RURAL TRANSPORT IN GHANA –COST-BENEFIT ANALYSIS OF ROAD AND RAIL INTERVENTIONS

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Abstract

This paper assesses the economic viability of two rural transport interventions in Ghana; (1) the development of paved roads between district capitals and certain areas of high agricultural production and tourism, and (2) the revamping existing rail network and building new rail network to extend coverage to the north of the country. The benefit-cost analysis (BCA) results show that improving rural roads has the potential to, significantly, limit post-harvest losses. The estimated PHL savings from the road intervention is GHS11.5 million per kilometer of paved road per year. Overall, the BCRs for the road intervention project is noted to be 1.5, 1.2, and 0.9 for the reference parameters for the opportunity cost of capital, 5%, 8% and 14%, respectively, on a 30-year reference period. The BCRs are still observed to be in excess of 1, at 5% and 8%, when (1) the cost overruns are doubled to 45%, and (2) the estimated post-harvest losses attributed to transport is altered by +/- 10%. For the rail expansion project, the greatest gains accrue in the form of transport cost savings. The analysis reveals the project is sensitive to the discount rate and only yields positive BCRs of 2.3 at 5% discount rate and, 1.5 at the discount rate of 8%. The results of BCR analyses show that support for the expansion of rural infrastructure is not just a matter of social equity and can be supported on economic grounds.

Policy Abstract

Key Take away

There is clear economic justification for public policies to direct economic resources to road and rail infrastructure development in rural areas in Ghana. This paper arrived at this determination by comparing the expected cost of committing such resources to financing road and rail infrastructure against the expected benefits.

Specifically, for road infrastructure, we identify and monetize four (4) benefits from building roads that link certain high agricultural producing areas and tourist attractions to nearest main centers in the country. These are generalized cost savings, value of carbon emissions avoided, transport cost savings, and reduction in post-harvest losses (PHL). Of these, the reduction in the PHL brings about the greatest gain.

After accounting for all expected costs, including cost overruns, the analysis indicates that linking the identified areas of high agricultural production and tourist attractions to nearest main centers in the country will return 123 pesewas for every cedi spent. This informs that the project will deliver positive net present value to the country.

The rail intervention project involves the conversion of 668km of existing narrow gauge to standard to single-track standard gauge 1,435 mm (4 ft 8 1⁄2 in) and the construction of new 3340km rail tracks. Similar to the road intervention project, we identify and quantify, in monetary terms, six benefits that are reasonably expected to result from the implementation of this intervention. These are time savings, avoided cost of road transport, revenue from increased passenger traffic, carbon emissions saved, accident (road) savings, and post-harvest losses. Among these, time savings presents the highest benefit.

Compared to the expected cost of the rail project, the analysis shows that a cedi spent on rail intervention returns 150 pesewas per kilometer, confirming the viability of the intervention.

The Problem

The economic growth literature suggests that the volume of infrastructure stock as well as its quality positively and impacts economic growth by, among others, decreasing the cost of production and transportation of goods and services, improving the productivity of input factors, and creating indirect positive externalities. The extant evidence in Ghana, however, depicts a significant deficit in both volume and quality of infrastructure, thereby, limiting the country's potential in harnessing its resources. The road infrastructure, for example, has a total network of 78,402 kilometers with only 49% either maintained or rehabilitated. In addition, the total track length of the rail network is 1300km, with the rail industry operating a route length of 947km. Notably, up to 60% of the rail network is not used on a regular basis, with the decay of the rail infrastructure often cited among the main causes. There is, thus, a strong need for interventions aimed at revamping and extending both the road and rail routes to link important points, especially rural areas to main district capitals to enhance economic activities. Public policies should, thus, direct economic resources towards developing such infrastructure. This is necessary to boost the competitiveness in doing business in Ghana and stimulate and enhance the country's growth prospects.

Intervention 1: Development of Rural Roads

The greater part of the inland transport in Ghana happens on the roads, with the road transport system taking up 96% of freight and 97% of passenger traffic. However, the road network is poor, with only 49% of the total length of the road network either maintained or rehabilitated. Of particular note, the feeder *roads networks* constitute 62% of the total road network. These feeder *roads* link a large part of *rural* communities, where the majority of the population lives, to main centers of commerce, among others. In addition, many of the tourist attraction in Ghana, e.g., Kakum and Bole National Parks, Tagbo & Wli waterfalls as well as Mount Afadjoto, are all located in rural areas. However, 65% of feeder roads is deemed to be not in good shape. This limits commerce in the rural areas and the contribution of the rural economy to Ghana economic growth prospects. Committing public resources to develop the road network, particularly in agricultural producing areas as well as tourist attractions, has the potential to enhance the welfare of rural dwellers as well as improving Ghana's growth prospects.

Implementation Considerations for road intervention

The intervention consists of the construction of 1888km of roads to be completed over a period of 11 years. We assess the viability of the intervention over a 30-years period, starting in 2019. The expected net present values of the cost of the project is GHS5.3 billion at 8 percent discount rate.

Costs and Benefits

Costs

The total cost of the project comprises construction cost, including a 22.5% cost overrun, routine and periodic road O&M costs. The total estimated cost for the intervention amounted to GHS5.3 billion at 8 percent discount rate. An annualized cost breakdown is further provided.

Benefits

The total monetized benefit for the intervention encompasses a reduction in generalised cost (comprising vehicle operating cost, and travel time), carbon emission avoided, reduction in transportation cost and reduction in post-harvest losses. The expected total net present value of the benefit for the road intervention is estimated to be GHS6.5 billion at 8% discount rate.

Intervention 2: Rehabilitation and expansion of Railway tracks

Railway transport is a viable alternative to road transport especially regarding the transportation of bulk cargoes and freights across the country. However, the poor state of the Ghana railway transport sector has remained a drag on the development of the sector and the economy. Rail transport accounts for a mere 4% and 3% of passenger and freight traffic in Ghana, respectively. Although there were initially only two operational railway lines; the Western and Eastern railway lines, only the eastern line has remained operational as the western railway line was suspended in 2008. It is noteworthy to highlight the meagre coverage of the rail tracks network of 947 km, out of which more than 60% is often out of use due the poor state of disrepair. Public investments in modern railway system would improve Ghana international competitiveness and market access, stimulate industrial and labour productivity growth rates, attract agglomeration effects and boost economic growth with huge social welfare implications.

Implementation Considerations for rail intervention

The rail intervention project consists of the rehabilitation of 668 km of existing narrow gauge tacks by converting them into single-tracks standard gauge as well as the expansion of rail networks to the northern region of Ghana by constructing new standard gauge tracks with a total length of 3340km. We assess the viability of the intervention over a 30-years period, starting in 2019. The expected net present value of the cost of the rail project is GHS72.1 million per kilometer at 8 percent discount rate.

Costs and Benefits

Costs

The total cost of the rail project comprises new construction and rehabilitation cost, routine and periodic track maintenance costs, rolling stock capital cost as well as the rolling stock maintenance cost. The expected total net present value of the cost for the rail intervention is estimated to be GHS 72.9 million per kilometer. An annualized cost breakdown is further provided.

Benefits

The total measured benefit for the rail intervention encompasses travel time savings, avoided cost of road transport, carbon emissions avoided, accident fatalities avoided and reduction in postharvest losses. Other expected benefits include the residual values accruing from both new track construction and rehabilitation of existing tracks. The expected net present value of benefits for the rail intervention is estimated to be GHS109 million per kilometer.

BCR Summary Table

Intervention	*Total Benefits (GHS)*	*Total Costs (GHS)*	*BCR*	*Quality of Evidence*
Linking Agricultural producing areas and tourist attractions to district capitals	6.5 billion	5.3 billion	1.2	Medium
Rehabilitating 668km of rail and constructing 3340km of new rail	109 million per km	73 million per km	1.5	Medium

Notes: The road intervention project reports the lump sums for both investments costs and benefits. The rail intervention project, on the other hand, reports costs and benefits per kilometer. All figures assume an 8% discount rate

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1. Introduction

The level and efficient utilization of economic resources available to any country are essential in determining its ability to realize significant economic growth. Among the available economic resources, infrastructure, a heterogeneous term encompassing both social and economic infrastructure, has been posited to exert significant and positive influences on national output. These measurable influences can be both direct and indirect. The direct effect can be observed through the sector's input to GDP formation and as an additional contribution in the production process of other sectors. The indirect effect, on the other hand, can be through improvements in total factor productivity by decreasing transaction and other costs, thereby, enabling a more efficient use of conventional productive inputs (see e.g. Aschauer, 1989; Munnell, 1990, 1992). Calderon (2009) also shows that the volume of infrastructure stocks as well as the quality of infrastructure services impact economic growth in Africa. It can, thus, be said that well-designed infrastructure is important for specialization and the efficient production and consumption of goods and services in any country, as it helps reduce costs of trade and facilitates economies of scale. However, the reality in most African countries, including Ghana, depicts a deficit in the infrastructure stock. This, in a sense, reflects the stagnated growth across the continent. The AfDB's *African Economic Outlook 2018*, estimate the annual infrastructure deficit in Africa to be $108 billion, suggesting an urgent and continuous need for interventions to boost the infrastructure stock to facilitate enhanced growth.

In this study, we examine two economic infrastructure interventions in the road and rail sectors in Ghana with a view of boosting the infrastructure stock of the country to speed up economic growth. Specifically, we examine (1) the development of roads between district capitals and certain areas of high agricultural production and tourism, and (2) the revamping existing rail network and building new rail network to extend coverage to the north of the country. The World Bank African Infrastructure Diagnostic Report (2010) notes that although Ghana spends the equivalent of 7.5% of GDP (about USD$1.2 billion) per year on infrastructure, the contribution of infrastructure to Ghana's per capita growth is very low (less than 2% in the 2000's). The report also suggests that improving Ghana's infrastructure endowment to that of other middle-income countries in Africa can, potentially, raise annual growth by more than 2.7%, providing a strong impetus for interventions in infrastructure.

On road infrastructure, Ghana has spent, on average, 1.5 per cent of the country's GDP, one of the highest shares in West Africa (World Bank African Infrastructure Diagnostic Report, 2010). Table 1 presents information on the national road network in Ghana gathered from the Ministry of Roads and Highways publication, *Medium Term Expenditure Framework 2019-2022*. We detect from the table that the total road network length is 78,402 kilometers. Of this, 61.7% consist of feeder roads. The rest is split between urban roads (19.7%) and trunk roads (18.6%). The Ministry of Roads and Highways publication also indicated that only 49% of the road network was either maintained or rehabilitated.

Table 1: National Road Network (Ghana)

National Road Network Mix (2018)

National		78,402km	100%
Trunk Roads	Kilometres	14,583km	18.6%
Urban Roads	of Road	15,462km	19.7%
Feeder Roads		48,357km	61.7%

Source: Ministry of Roads and Highways, Ghana (2019)

As indicated by Calderon (2019), the quality of service of infrastructure stocks is important in defining how infrastructure impacts on economic growth. Thus the condition of the road network in Ghana is critical. In addition, a greater part of the inland transport in Ghana happens on the roads, with the road transport system taking up 96% of freight and 97% of passenger traffic.1 This underlines its enormous significance to economic activity in Ghana. Table 2 presents a further breakdown of road network in Ghana, based on the road conditions. We observe that 76% of the national road network is unpaved, with 60% deemed to be not in good shape. The dependence of inland transport on the road network in Ghana makes these statistics glaringly deficient.

[1] See https://www.gipcghana.com/invest-in-ghana/why-ghana/infrastructure/transportation-infrastructure.html; also see the Medium Term Expenditure Framework 2019-2022 (MORH).

Table 2: Inventory of the National Road Network

Road Network

	Trunk	Urban	Feeder	Total	%
Paved (km)	9,218	6,004	1,928	**17,150**	24
Unpaved (km)	5,655	9,458	40,117	**55,230**	76
Total (km)	14,873	15,462	42,045	**72,380**	100

Road Condition Mix

	Trunk	Urban	Feeder	Total
Good (%)	57%	37%	35%	**40%**
Fair (%)	36%	17%	34%	**31%**
Poor (%)	7%	46%	31%	**29%**

Source: Ministry of Roads and Highways (2019), Ghana

The literature generally shows that road infrastructure development can positively impact economic growth (see e.g. Canning and Bennathan, 2000; Gunasekera, Anderson, and Lakshmanan, 2008; Boopen, 2006; Fan and Chan-Kang, 2008; Jiwattanakulpaisarn et al, 2009; Ding, 2013; Zhang, 2013). Good road infrastructure lowers physical barriers by enabling efficient movement of people, goods and services, and provides improved accessibility to both social and commercial activities. There is also the added benefit of reduced transit times and costs (see e.g., Meyer and Miller 2001; Motamed, Florax, and Masters 2014). Relating to paved roads, the empirical literature documents that investments in paved roads, especially in countries that lag in the provision of such loads, have the potential to enhance national output. For example, Gunasekera et al. (2008) show an increase in industries' output by more than 60% following investment in highway infrastructure in Sri Lanka. Fan and Chan-Kang (2008) also report that investments in rural roads raised China's GDP four times higher than high-grade roads.[2] Further, Aggarwal (2018) provides convincing evidence that reinforces the significant benefits resulting from investments in paved roads connecting rural areas to nearby towns or urban areas. The paper suggests that, among others, enhanced rural roads resulted in

[2] Jiwattanakulpaisarn et al (2009) and Banerjee et al (2012) find no evidence of a positive association between road infrastructure and economic growth.

better integration of India's rural economy into the general market as well as better adoption of agriculture technology in rural areas.

The documented evidence provides impetus for the assertion by the World Bank African Infrastructure Diagnostic Report (2010) that an improvement in Ghana's infrastructure endowment can, potentially, yield higher annual growth. According to Caselli and Gollin (2012), rural farming populations in Ghana pay steep transportation costs to transport their produce to markets. The paper also reports that about 60% of Ghana's rural population resides a couple of hours away from a market center, and approximately 10% live, at least, 5 hours away. However, as can be seen on Table 2, 65% of the roads connecting the rural population to main centers is deemed not be in good shape. Thus improving the road network (which will, invariably, lead to reducing travel times and transportation costs) could potentially improve incomes for rural populations. Consequently, it can be said that all efforts or interventions aimed at improving the condition of the road network system in Ghana can unlock the country's potential both at micro-and macroeconomic levels. Examining the development of roads in district capitals as well as certain areas of high agricultural production and tourism in Ghana, thus, has significant merits.

Besides roads, the literature also suggests that railways have been a critical catalyst for economic transformation and development (see e.g., Richards & MacKenzie, 1986; Stover, 1997; Majewski, 2006; Sinha & Sarma, 2016). Jedwab and Moradi (2011), examining colonial investments in 2 railway lines in Ghana, find a positive and causal link between rail connectivity and agricultural production. In recent times, the Economic Times (2017)3 of India reports that the railway transport system has been a fundamental driver of the economic transformation experienced by India. In Ghana the development of the rail industry has stagnated in the past few decades, resulting in rail transportation not being utilized, thereby, severely denting service delivery. The total track length of the rail industry for Ghana, a country with a land area of 238 thousand square kilometers, is 1300km and the rail industry operates a route length of 947km. According to the World Bank (2011), up to 60% of the rail network is not used on a regular basis. Clearly interventions aimed at revamping and extending the rail routes to link important points, particularly the north of the country, are needed to boost the competitiveness in doing business in Ghana. In this regard, the Railway Master Plan to guide

[3] https://economictimes.indiatimes.com/why-transport-infrastructure-is-most-important-for-countrys-progress/articleshow/50865730.cms; accessed on November 06 2019.

the sub-sector development published by the government of Ghana is very welcome. Currently the triangular rail infrastructure system that links Accra, Kumasi, and Takoradi is concentrated in the south of the country and handles less than 2% of freight and passenger traffic (see Figure 1). The Railway Master Plan of the government of Ghana aims to create three corridors; central, eastern and western. A complete implementation of this master plan will increase the total track length of the rail industry 300% fold, from 1300km to 4008km.

There is great potential for railways to become a very significant part of the transport system in Ghana. Generally we can expect an increase in demand on the transport system as the Ghanaian economy continues to grow. The railways system is a viable alternative to the road transport system which currently dominates overwhelmingly in both passenger and freight traffic.

Figure 1: Existing Rail Network in Ghana

Source: Ghana Railway Development Authority, 2013.

As a preview to the analysis, we provide an overview of the traffic demand both for passengers and freight traffic (see Table 3). The baseline value for the roads without the intervention is obtained as follows; first we obtain the average passenger (freight) traffic demand per day (per year), estimated to be 730,000 passengers (36.3 million metric tonnes) for 2015 from the Railway Masterplan. We then adjust the values to the 2018 base year using the annual population growth rates (average freight growth rate obtained from PwC, 2016[4]) provided by the Copenhagen Consensus Center for the Ghana Priorities project. We subsequently forecast the traffic demand for both passenger and freight using the same growth rates.

As earlier on indicated, 96% of freight and 97% of passenger traffic happen on the roads. Given this, we computed the rail passengers and freight traffic demand as 4 and 3 percent of the total values for the base year and subsequently forecasted over the reference period using population and freight growth rates, respectively. The estimates show that, without the intervention, passenger traffic demand for road (rail) will be 1.7 million (62,000) passenger per day (per day) in 2048. The corresponding values for freight are 870 million tonnes per year and 35 million tonnes per year for road and rail freight, respectively. With-the-project road intervention, both passengers and freights traffic demand exhibit only a marginal increase. This is because the road intervention, consisting of in 1888km of new roads, constitutes only 3% to the total road networks in Ghana and, consequently, increases passengers traffic demand volume by 3%.[5] The rail intervention show more significant increase. For example, freight volumes are projected to be 226 million tonnes per annum in 2048.

[4] In line with the PwC (2016) report, we forecast freight traffic using an 8-year average freight growth rates of 11.125%. This is based on the historical freight traffic volumes at the port of Tema.
[5] The post intervention increase in passengers and freights traffic demand is computed by applying a 3% increase in the counterfactual traffic demand given that the project length of 1888km is 3% of the total road network in Ghana. An alternative approach would be to compute the sum of the counterfactual traffic demand and per kilometre increase in passengers and freight traffic demand attributable to the total length of the post-intervention (1888km). We observe no significant difference in values using both approaches.

Table 3: Estimated traffic demand forecast with-and without-investment

	Without Investment				With Investment			
	Road		Rail		Road		Rail	
Years	Pax (000/d)	Freight (Mt/y)	Pax (000/d)	Freight (Mt/y)	Pax (000/d)	Freight (Mit/d)	Pax (000/d)	Freight (Mt/y)
2018	786	50	23.6	2.0	805	51	81.6	13.0
2028	1006	144	30.2	5.8	1031	148	104.5	37.4
2038	1288	415	38.7	16.6	1328	425	134.2	108.2
2048	1649	870	61.5	34.8	1689	891	171.6	226.2

Estimates based on projections from traffic demand obtained from the Ghana Railway Masterplan

We assess the economic viability of the two aforementioned interventions within the broad framework of benefit-cost analysis (BCA), a method used in appraising public investment projects. The approach represents an important step in the design of transport policies based on economic principles. BCA, an analysis that calculates and adds up the equivalent money value of the benefits and costs to public projects to ascertain whether the projects are worth pursuing, can communicate powerful economic value of such projects. The rule of thumb in BCA is that projects should be undertaken if the sum discounted benefits is higher than that of the discounted (investment and ongoing) costs. We follow the steps enumerated below:

(i) An estimation of capital and maintenance costs (both routine and periodic) at economic prices
(ii) An identification, categorization, and quantification of the economic benefits and costs
(iii) Discounting the cost and benefits to obtain present values
(iv) Estimation of the BCR values
(v) Sensitivity test for different scenarios.

As noted by Lakshmanan, Nijkamp, and Rietveld (2001), the transport sector has a number of idiosyncrasies. For one, the demand for transport is mainly *derived demand* as it connects spatial divergences between demand and supply on various markets (e.g., goods markets for freight transport). Thus transport infrastructure supply must be viewed not in isolation, but in the context of its interaction with the entire economic system, the spatial structure and the dynamic behaviour of these two. In addition, the benefits and costs of the entire transport system emanates from both the supply and existence of infrastructure, and through its usage, with significant implications for the policy prescription. Also transport activities generates a variety of costs, both internal (e.g., fuel, time) or external (e.g., 'inter-sectoral': pollution; and 'intra-sectoral': congestion) in nature and can have local (noise) or global (CO_2) impact.

The rest of the discussion is structured as follows: Section 2 discusses *Intervention 1*, improving the road network to link roads in district capitals and areas of high agricultural production as well as tourism areas. Section 3 presents the analysis on *Intervention 2* (revamping the railway system) and Section 4 concludes.

2. Development of Rural Roads

We first examine the viability of the development of roads in district capitals as well as certain areas of high agricultural production and tourism. As indicated earlier on, evidence in the extant literature suggest a boost to the rural economy resulting from such intervention. To make this exercise practical, we examine this issue as a whole by linking several identified high agricultural production areas as well tourism areas to the nearest commercial centers. The inherent logic in our supposition is that the commercial centers serve as the main market points for the agricultural goods produced or harvested in those areas. As such linking the two will generate the highest impact. This approach is supported by Caselli and Gollin (2012) who note that a significant proportion of the rural farming populations in Ghana live several hours away from market centers and pay steep transportation costs to transport their produced to markets. In addition, we motivate this approach by information contained in the annual report of the Ministry of Roads and Transport (2002) that, seemingly, links the condition of roads to poverty in Ghana (see Table 4).

Table 4: Impact of Poor Road Conditions on Poverty

Region	*Area (sq. km)*	*% Living below Poverty Line (1999)*	*Length in poor condition (km)*	*% of roads in poor condition*
Upper East	8 842	88.2	1 620	65.0
Upper West	18 376	83.9	1 663	59.4
Northern	70 386	69.2	4 235	64.1
Brong Ahafo	39 557	35.8	2 942	39.0
Ashanti	24 389	27.7	3 350	40.9
Volta	20 570	37.7	1 488	34.5
Eastern	19 323	43.7	2 140	47.3
Greater Accra	3 245	5.2	1 005	33.0
Central	9 826	48.4	1 375	35.8
Western	23 921	27.3	2 645	45.0

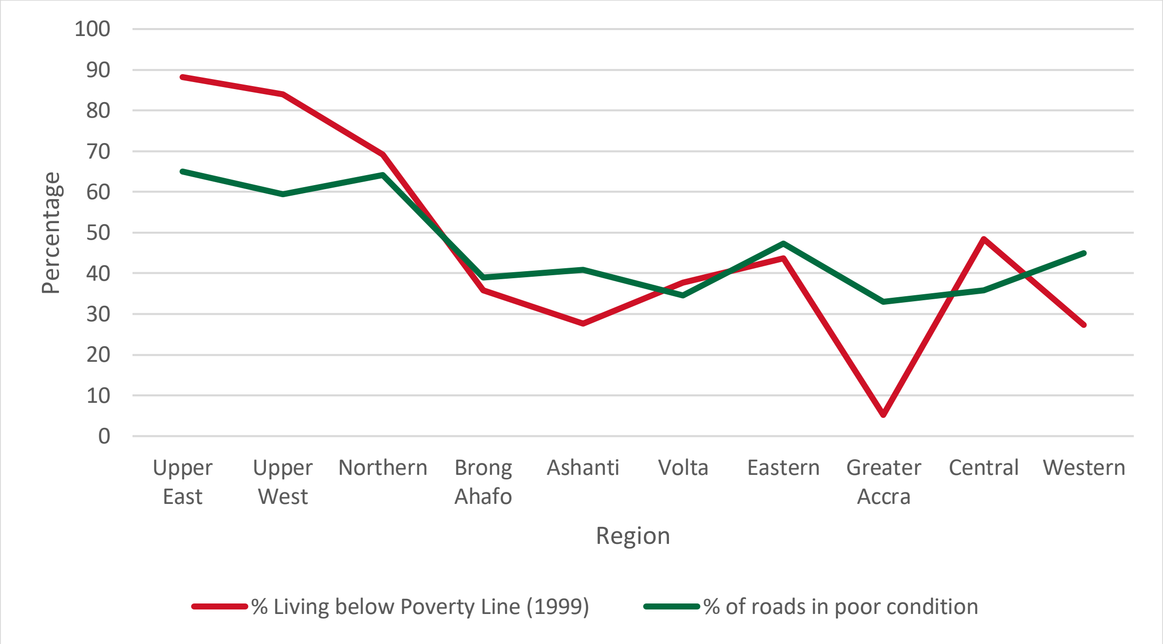
Source: Ministry of Roads and Transport Annual Report (2002)

It can be observed from Table 4 that areas with relatively higher fractions of roads in poor condition also have greater incidence of poverty. For example, in the Upper east (Central) region, 65% (35.8%) of the road network was reported to be in poor condition, with a corresponding 88.2% (48.4%) of the population in that region living below the poverty line. This suggests a link between the road conditions and poverty line and across the different regions of Ghana (also see Figure 2). Thus interventions aimed at further developing the road network in Ghana, particularly in certain areas of high agricultural production and tourism developing (which are rural), have the potential of contributing to a reduction in poverty levels.[6] Also, given that close to 80% of the national road network is unpaved, with 60% deemed to be not in good shape, an additional assumption made is that all the roads identified will be newly constructed roads. There are news reports as well as published papers indicating that the general conditions of such roads in Ghana are poor, thereby, providing support for this assumption.[7]

[6] It must be emphasized that road infrastructure, on their own, is not a solution to poverty. They can, however, be catalysts to creating wealth (see Howe and Richards, 1984; Ministry of Roads and Transport Annual Report, 2003).

[7] See e.g., https://africanharvesters.com/2019/03/20/ghana-poor-road-network-affecting-pfj-programme-in-kwahu-afram-plains-north/ ; Also Taiwo and Kumi (2013) report that only 28.33% of roads in the Sekyere Central District can be deemed to be good.

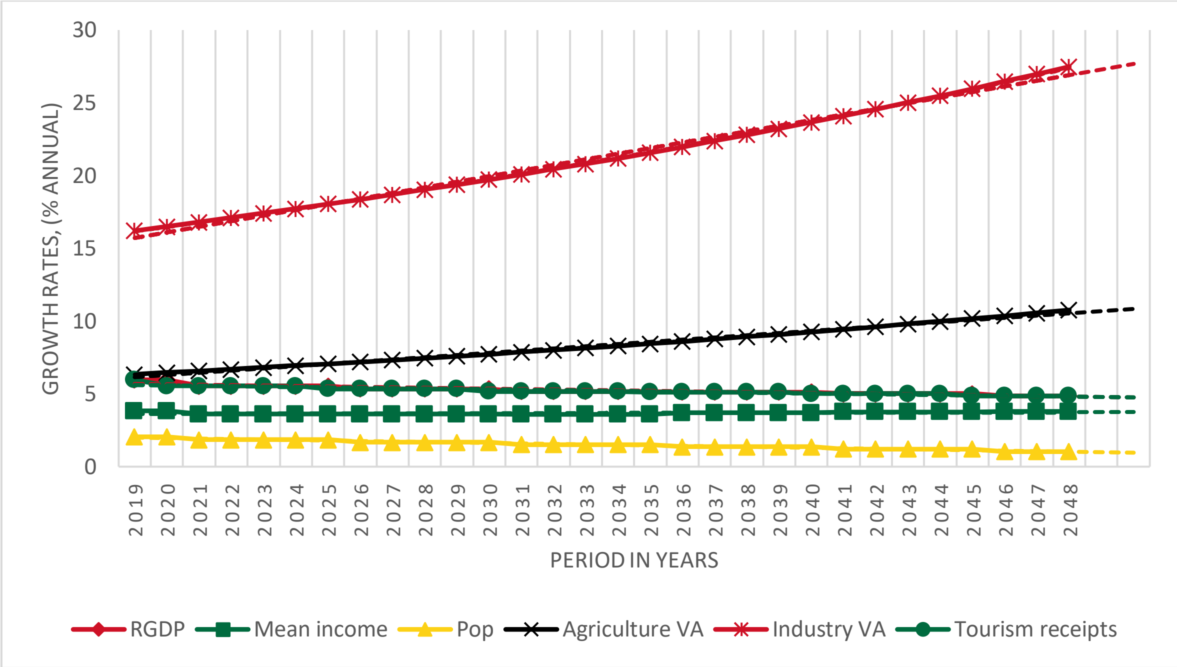
Figure 2: Poverty Levels and Road Conditions in Ghana



Source: Ministry of Roads and Transport Annual Report (2002)

Our reference period for the BCA analysis is 30 years, with 2018 being our base year. We present the socioeconomic trend in Ghana for this reference period (see Figure 3) as a prelude to our analysis. The projections depicted in Figure 3 are based on baseline data obtained from the World Bank World Development Indicators database. We then applied a forecast factor to the baseline data based on projected economic growth assumption obtained from the economic projections of the Ghana Priorities Project of the Copenhagen Consensus Center. The generally positive projected trend for industry value add and agriculture value added over the 30-year reference period for the evaluation of this project is indicative of the expansion in economic activities and, possibly, buoyant investment prospects. Given that these projections, as well as that for mean income, exceed the population growth rate over the reference period, it raises the potential that investments in transport infrastructure projects such as roads and rails would have a high probability of success.

Figure 3: Socioeconomic Projections for Ghana over the 30-year Reference Period



Source: The baseline data for key socioeconomic projections were obtained from the World Bank's (2019) World Development Indicator.

2.1 Identifying high agricultural production and tourism areas

We based our identification of certain high agricultural production areas (districts) on a survey conducted by International Food Policy Research Institute (2011) to identify such areas in Ghana (see Table 5). We then used Google map to estimate the distances between the named districts and the nearest commercial centers. Regarding tourist attractions, we identified them from the website of Ghana Tourism Authority.[8] These areas are marked with asterisks in Table 5. Again we use Google map to estimate the distance between the tourist areas and the nearest commercial centers. We reason that, connecting the tourist attractions with the nearest commercial centers would create the highest impact. In total, we estimate that the total length of road need to be developed to be 1888.1km spanning 27 districts across different administrative regions in Ghana.

[8] https://www.ghana.travel/

Table 5: List of selected high agricultural production areas and tourist attractions

Region	***Districts***	***Length (KM)***	***Commercial Centres***
Ashanti	Amansie West	75.2	*Kumasi*
	Sekyere Afram Plains	57.7	
	Lake Bosomtwe*	37.1	
Brong Ahafo	Dormaa East	59	*Sunyani*
	Techiman Municipal	77.6	
	Kintampo Falls*	74.2	*Techiman*
Central	Assin North Municipal	108.8	
	Saltpond	48.3	*Cape Coast*
	Mfantsiman	71.75	*Kasoa*
Eastern	Atiwa	69.7	*Koforidua*
	West Akim	68	
	Boti Fall*	23	
Greater Accra	Ga East	12.1	*Madina*
	Ga West	30.3	*Makola*
Northern	Gushiegu	117.3	*Tamale*
	Yendi	99.3	
Upper East	Bawku Municipal	80.1	*Bolgatanga*
	Kassena Nankana East	60.9	
Savanah	Bole National Park*	98	*Damongo*
Upper West	Lawra	85.6	
	Sissala East	136.3	*Wa*
Volta	Keta	126.4	
	Hohoe (Tagbo & Wli waterfalls, Mount Afadjoto)*	91.5	*Ho*
	North Tongu	46.6	*Tema*
Western	Bia	127.9	*Takoradi*
	Prestea Huni Valley	121.9	
	Axim	59.9	
Total	***27***	***1888.1***	

Source: Ministry of Food and Agriculture (2011).

We, therefore, undertake a benefit-cost analysis for the construction of 1888.1 kilometers of new roads linking areas of high agricultural production and tourism attractions to the nearest commercial centers. Developing these roads is expected to improve travel conditions for both freight and passenger traffic with a concomitant improvement in the quality of life of the population which is served by the reduction in travel time as well as traffic congestion due to increase in vehicular velocity stemming from the improved conditions of the roads. We also expect a reduction in the vehicle operating cost as a result of reduction in fuel, tires and lubricant cost occasion by the improvement in the road standards, as well as the volume of carbon as well as other greenhouse pollutants emitted into the atmosphere.

2.2 Financial and economic analysis: Roads transport

As earlier on indicated, the road project appraisal was performed on a 30-year reference period. The 30-year reference period is commonly used in transport project evaluation (see e.g., European Commission, 2014; Ghana Railway Development Authority, 2013). All historical costs were adjusted to the base year of 2018 using the US GDP deflator. Following the Copenhagen Consensus Center guidelines, we use three reference parameters for the opportunity cost of capital; 5%, 8%, and 14%. Similarly, all financial and economic forecasts of costs and benefits were carried out using either the real GDP growth rates or real GDP per capita growth rates (especially when the main driver of the future costs is labour). All the underlying growth rate projections are provided by the Copenhagen Consensus Center for the Ghana Priorities project.

The benefits derived from both the road and rail transport system emanates from the usage of the transport networks. That is, without usage, no practical benefits of such infrastructure supply can be recorded. We can, therefore, discern the overall benefits of road and rail infrastructure as the sum net benefits of the usage (net of the costs of usage) over the life of the infrastructure (see Lakshmanan et al, 2001). We discuss in this section both the costs and benefits the identified road intervention. Generally, the costs of infrastructure supply are broken into (1) costs incurred during the construction, and (2) costs subsequently incurred over the lifetime of the project (e.g., maintenance costs). The benefits, on the other hand, is derived from the opportunity to supply or demand specific goods (for freight transport) or services (for passenger transport) at diverse locations.

2.2.1 Investment cost

A 2003 road infrastructure appraisal report by the African Development Bank (AfDB)[9] indicated that a total of length of 1071 kilometres of roads was constructed between 1997 and 2002. Based on this information, we assume an average annual construction of 170km of road for Ghana and use this value as our estimated length of new roads to be constructed per annum.

[9] See Section 3.7.2: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Ghana_-_Road_Infrastructure_Project_-_Appraisal_Report.pdf

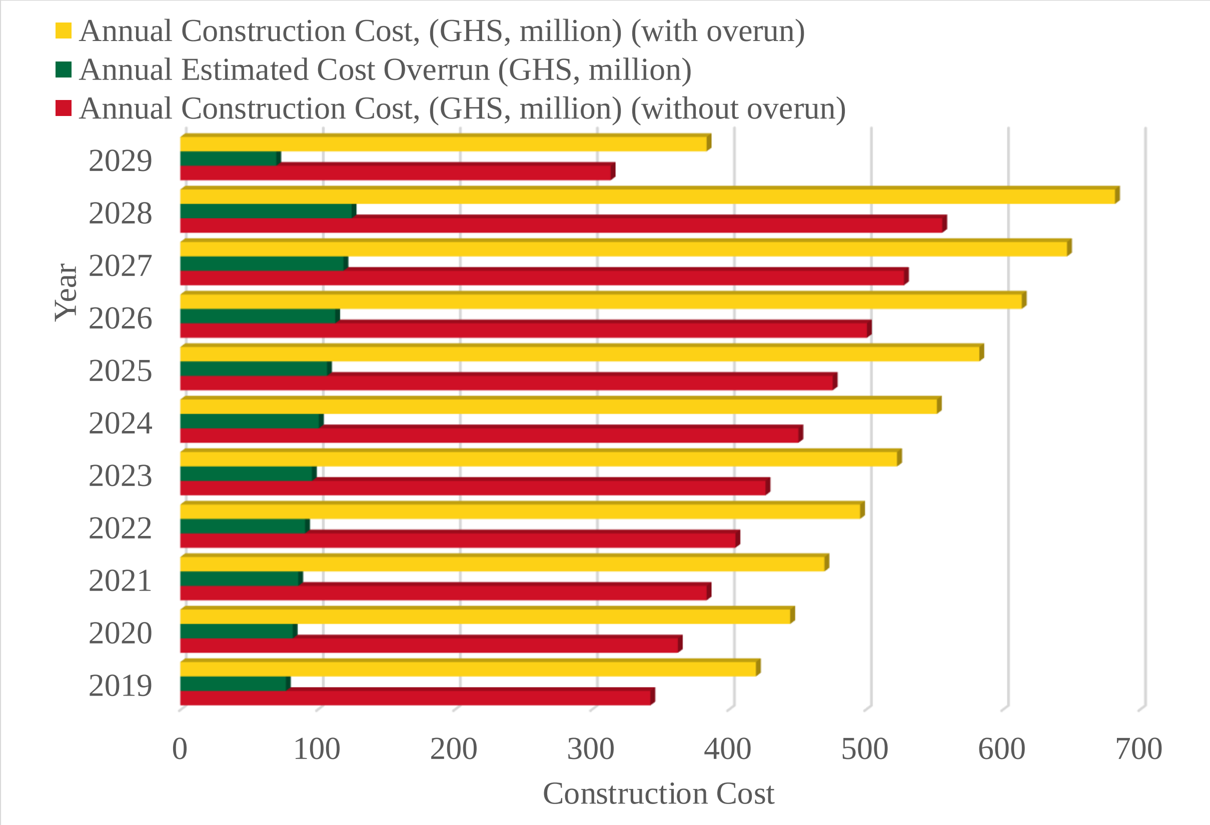
This will imply a construction period of 11 years. In this analysis, we also assume the proposed roads to be constructed will be a two-lane paved asphalt road. The Millennium Development Authority (2012) peg the actual cost of constructing the Afram Basin road, a key route for agriculture produce, at UD$379,000 per kilometre in 2012 (also see Rangarajan et al, 2017). In this analysis, this value is adjusted to the base year of 2018 using the US GDP deflator to arrive at the value of US$418,352 (approximately GHS1.2 million[10]) per kilometre. We inflate by the real GDP growth rates to forecast the construction costs for the ensuing years. We present the estimated construction costs over the construction period in Figure 4. As discussed by Gibson and Wallace (2016) and in the Cost-Benefit Manual: A Theoretical Guide (2011), other costs, e.g., cost of land and environment as well as drainage, are usually embedded in the investment cost of the road construction. Thus, the reported construction cost is assumed to include all other costs. For the period of the analysis, the cost of constructing 1888 km of road is estimated to be GHS2.9 trillion at an 8% discount rate.

2.2.2 Cost Overruns

Cost overruns refer to the difference between actual project cost at completion and budgeted estimate at project approval after adjusting for expenditures due to cost escalation. Cost overruns are a widespread challenge and a common feature of road infrastructure projects procurement. Therefore, making certain percentage allowance over and above the base cost estimates is an essential cost overruns mitigating strategy (see Gbahabo and Ajuwon, 2017). The probability and magnitude of infrastructure project cost overruns varies across economic sectors, geographical terrains, level of economic development as well as the size and level of complexity of the project (Flyvbjerg et al., 2003). According to Amoatey and Ankrah (2002), the probability of road transport projects in Ghana undergoing cost overruns is 52 percent by an average budget increase of 22 percent above the initial stipulated estimate. Therefore, this analysis adopts 22.5 percent above the base cost as an allowance for the probability of cost escalation. The value of the cost overrun is therefore GHS647 million using an 8% discount rate. We present the annual estimated cost overruns graphically in Figure 4. The Figure also presents a summary of the estimated total construction costs over the construction period, with and without the cost overruns.

[10] We use an exchange rate of 4,565, provided by the Copenhagen Consensus Center for the Ghana Priorities project.

Figure 4. Construction Costs



Source: Authors computation

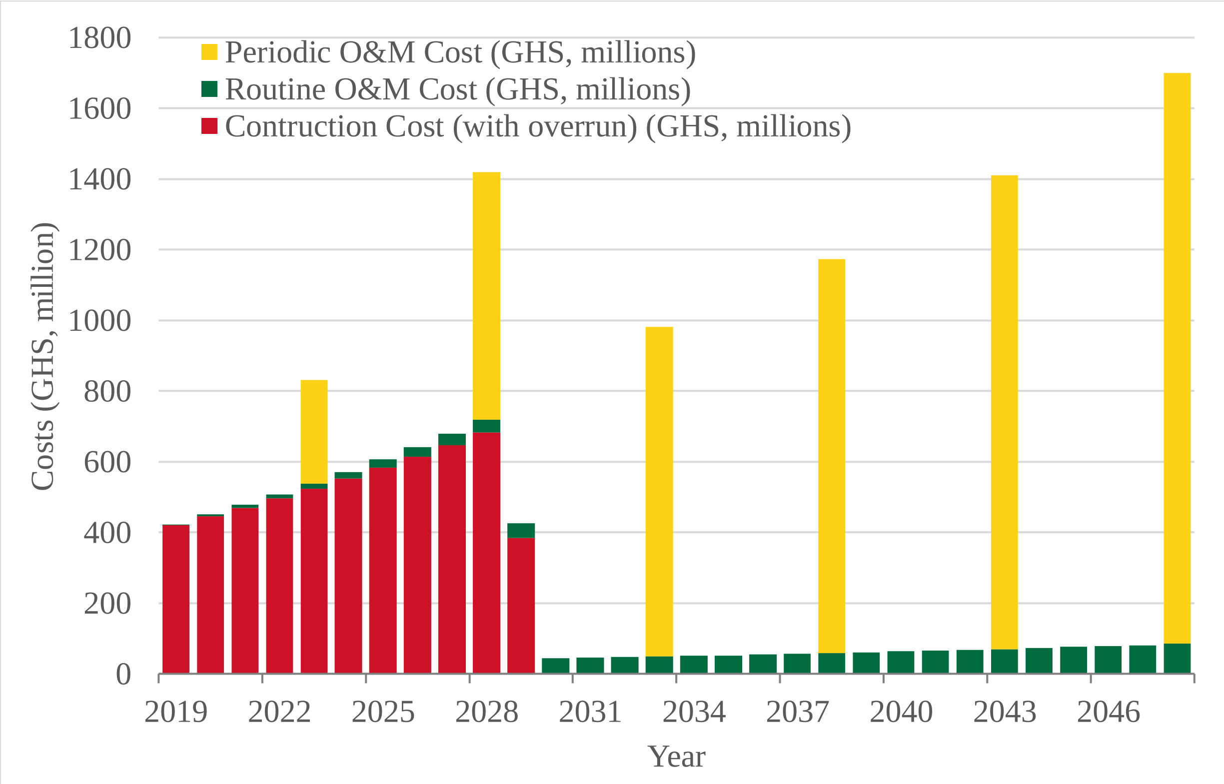
2.2.3 Operation and Maintenance (O&M) costs

The O&M cost can be classified into two categories, namely the routine and periodic maintenance. The routine maintenance, which is often carried out annually, is completed to keep the roads technically safe and prevent deterioration. This entails ensuring proper drainage and making spot repairs, such as fixing potholes or sealing cracks. The periodic maintenance, on the other hand, involves more extensive roads work and relate to activities aimed at restoring the original condition of the road. These include rehabilitation and reconstruction, asphalt mix, gravel and treatment resurfacing as well as strengthening, widening and upgrading of paved roads. Periodic maintenance is usually conducted after every 5 years, a timing that is dependent on several factors including degree of road use, climate, and the quality of the original construction.

To estimate routine and periodic O&M costs, we make use of the World Bank's Road Construction Cost Knowledge System (ROCKS, 2006). The database provides historical cost per kilometer for both routine and periodic O&M. We subsequently adjust these costs to the base year using the US GDP deflator and obtained US$3182 (approximately GHS14,500) and

US$60750 (approximately GHS277,300) for the routine and periodic O&M, respectively. Given that the main cost driver of routine Q&M is labour cost, we employ the projected real GDP per capita growth rates to all future routine O&M costs. We present, in Figure 5, all cost across the project life.

Figure 5. Costs across project life



Source: Authors computation

2.3 Project Economic Benefits

The economic benefits emanating from road transport interventions are diverse and wide ranging. Due to data constraints, we identify and include four (4) benefits that could be quantified. These are the generalized cost savings, value of carbon emissions avoided, transport cost savings, and reduction in post-harvest losses. We discuss them in turn.

2.3.1 Generalized Cost savings

Generalized cost is a composite sum of all the different elements that travelers give up to embark on a journey including travel time, vehicle operating costs, traveler's comfort and reliability (see e.g., Brent, 2006; Bullock, 2009). Therefore, where relevant data on generalized cost exists for different scenarios with and without transport project intervention, it becomes the most convenient approach to establishing the user benefits associated with the project. The user benefits are estimated as the change in generalized cost between the *with-investment* and *without investmen*t cases (Bullock, 2009). However, the various components that constitutes the user benefits of transportation projects could also be estimated separately, especially where availability of data on generalized cost is lacking.

In this analysis, we employ the generalized cost approach to estimating the user benefits of road projects with supporting data obtained from The Ministry of Finance and Economic Planning's Integrated Transport Plan for Ghana (2010). The generalized cost estimation is captured in equation (1):

$$Generalized\ Cost = monetized\ travel\ time + vehicle\ operating\ costs \qquad (1)$$

The total savings generated from the generalized cost is derived as the sum of the generalized cost differentials between the *with investment* scenario and the *base case* scenario and estimated to be GHS735 million over the 30-year period.

2.3.2 Value of carbon emissions avoided

Computing the value of carbon emissions avoided from a road transport intervention requires the identification of the relevant accrued benefits from the road intervention that would impact the level of carbon emissions in the economy. The identified carbon-centric benefits accruing from the road intervention includes growth in the number of passenger vehicles (PVs) and trucks as well as reduction in travel time over the reference period. We estimate the post intervention growth in the number of passenger vehicles and trucks as follows (see the African Development Fund, 2019):

(i) We determine the counterfactual number of passenger vehicles (PVs) and trucks for the base year as the product of the ratio of total traffic volumes to annual change of construction kilometers, the percentage of PV/trucks transport of total road transport vehicles and the annual factor.

(ii) We compute the post-intervention number of passenger vehicles and trucks as the product of the estimated counterfactual number of PVs and trucks and the growth rate of PVs and trucks over the 30-year reference period.[11]

[11] Following the Australia Ministry of Transport and Main Roads (2011), we applied a 2% traffic growth rate per annum on counterfactual forecast to determine the post-intervention increase in number of passenger

(iii) We then sum the post-intervention number of PVs and trucks to arrive at the total number of vehicles stemming from the intervention over the reference period.

The value of carbon emissions avoided for PVs and trucks (in grams) is computed as the product of the reduction in time travelled (km) by both PVs and trucks, the emissions per km, and the social cost of carbon. The values of the social cost of carbon was obtained from the Copenhagen Consensus Center Ghana Priorities project). Generally, passenger vehicles running on petrol emit an average of 198g of CO2 per km while heavy vehicles such as trucks emit an average of 269g CO2/ km. The total estimate for the carbon emissions avoided per kilometer over the 30-year period is computed to be GHS1,189 (US$261) (see Table 6).

2.3.3 Transport cost savings

The potential transport cost savings from building the proposed new roads is computed separately for passenger vehicles and trucks for each year. The projection for each year for both passenger vehicles and trucks is given as the product of the level of new road usage (in days)[12], the change in transport cost per kilometer (passenger/freight), growth rate, and the kilometers travelled per vehicle (passenger/freight) per day.. We estimate the total cost savings over the 30-year period to be GHS1.43 million (US$314,000) per kilometer (see Table 5).

2.3.4 Reduction in Post-harvest losses

The FAO defines post-harvest loses (PHL) as measurable losses in edible food mass (quantity) or nutritional value (quality) of food intended for human consumption. Generally, the post-harvest system includes a wide range of interconnected activities starting from the period of harvest to final use at the consumer level. We estimate the reduction in post-harvest losses using the following procedure;

(i) First, we computed the counterfactual post-harvest losses attributable to transportation for the predominant food crops cultivated in Ghana comprising both perishables (tomatoes and mangoes) and non-perishables (rice, maize, millet, sorghum, groundnuts, cassava and yams) for the base year denominated in US

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vehicles and trucks. Given that the increase in number of passenger vehicles and trucks is marginal, the major contributing factor to carbon emission in this context is, therefore, the median reduction in travel time of 30% which is significant.

[12] For passenger vehicles this is given as: (traffic volume/construction time, km/year) x % of trucks x total project length x 365 x growth rate of passenger vehicles$^{\text{year of construction}}$; For trucks the estimation is as follows: (traffic volume/construction time, km/year) x (%passenger vehicles - % of large busses) x total project length x 365 x growth rate of trucks$^{\text{year of construction}}$.

dollars. While the underlying data for the computation of the postharvest losses were obtained from the Food and Agriculture Organization database (FAO) and the Africa Postharvest Losses Information System database (APHLIS), the proportion of the losses attributable to transportation issues were obtained from the literature on postharvest losses (Hodges, Bernard and Rembold, 2014; AGRA, 2014 and FAO, 2015).

The total monetary value of the counterfactual post-harvest losses attributable to transportation in the base year is estimated to be US$276 million (approximately GHS1.3 trillion). The base year counterfactual postharvest losses are subsequently forecasted over the 30-year reference period using the Ghana annual percentage change in Agricultural commodity losses for the last three decades.

(ii) Rosegrant et al. (2015) show that, in developing countries, having 100% paved roads reduces the odds of PHL by a factor of 0.57. In our analysis, 1888km of road built suggests a maximum reduction in PHL of 28%. We therefore calculate the annual PHL avoided using this figure and also taking into account that benefits ‘ramp-up’ over the 11-year construction phase. The total estimated benefits are GHS21.2 trillion.

The total benefits are estimated as GHS10.2 million, GHS6.5 million, and GHS3.1 million, respectively, for the three reference parameters for the opportunity cost of capital, 5%, 8% and 14%, on a 30-year reference period. Most of the estimated benefits are concentrated in the reduction of post-harvest losses (86%). This is not surprising given that the roads considered in the analysis are rural roads. As noted earlier on, 60% of the rural population in Ghana, where farming is concentrated, live at least, 2 hours away from a market center. In these areas, the conditions of the road are, generally, not in good condition (see Table 3). In addition, the rural farming populations in Ghana experience significant transportation costs to cart their goods to market (see Rangarajan et al, 2017; Caselli and Gollin 2012). These have significant implication for the marketing of agricultural produce and emphasizes the relative economic importance of road networks in transporting agricultural produce as well as the huge impacts of road transport upgrade in reducing the prevailing high incidence of transport-related PHL.

Noting the seriousness of the menace of post-harvest losses, the current government of Ghana has begun the construction of a 1,000-metric tonne capacity warehouse across the various administrative districts to help curb it.[13]

2.4 Results of the Benefit-Cost Analysis and Discussions for the Road Project

Table 6 presents a summary of the BCRs, calculated for the three reference parameters for the opportunity cost of capital, 5%, 8% and 14%, on a 30-year reference period. The rule of thumb in BCA, as indicated earlier on, is that projects should be undertaken if the discounted benefits are higher than discounted investment costs. This translates into accepting all projects with BCRs in excess of 1.

Table 6. Summary of Benefits and Costs for Road Intervention

	Benefits (GHS, Millions)	Costs (GHS, Millions)	BCR
	Without Cost Overruns		
5%	10,237	6,220	1.65
8%	6,494	4,650	1.40
14%	3,092	2,990	1.03
	With Cost Overruns		
5%	10,237	6,973	1.47
8%	6,494	5,297	1.23
14%	3,092	3,481	0.89

It can be observed that the discounted cost of the proposed road intervention is significant (between GHS3.4 billion and GHS7.02 billion, including cost overruns). However, the results show that the BCRs of the intervention at the two reference parameters for the opportunity cost of capital, 5% and 8% are both in excess of 1. This indicates that the road intervention is economically viable. The result also suggests an implicit benchmark cost of capital in making the road project economically feasible in Ghana.

2.5 Sensitivity Analysis

We vary two key parameters to test the sensitivity of the results to the assumptions; (1) cost of construction, and (2) the post-harvest losses. Odeck (2004), Flyvbjerg et. al. (2003), and Love

[13] See https://www.foodbusinessafrica.com/2019/01/28/ghana-sets-up-storage-facility-to-curb-post-harvest-losses/

et al. (2012) all note a very high probability of experiencing cost overruns in infrastructure projects (between 70% and 103%). As indicated above, the probability of road transport projects in Ghana undergoing cost overruns is in excess of 50%. Therefore, we place greater emphasis on cost increases relative to cost declines as these overruns can erode the viability of the road intervention project. For that reason, we increase the cost overruns to 45% (doubling the initial assumption), the highest reported average overrun for infrastructure projects (see Flyvbjerg et. al., 2003), and observe its effect on our BCRs. The results from this exercise confirm the positive BCR values for the same two reference parameters for the opportunity cost of capital. For instance, using an 8% discount rate, it can be observed that the increase in construction cost overruns leads to a BCR of 1.09 (see Table 7). Although the BCR at 8% is marginally above 1%, it still lends some credence to the viability of the road intervention project.

The projected benefits from the road intervention overwhelmingly accrue in the form of reduction in the post-harvest losses. In our sensitivity analyses, we also vary the post-harvest losses attributable to transport by +/- 10% in the base year. We show that a 10% decrease in this variable decreases the BCRs. We report BCRs (with cost overruns) of 1.33, 1.12, and 0.83 for the 5%, 8%, and 14% discount rates, respectively. Although reduced, the BCRs are still above 1 for the 5% and 8% discount rates. On the other hand, a 10% increase in the post-harvest losses attributable to transport improves the base case BCRs, reported as 1.8, 1.71, and 1.65 for the 5%, 8%, and 14% discount rates. These, seemingly, confirm the viability of the rural road intervention.

Table 7. Sensitivity Analysis for Road Project

	45% Cost Overruns	*10% Increase in PHL Attributable to Transport*	*10% Decrease in PHL Attributable to Transport*
Discount rate	BCR	BRC	BCR
5%	1.39	1.8	1.33
8%	1.09	1.71	1.12
14%	0.79	1.65	0.83

2.6 Wider economic benefits and other considerations in road transport BCA

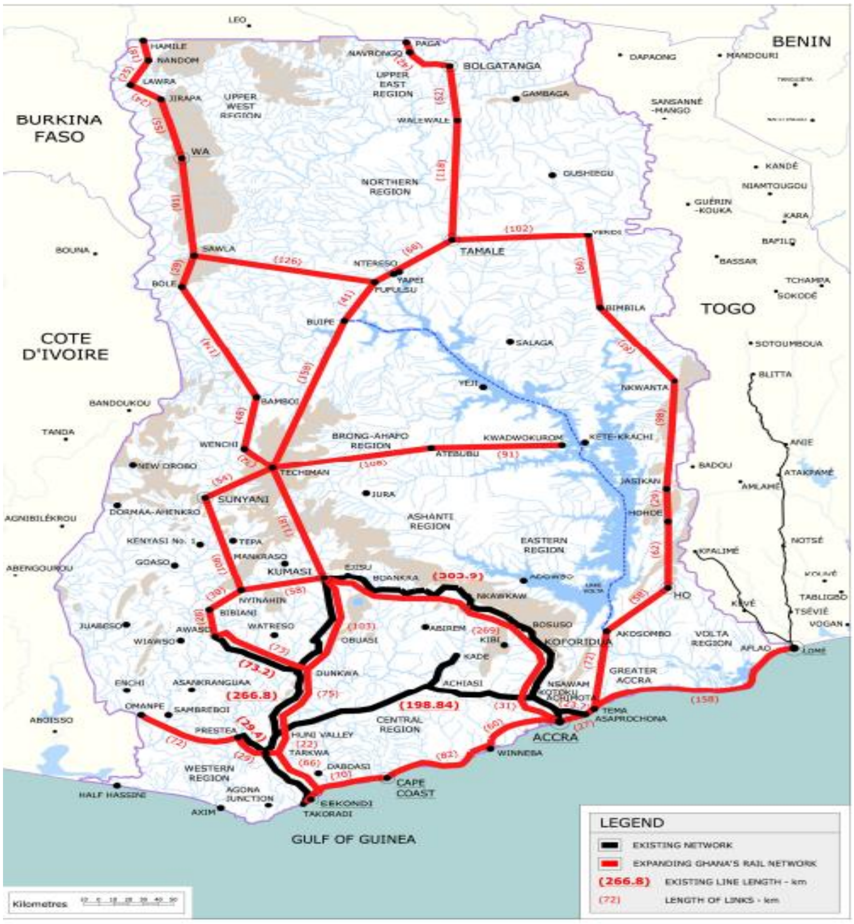
The wider economic benefits/impacts in transport investment appraisals refers to positive externalities that arise as side effects of the activities of economic agents including firms, households and governments stemming from road use on the whole economy. Examples of these wider economic benefits include agglomeration and productivity gains, investments and competition effects, migration and labor markets effects, improvement in health, education and markets access as well as improvements in government taxes, grants and subsidies. These wider economic impacts, though widely recognized in the broader transport economic literature, are often ignored in many traditional transport appraisals due to their indirect impact (Mackie, Graham, and Laird, 2011).

Other pertinent issues often ignored in many traditional road transport appraisals include the economic costs of lack of road maintenance. Poorly maintained roads are deadweight loss to the economy as they significantly increase the generalized cost of transport including travel time, vehicle operating costs, comfort and reliability as well as deteriorate road safety and erode the wider economic benefits of road transport interventions. Road transport investment must be followed by a program of well-planned routine and periodic maintenance. Otherwise the road improvements can quickly fall into disrepair and become a drag on the realization of the anticipated benefits (see Burningham and Stankevich, 2005).

3. Revamping the rail sector in Ghana

The Ghana railway project is estimated to cover a total of 4008 km comprising the conversion of 668km of existing narrow gauge to standard to single-track standard gauge 1,435 mm (4 ft 8 1⁄2 in) and the construction of new 3340km rail tracks (see Figure 1). The construction of new railway lines would extend the existing rail network to Northern Ghana (Ghana Railway Development Authority, 2013).

Figure 5. Map of Proposed New Rail Network



Source: Ghana Railway Development Authority.

The rail project would be divided into two separate rolling stocks; the passenger-based operations and freight-based operations. The main objective of the rail project is the improvement in travel conditions for both goods and passengers within the Ghanaian economy. Specifically, the railway project intervention aims to change the characteristics of trip for passengers and rail. These include:

- Reduced the travel time;
- Reduced traffic congestion on the roads by diverting traffic from substitute roads;

- Improvement in the capacity and efficiency of the railway line;
- Reduced operating and maintenance costs for service providers;
- Improvement in the traffic safety as well as passenger comfort.

The railway master plan specifies a 33-year period for the realization of the 4008 km of rail in 6 phases.

3.1 Cost-benefit analysis: Rail transport

Sections 3.1.1 and 3.2 present the costs and benefits of the rail transport intervention, respectively. The cost of the project encompass all the economic resources required to bring about the intervention's expected benefits, defined as the sum of the monetized positive outcomes that are reasonably expected from implementing the intervention. We include three costs, construction costs, operation and maintenance (O&M) costs, and cost of rolling stock and its maintenance, in our analysis. For the benefits, we estimate and include the monetize value of time saved, transport cost savings, carbon emissions avoided from road transport, accidents avoided, post-harvest losses avoided and residual value of the acquired assets. The analysis timeline is from 2019 to 2048, and the results are presented on a per km basis.

3.1.1 Construction cost

The rail construction project consists of two phases; (1) the rehabilitation of existing rail tracks into standard gauge covering 668 km, and (2) the construction of new rails expansion to northern Ghana. For the construction of new rails, Blumenfeld et al. (2019) present data on railway construction and cost from Sino-Africa railways development in Africa (see Table 8) that can be adapted for this analysis. It can be seen from the Table that the highest (lowest) per kilometer cost of the Sino-African rail projects is US$8.2 million (US$4.1 million). We adopt the highest cost per kilometer in our analysis to minimize the risk of undervaluing the investment costs and negate a need for performing sensitivity analysis using a higher cost. We note here that the construction cost adopted for our analysis is 4% higher than the average construction cost per kilometer, USD7.9 million, reported by the International Union of Railways (2019) document on regional differences in global rail projects by cost, length and project stage.

Table 8. Sino-African railway development projects

Country	*Project*	*Length*	*Total Cost (US$)*	*Cost Per Kilometer (US$)*
Chad	Chad Railways	1364 km	5.6 billion	4.1 million
Ethiopia-Djibouti	Addis Ababa–Djibouti line	751 km	4 billion	5.3 million
Mali	Mali–Guinea Railway line	900 km	11 billion	5 million
	Mali–Senegal Railway	1286 km		
Nigeria	Lagos–Calabar line	1400 km	11.1 billion	7.9 million
	Lagos–Kano line	1124 km	8.3 billion	7.4 million
Kenya	Mombasa–Nairobi line	485 km	4 billion	8.2 million

Source: Blumenfeld et al (2019). Authors added the last column of the Table.

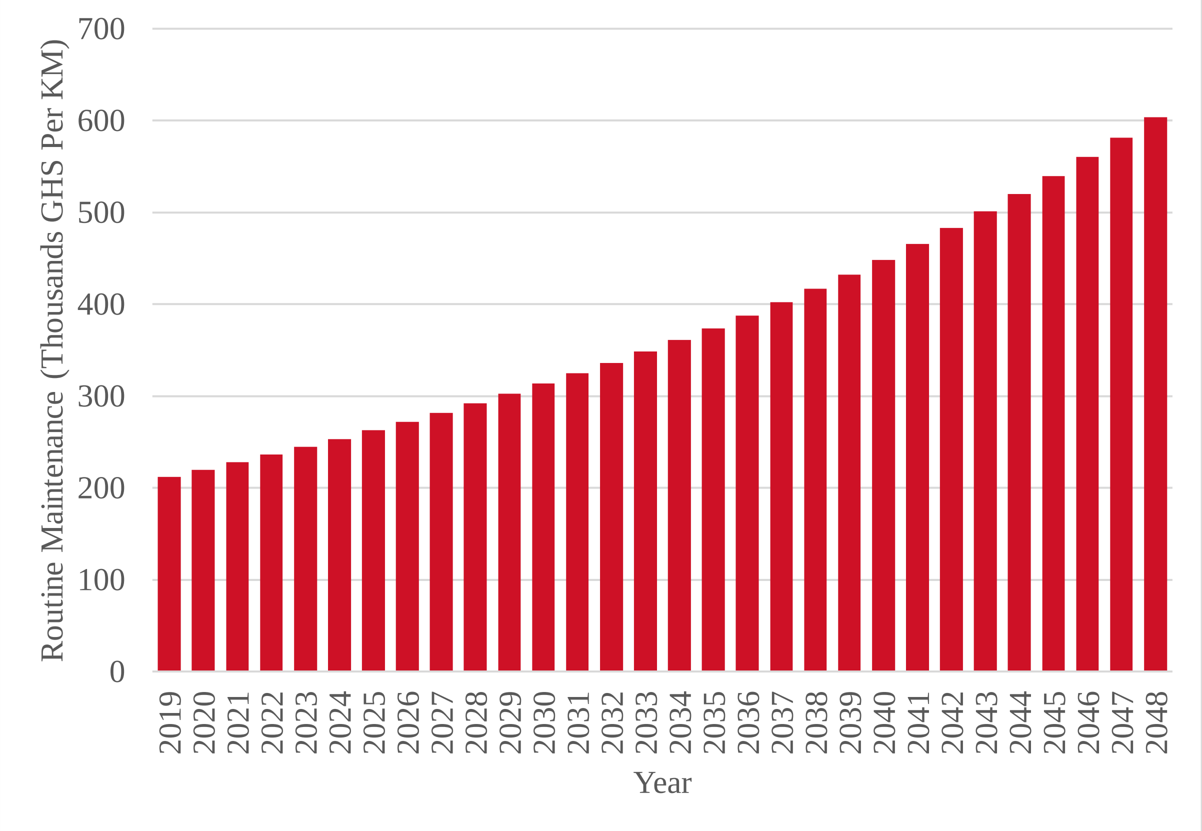
Following the cost ratios inferred from the Ghana Railway Masterplan, the cost of rehabilitation of the existing rail tracks is assumed to be 75% of the cost of constructing new railway tracks. This is estimated to be US$6.2m (GHS 28.3m) per kilometer.

3.1.2 Operation and Maintenance (O&M) costs

As pointed out in the literature, cost estimates in BCR analysis must reflect a lifecycle cost approach. That is, both the initial construction cost and the on-going operating and maintenance costs must be included to present a fuller picture of the total cost over its entire useful life (see US Department of Transportation, 2016). We discuss the operation and maintenance cost of the rail intervention project in this section.

The implied cost of operations and maintenance is obtained from the Ghana Railway Masterplan (2013) and PwC (2016). Similar to the road intervention project, the O&M cost comprises two categories; routine and periodic maintenance. The cost per km for routine maintenance is estimated to be US$45,000 (GHS 206,000) in the first year, increasing each year in line with GDP per capita growth (Ghana Railway Masterplan, 2013) (see Figure 6). The maintenance cost is expended annually to preclude the deterioration of the railway infrastructure asset and to keep it technically safe. In line with PwC (2016), we assume a periodic maintenance cost of 5% of the capital costs per kilometer occurring in years 10 (GHS2.7 million), 20 (GHS3.9 million), and 30 (GHS5.6 million) following the implementation.

Figure 6. Growth of Routine Maintenance Cost (2019-2048).



Source: Authors computation

3.1.3 Rolling stock

The literature on public transit project evaluation models suggests that the rolling stock capital cost is also a vital cost input as well as the network track length (see e.g., European Commission, 2015; AfDB, 2015; Litman, 2019). Thus we include cost estimate for new rolling stock, in addition to the construction and operations and maintenance costs. This comprises of the initial capital expense to procure the stock, which we discuss in this sub-section, and the cost of a routine maintenance program (e.g., preventive maintenance and repairs), which we discuss in the next sub-section.

The rolling stock in this context comprises the locomotive vehicles, passenger coaches and freight wagons. The data used in estimating the rolling cost was obtained from a combination of sources, including the Ghana Railway Masterplan (2013) and AfDB (2015). The unit cost of rolling stock per vehicle-kilometer is estimated to be US$1,484 (GHS 6800) in the base year.

3.1.4 Rolling Stock Maintenance

As we indicated in the previous sub-section, a lifecycle cost estimate for new rolling stock also includes the maintenance cost. We obtain the average value for maintenance cost (routine, periodic, general overhauls, repairs) per km-locomotive for diesel locomotive, passenger coaches, and wagons from Baumgartner (2001).[14] We subsequently adjust the sum of these values to the base year using the US inflation, obtaining an estimated value of US$8360 (GHS 38,165) per vehicle kilometer in the base year. We assume a 10-year periodic maintenance for the locomotive, passenger coaches and freight wagons and forecast these maintenance values for years 10 (54,380), 20 (GHS78,240), and 30 (GHS113,450) using GDP per capita.

3.1.5 Total costs

The total estimated costs for the rail project is given as GHS75.6 million, GHS72.1 million, and GHS69 million per km for discount rates of, 5%, 8% and 14%, respectively over the project life.

3.2 Project Economic Benefits

We identify and discuss, in this sub-section, the benefits that are reasonably expected to result from the implementation of this rail intervention. Following the Ghana Railway Master Plan (2013) and PwC (2016) we identify the following benefits; time savings, avoided cost of road transport, revenue from increased passenger traffic, carbon emissions saved, accident (road) savings, and post-harvest losses. We discuss each of these benefits in turn.

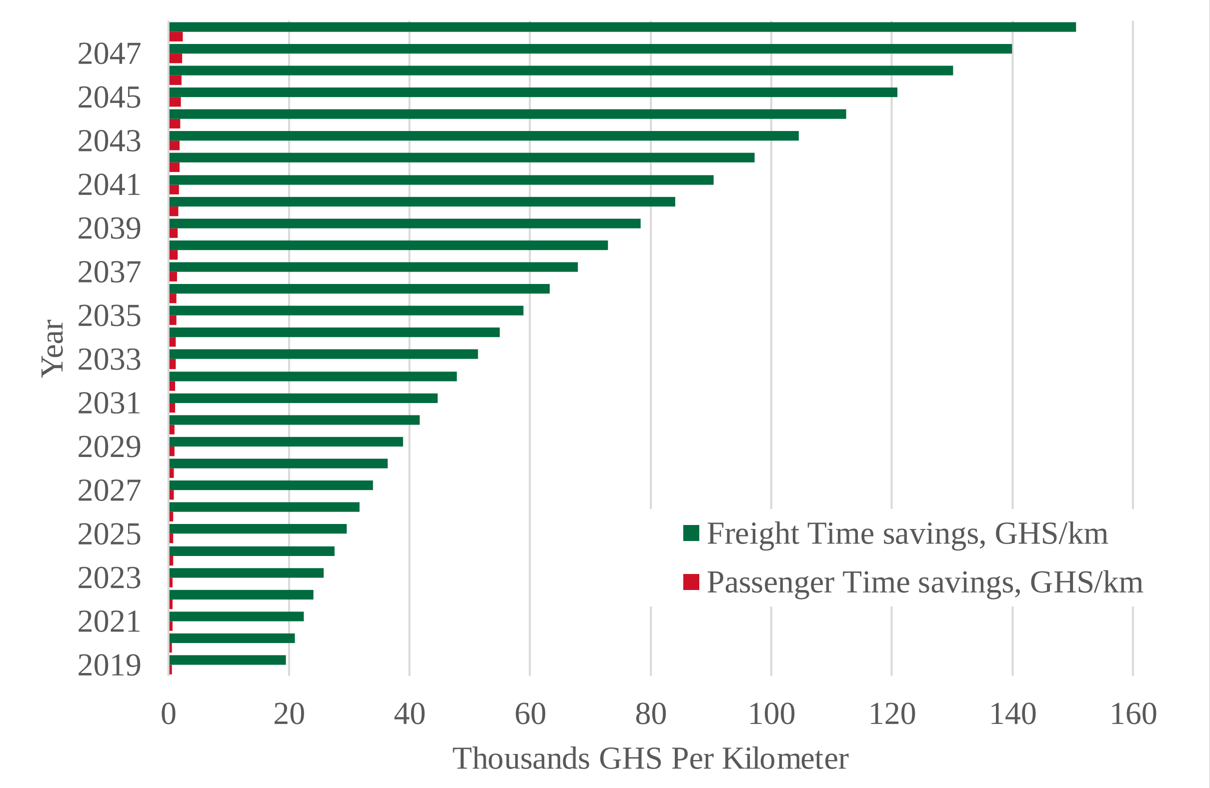
3.2.1 Time savings

The reduction in the delay of passengers and freight transportation is a major purpose of investments. The shift from road to rail leads to faster journey times for both passengers and freight. In this analysis, we assume, for passengers, that the average speed of a bus on a paved road is 77km/hour whereas for rail it is 160km/hr for passengers. For freight, we assume an average speed of 74km/hour and 100km/hour for paved road and rail, respectively (see Railway Master Plan, Ministry of Transport, 2013). These imply a time saving of approximately 24 seconds/km for passengers and 13 seconds/km for freight. The time saving is multiplied by the expected number of passenger-km per year (or expected freight volume), starting at 79,500 in 2019 and rising to a million by 2048 to calculate the total expected time saving per year. These figures are multiplied by the value of time provided by the Copenhagen Consensus, equivalent to approximately GHS 6 per hour. The monetized expected time savings for passenger (freight) is estimated to be GHS575 per km (GHS19,500 per km) in 2019 rising to GHS2,400 per km

[14] The literature suggests the inclusion of operations and maintenance cost of the rolling stock (AfDB, 2015). However, current study only considers maintenance cost of the rolling stock due to data constraints.

(GHS151,000 per km) in 2048. We present the annual estimated time savings for passenger and freight over the life of the project in Figure 6. The Figure shows the virtually all of the savings accrue to freight over the life of the project.

Figure 7. Times savings for passengers and freight



3.2.2 Avoided vehicle operating and other transport costs

Shifting from road to rail will lead to a reduction in direct transport costs for both passengers and freight, due to the greater efficiency of rail. The Ghana Integrated Transport Plan (Ministry of Finance, 2010) notes that the operating cost of passenger vehicles on roads such as busses is USD 0.6 per km whereas for rail it is USD 0.04 per km, leading to a cost saving of USD 0.56 per km. The equivalent saving for freight is USD 0.89 per km (for one tonne of freight). These figures are multiplied by the expected passengers (13, 418pax/km) and freights (877,000 tons/km), that switch to rail each year, and then converted to GHS using the project exchange rate. The transport cost savings in 2019 for both passengers and freights are estimated as GHS38,000 and GHS3.9 million, respectively. These rise over time with expected growth in passenger and freight numbers.

3.2.3 Carbon emissions avoided from road

Reduction in carbon emissions due to modal shift from road to rail transport is an essential aspect of the benefits of rail transport infrastructure procurement. Rail transport is faster and emits fewer carbon equivalent greenhouse gases relative to road transport. In this report, we computed the change in carbon emission per kilometer due to modal shift from road to rail transport in Ghana for both passenger and freight rail. The modal shift differential is then multiplied by the unit value of the social cost of carbon expressed in US dollar/tonne (Copenhagen Consensus Center, 2013) to arrive at the carbon emission avoided per kilometer due to the shift in transport mode. The underlying greenhouse gases carbon equivalent data supporting the analysis are obtained from the Ghana's Environment Protection Agency (2019).

3.2.4 Accident (Road) savings

Accidents savings is the reduction in road accidents fatalities attributable to the modal shift in transportation to rail. Generally, rail transport accident fatalities are less frequent and, therefore, tend to be fewer than road accident fatalities. In this report, we estimate that rail would lead to roughly 1 death avoided per km of rail network per year equivalent to 1,394 deaths per year. Using standard Ghana Priorities valuation assumptions, the value of the lives saved is equivalent to GHS 118,000 per km in the first year.

3.2.5 Post-harvest losses

We estimate the reduction in post-harvest losses attributable to rail transport intervention through the following procedure;

(i) First, we computed the total post-harvest losses (in tonnes) for the base year. Then we computed the transport component of these losses. As reported earlier on, we base the computations on data obtained for post-harvest losses as well as the producer price per tonne and percentages of losses attributable to transport for the following crops in our analysis; tomato, mango, yam, maize, groundnut and cassava from the FAO database. These losses and producer prices are reported per crop.

(ii) The sum total of the base year post-harvest losses attributable to transportation for the above-mentioned crops totaled 8020537 tons amounting to the total monetary value of US$ 276.2 million (GHS1.3 billion).

(iii) To forecast for the 30-year reference period, we apply the Ghana annual percentage change in Agricultural commodity losses for the last three decades.

(iv) Following Ghana Railway Masterplan (2013), we adopted the projected modal change percentage of 30 percentage shift from road to rail in transporting freight on the base year to arrive at the PHL savings attributed to modal shift to be GHS/km 20160.

3.2.6 Residual value

The residual value of capital infrastructure is the excess of the present value of the benefit streams beyond the reference period. According to the Ghana Railway Masterplan, 70% of the value of capital infrastructure in each category of the project should be recapitalized as residual value. We adopt this recommendation in the analysis. We estimate the residual value for the new tracks construction and rehabilitation of existing tracks in 2048 as GHS5 million per kilometer and 4.3 million per kilometer, respectively. For the rolling stock, we assume a zero residual value.

We estimate the total benefits for the rail project to be GHS175 million, GHS109 million, and GHS52 million for the three opportunity cost of capital, 5%, 8% and 14%, respectively.

3.3 Results of the Benefit-Cost Analysis and Discussions for the Rail Project

Table 9 presents a summary of the BCRs for the rail intervention. It is shown in the table that the BCRs of the intervention at two of the three reference parameters for the opportunity cost of capital, 5%, and 8%, are in excess of 1. This indicates that the rail intervention is economically viable.

Table 9. Summary of Benefits and Costs for Rail Intervention

	Benefits (GHS, Millions)	*Costs (GHS, Millions)*	*BCR*
5%	175	76	2.3
8%	109	72	1.5
14%	52	69	0.8

For sensitivity tests, we reduce the discounted benefits by 10% and observe the effects on the computed BCRs. The results show that only a marginal change in the computed BCRs; 2.1, 1.4 and 0.7.

Conclusion

This paper undertook BCR analyses for 2 economic infrastructure interventions in the road and rail sectors in Ghana. The first intervention relate to the development of roads linking areas of high agricultural production as well as tourist attractions to market centers. The results from the analyses indicate that the total expected benefits, overwhelming concentrated in the potential reduction in post-harvest losses, exceed the cost for the road project. Taking cost overruns into consideration, the BRCs are observed to be in excess of 1 for the two reference parameters for the opportunity cost of capital, 5% and 8%. (BCRs are obviously higher without the cost overruns). The sensitivity analysis conducted suggests that the result is robust which, invariably, provides economic justification for expanding the road network in rural Ghana.. The BCRs for the rail project also provide economic justification for the expansion. The BCRs are in excess of 1 for two of the three reference parameters for opportunity cost of funds, 5% and 8%.

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