2008). In this model, accessibility is measured in terms of the distance to the nearest location of the road network for any residence or business area. The random model assumes that the road track is straight and distributed randomly on a plane. The time series data available for the period 1951 to 2018 is computed to check the impact of the road network expansion on accessibility during the three regimes.

For a given pattern of roads, the average distance to be travelled per person to a road link is inversely proportional to the area's road density. Assume that, for an area *'A'* with road length *'L'* the *mean distance* to the road network *'M'* is given by *0.5A/L*. i.e. the constant of proportionality is around half. Within the given area, the average distance to the nearest all weather road may take long hours before the construction of additional roads. But if the government or local communities intervene and developed the road network length in the same mentioned area, time or distance of taken to arrive to the nearest all weather road obviously reduces since the road density per area is increased. For instance, the total area of Ethiopia in the Imperial and the Derg periods is the same, 1.22 million km^2 whereas in the EPRDF period, it is 1.1million km^2. The total road length in 1951 and 2016 is 6,400 and 113066kms of randomly distributed network of the country, respectively. The mean distance to the network is calculated as:

In 1951(during Imperial period) = 0.5(1220 000km^2)/ 6400km) = 95.31km*

In 1970(during Imperial period) = 0.5(1220 000km^2)/ 8600km) = 70.93km*

*In 1990(during the Derg Period) = 0.5 * (1 220 000 km^2 / 18946km) = 32.20km*

In 2013(during EPRDF) = 0.5(1100 000 km^2) / 85966km = 6.4km*

In 2018(during EPRDF) = 0.5(1100 000 km^2) / 226773km = 4.34km*

The computed result shows that the mean distance of the network had decreased from 95.31kms in 1951 to 70.93km in 1970 during the Imperial period; and to 32.20kms in 1990 during the Derg period and finally to 4.34kms in 2018 under the EPRDF period. As illustrated in Figure 4.4 the result shows that the accessibility (proximity to the network) is increasing from year to year with decreasing in the average distance within each network. Based on this, the *proportion* of the area farther than a given distance, '*d*' to the network is given by the formula $P = e^{-d/m}$. The proportion of the area, for instance, more than 5 km from all-weather road networks in 1951 in the country was 95 percent.

$P = e^{-5/95.31}$ *= 95 %; where 'e' is transcendental number given as 2.718 282*

As computed based on the above formula, the change in 1970 was 93%; in 1990, 86%; in 1997, 79% and in 2018, 34%. Figure 4.4 shows that the *proportion of areas beyond 5km of all-weather roads* is declining. In other token, the proportion of the area within a distance of 5 kms from all-weather roads had increased from 5 percent in 1951 to 66 percent in 2018. The result confirms the existence of a gradual increase in network accessibility under all of the three regimes. Accordingly, one can say that such change contributes to socioeconomic development of the country at macro level in general and its citizens in particular as briefly summarised below.

The findings show that there are more positive and less negative temporal and spatial socioeconomic impacts generated by the three corridors notwithstanding disparities among the different locations. Accordingly, the paved highway is found to have more powerful positive impacts than the gravel roads, which are of low standards and functioning poorly. The status of truck and bus terminals which should have been integrated in the highway development projects are still underdeveloped with obvious effects on the sustainability of their socioeconomic impacts in the study areas. Specifically economic and social impacts are briefly summarised below.

Figure 4 Trend of Average Distance to all Weather Roads(km) and Proportion of Area More than 5km from all Weather Roads(%) in Ethiopia(1951-2018)
Source: Computed by the Author based on data of ERA, 2018

The positive socio-economic impacts (benefits) gained due to such all-weather road accessibility growth are many among which the empirical study of three highways of Amhara, Afar and Oromia regions, can be recent evidences. Based on the empirical data from 392 households, the results show that road access has brought about economic and social impacts temporally and spatially as summarised in the following sections.

Temporal and spatial impacts of road network accessibility on economic and social aspects

As stated by Bogale(2016), governments' intervene temporally and spatially on road construction and maintenance. Such strategy implementations bring about short, medium and long term economic, social and environmental impacts. The results of empirical study taken from 392 respondents in 2014 from three road corridors (Gendewuha-Gelago, Mile-Weldiya and Ginchi-Kachsi) by Bogale are summarised in the following sections.

Economic impacts

- The paired sample t test shows that there are significant changes in individual incomes between the "before" and "after" the project intervention throughout the study corridors. All results are significant at p value of less than 0.001.
- Regarding the use of agricultural technologies, improvements have been achieved due to road intervention though still at infant stage. Fertilizer use in Gendewuha-Gelago, Mile-Weldiya and Ginchi-Kachsi is found to be 1.15, 1.02 and 1.18 times greater after road intervention than before.
- The road intervention has strong significant impact spatially on the productivity of maize within less than 5kms than 5 to 10kms from the study roads (at P value of less than 0.001 and 0.05, respectively). On the other hand, the significant differences from Mile to Weldiya and in all corridors show negative road intervention impacts for sorghum.

- In terms business expansion, the average initial capital the businessman before road intervention was ETB 12,093.18, whereas, during the follow-up period, it had been increased to ETB 138,229.84. The increase is 1043 percent and is significant at P value of less than 0.001.
- As regards the average amount of tax businessman pay per year is calculated to be ETB 1,231.04 and 4,380.56 before and after the road intervention, respectively. The increase in this regard is 245.85 percent and is significant at P value of less than 0.05. This contribution shows how the road development adds value on GDP of the Country.

Social impacts

- The density of population is found to be higher near the study roads, which was observed to be even higher in 2014 as compared to the base line situation in 2007.
- Households were getting lower number of meals per day before than after the road intervention, with households located near the study roads (<5kms) getting 1.3 times higher number of meals than those households located away (>5kms) after the road intervention except in some parts of highway in Afar region.
- In terms of access to education, it has been computed that the longer the distance of a household from the study roads, the lower is students' school enrolment.
- As computed based on mean values, there is positive change in terms of access to health facilities (km) by 1.82, 5.80, 9.0 and 6.18 percent for Mile - Weldiya, Gelago - Gendewuha, Ginchi - Kachsi highways and for all corridors, respectively, and the result is found to be significant for all corridors taken together at p value of less than 0.10.
- Women are thus found to have had more intense work burden before the road intervention than after, while the same holds true for women within less than 5kms than 5 to 10kms from the study roads.

Temporal and spatial impacts of road sector development program (RSDP) on road network quality, mobility and urban settlement expansion

Since there are no complete data available for the previous two regimes, the researcher has used the last seventeen years data to analyze trends in quality and mobility.

Impacts on road network quality in Ethiopia

The share of the road network categorized under good condition had been increased from 22 percent in 1997 to 72 percent in 2016**.** In other words, during the first year of RSDP, 52 percent of the road network was found to be in poor condition and only 22 percent was in reasonably good condition. The proportion of roads in good condition has overtaken the proportion of roads in poor condition from 2004 onwards. Another observation is that the roads in fair and poor condition are consistently declining shifting to good condition since 2002. This change is mainly linked with the rapid expansion of roads with better standards as well as attention given to road maintenance.

In general, interventions made to standardize and maintain roads had contributed for further improvements in the quality of roads. Yet, the World Bank study (2014) mentioned above pointed out that the density of paved road of Ethiopia still remains far below the standard of 260 middle-income countries in 2013. When changes in road condition over time are viewed in terms of their classification, that is asphalt and gravel roads, it shows improvement in good condition from 17 to 74 percent and from 25 to 55 percent between 1997 and 2011 respectively (RSDP III- 2009, ERA, 2014, 2016).

Impact on mobility

Classified traffic counts have been undertaken on most of the road network in Ethiopia. An assessment of traffic on main roads reveals that there is a rapid and continuous change in the volume of motorized traffic mobility (3,771,565 VKM in 1997 to 27,119,110VKM in 2015). It shows that rate of traffic growth is about 10.6 percent per annum on average(ERA, 2018). This is the fact that with an increase in road expansion and road quality, traffic mobility increases.

Impact on urban settlement

- Based on the study of three corridors stated under section 4.8, the expansion of the built up areas in general exhibited a peak immediately after the road interventions as shown in Chifra town of Mile to Weldiya study highway. It is evident that this pattern also holds true in the others study roads.
- The annual average expansion rate of settlements along paved study roads is found to be higher than that has occurred in the gravel roads. This shows that paved roads have more strong impacts in settlement expansion than gravel roads. As computed employing GIS software, the annual average settlement expansion in Chifra and Hara towns (along paved road of Mile to Weldiya study highway) is 11.7 and 4.5 percent, respectively, whereas, in Shikute and Kachisi (along gravel road of Ginchi to Kachisi) is 1.1 percent. That means, the lower the distance against each road, the higher is the settlement density.
- In all the study corridors, the proportion of houses with wood and mud walls has exhibited a slight decline from 91 to 88%, while those with stone walls increased from 1 to 3 percent. On the other hand, there has been considerable conversion from thatched to corrugated iron roofed houses after the road intervention

Satisfaction level of end users on accessibilities and facilities of road infrastructure

Accessibility ensures that all citizens have nearness of the road transport services which the users require. Facilities also deal with the conditions and appropriateness of the road transport service delivery sites and their appearances to meet the users' needs and expectations. In both cases, the finding of empirical data of 4309 passengers in all regions of Ethiopia(a study by Federal Transport Authority) indicate that their satisfaction rate is 54 and 51 percent respectively where Addis Ababa is the least among all regions (FTA, 2018)

As the results of interview made by the Author (2018) author the disabilities confirmed that the designs of roads, parking and terminal facilities for disabilities are with very poor access in Ethiopia. For instance, road crossing accesses are not to the standard. For some roads lines, ditches are constructed at both or at one side of road, but the design excludes for disabilities crossing particularly for physically impaired and visually impaired community. For instance at the place where interviewee lives, ditch had been constructed parallel to the route. To cross this open ditch, she asks her family or neighbours to lay a lumber. Some roads are also with elevated and traditional stares difficult to climb as observed at Hara, Chifra and in many other secondary cities of the country. Some are also being excavated by other sister sectors like telecommunication, electric power and water resources for reconstruction or to fix their network and stay damaged for long years. Holes along main roads are common dangers of disabilities particularly for visually impaired persons. The existing condition in this regard shows that the federal and local governments are not abiding to the rules and international conversions. Disabled and non-disabled end users of the road service customers walk more than 10 minutes at an average to access nearest

motor-able road terminal or parking in many cities of the country. This shows that the nearest road access is below the world standard distance of 5 minutes' walk. Generally the access and facilities of roads what we call physical infrastructure have satisfied the disabilities by more than 30 percent. Therefore, even though there are physical changes in terms of overall road development, the satisfaction level of end users is very low as quantitative and qualitative evidences confirm. Under the following sections the negative impacts due to road development will be discussed.

Road traffic accident (RTA), which is one of the main direct negative impacts of road development, is increasing from time to time and has impacted in Ethiopia as fatalities, disabilities and property damages (which is estimated to be reduction of equivalent to about 1 percent of the national GDP per year). Many economies in the world should pass through the growth of population, road network and motor vehicles. These can be viewed as opportunities and non negligible to be attained in the life of the countries and have paramount roles in the socioeconomic developments.

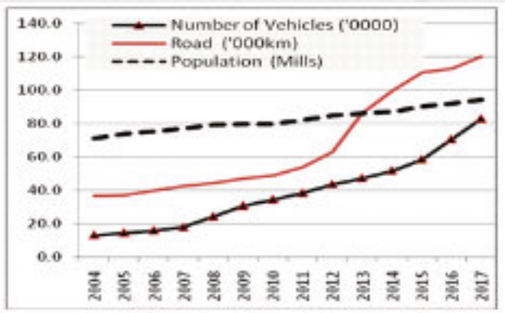

Figure 5: Trends Vehicles, Roads and Population Growth in Ethiopia (1996-2017)
Source; Computed by the Author based on data of ERA, and MoT, 2018

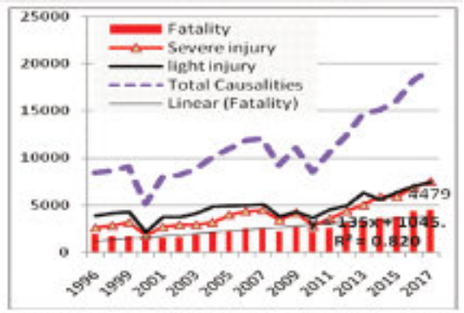

Figure 6: Traffic Accident Trends in Ethiopia (1996-2017)
Source; Computed by the Author based on data of ERA and MoT, 2018

Overview of negative impacts of road development in Ethiopia

Road development has much positive socioeconomic impacts. However, one should not put this infrastructure development always as positive since it contributes to impacts of traffic accidents, traffic congestion and environmental degradation (particularly air, and noise pollution). The dominant problem happening in developing countries like in Ethiopia is the former outcome. In line with this, this section describes road traffic accident trend in Ethiopia in general and the impact in Addis Ababa in particular (where about 70% of Ethiopia's vehicles dominate).

Overview on road traffic accidents and impacts in Ethiopia

However, in other side, these opportunities also passes certain threats like road safety problems (road traffic accidents, road congestions and environmental degradations) which could be obviously happening dominantly in developing countries. Figure 4.5 and 4.6 and 4.7 illustrates part of the issues explained above in Ethiopia.
The increase of traffic accident is enduring as normal agenda in Ethiopia (a country of very low per capita vehicle ownership).The number of traffic fatalities in 2017 had been increased by 129 percent as compared to the baseline year (1996), with an average annual growth rate of 5.85 percent. In terms of fatalities in 2013, about 50, 34 and 15 percent were pedestrians, passengers, and drivers respectively. During

2017 and 2018; 4,479 and 5,118 people were killed along the road.

Bogale's study(2016) from FGD made at Hara (Highway of Mile - Weldiya) study centre illustrated that about 95 percent of the paved route is elevated from the normal surface (ground) level thus challenging to livestock and even old people that try to cross it. Due to poor road designs, some sections of the study roads that have sharp curves and sloppy route were prone to frequent traffic accidents. A good example is the locality named as Allewuha (Highway of Mile to Weldiya), which is 11 kmsfrom Hara town. That area is known by the frequent fatality of the road users. In addition, Ethiopia is with poor road safety audit system as compared to cross countries and this gap is said to be one of traffic accident escalation.

Impacts of road traffic accidents (RTAS) on quality of life, the case of Addis Ababa

Once individuals come across RTA, their chances could be death, heavy injury, light injury or property damage. The victims and their families will suffer from low quality of life, which would result from health related impacts such as pain, or temporary or permanent disability. Because of data limitation, this section focuses on the impacts of both heavy and light injuries in Addis Ababa.

As analysed by Bogale (2016), RTAs contributes up to 29 percent of the total annual disability caused by all forms of accidents in Addis Ababa. He indicated that musculo-skeletal injuries are ordinary in road users obviously for pedestrians. Moreover, severe limb strain, psychological disorders and depression are the long lasting wounds that road accident can bring about. People who are hurt can have physical and mental impacts and even they are people who are facing themselves with the problem of activities and capabilities which may be permanent upon them. Furthermore, the victims or their households can be further forced into financial burden or selling of their own assets, or interruptions from schooling. If the injured is from poor households, the impacts can run much deeper since the poor segment of the society also happens to be an extremely vulnerable group. In this case Quality Adjusted Life Years (QALYs) model can be used which the researcher could not show the measurements due to non-availability of complete data. QALYs is a health outcome measure that gives a value of one to a year of perfect health and zero to death (Gold *et al*., 1996, cited in Samson *et al*, 2012). This model is widely used by transport planning and transport economics.

Conclusion and recommendations

Using time series data, the performance of road expansion has been analysed since 1951. A spatial analysis on the trends in the distribution of the road network is made both at the national and regional level, which is also compared with the situation in other countries. This analysis of the performance of road expansion is the first objective related with programme theory and to a certain extent with graph theory. programme theory is understood as the underlying assumptions and delivery mechanism of how a programme set should work. It is related to the development of programme goals and objectives.

The remaining objectives of the study are also more of about positive and negative impacts directly and indirectly occurring temporally and spatially most importantly based on change theory. The primary data from temporal point of view confirms that there is a significant change due to road accessibility between before 5 years of road intervention and during study time as computed using paired sample t test. This temporal change has also a significant impact spatially benefiting households in influence zone of less than five kms as compared to households above five kms (control zones). With context of

spatial impacts, theory of change postulates that distance of individuals' residence from the road is inversely related to their income, suggesting that the longer the distance of individuals from the road, the lower is their income

In this regard, explanations had been given how the implementation of road development strategies had brought about changes in the stock of roads, accessibility, mobility, and overall socioeconomic changes upon households of the study areas notwithstanding their negative impacts due to road traffic accidents (RTAs). What should be advised for decision makers and stakeholders as to whether to expand, or improve road related interventions by way of programmes, projects and policies throughout the country to gain positive socioeconomic impacts from road development?

- Government at all levels should take appropriate measures towards upgrading the unpaved roads expand new links throughout the country by creating coordination and mobilizing the community at their local areas and implement sustained mobility environment for end users. .
- It is obvious that mobility on the road is accompanied by traffic accident related risks. With the rapid expansion of roads for vehicular use, about 95 percent of traffic-related accidents occur on the road mode as compared to other transport modes (Rodrigue *et al*, 2014). It can be said that RTA in Ethiopia is a major health scourge. Therefore, national and local governments should have strict measures on the accident spot areas, proper implementations of rules and regulations, road safety audit, road quality and standards and appropriate technology use.
- The rapid expansion of roads in Ethiopia is expected to invite further increase in motor vehicle ownership. Therefore, proactive actions must be made by measuring the quality of life in terms of impacts and costs that RTA can be caused by the increased in fixed facilities and flow entities.
- Federal transport authority and the regional transport bureaus in collaboration with other stakeholders should upgrade service points and ensure accessibility to all users (including the disabled and elder).

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