International Labour Organization

STRENGTHEN2

AFRICAN DEVELOPMENT BANK GROUP
GROUPE DE LA BANQUE AFRICAINE DE DÉVELOPPEMENT

Employment impact assessment of Luangwa-Mwami Road, Zambia, using LFS and GIS

Co-funded by the European Union

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International Labour Organization (ILO)

First published 2025.

ISBN: 9789220426678 (web PDF)

DOI: https://doi.org/10.54394/WKJT9306

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Acronyms and abbreviations

AFD	Agence Française de Développement
AfDB	Africa Development Bank
EmpIA	Employment Impact Assessment
EC	European Commission
EIB	European Investment Bank
EU	European Union
GDP	Gross Domestic Product
GIS	Geographic Information Systems
ILO	International Labour Organization
LFS	Labour Force Survey
MLSS	Ministry of Labour and Social Security
NRCP	Nacala Road Corridor Project
NTL	Nighttime Lights
SMEs	Small and Medium Enterprises
ZamStats	Zambia Statistics Agency

Acknowledgements

The authors would like to thank Mito Tsukamoto, Head of the Employment in Investments (EMPINVEST) Branch of the International Labour Organization (ILO) and Ralf Krueger, Chief Technical Adviser (ILO), for reviewing the report and guiding its production. The authors would also like to extend thanks to colleagues of the African Development Bank (AfDB), Rudolphe Petras, Francis Kemeze and Salim Abdullahi for their review.

This work was made possible thanks to the collaboration with ZamStats and the author would like to thank Gerson Banda (ZamStats) for his support with accessing and working with the Zambia Labour Force Survey data.

Executive summary

This report presents a second Employment Impact Assessment (EmpIA) of Phase 2 of the Nacala Road Corridor Project (NRCP) in Zambia, undertaken with the African Development Bank (AfDB). This assessment focuses on the Luangwa-Mwami section of the corridor, that was implemented under the national Great East Road Rehabilitation Project. Building on an earlier STRENGTHEN2 assessment, also produced in collaboration with AfDB, that used nighttime lights (NTL), this study leverages Labour Force Survey (LFS) data to analyse employment, sectoral shifts, wages and working hours, and uses Geographic Information Systems (GIS) to assess changes in access to social infrastructure.

We combine GIS travel-time modelling with an LFS-based difference-in-differences approach at the ward level using fixed effects and gender disaggregation. The identification compares wards within 2.5 km of the rehabilitated road to wards along untreated roads in Eastern Province. The accessibility analysis finds improved access to hospitals and secondary schools following road rehabilitation. Motorized travel times to hospitals fell by up to 20 minutes, and an estimated 17,800 additional people now live within a 30-minute drive of a hospital (approximately a 1 percentage point increase in coverage). Effects for primary schools and primary health facilities are smaller, reflecting already high baseline coverage. District patterns highlight persistent gaps, particularly in more rural areas such as Chipata and Sinda, that may warrant complementary investments in infrastructure and service provision.

Using LFS data, the econometric analysis does not detect a statistically significant change in total employment, but reveals sector-specific shifts. For men, industry employment increased by 4.3 per cent, consistent with better access to higher-productivity opportunities. Agriculture shows a small, non-significant decline. Wages rose by 6.5–8.3 per cent across total, male and female employment, pointing to improvements in job quality and earning potential. Years of schooling are positively associated with employment in services and with higher wages, underscoring the role of human capital.

Taken together and in comparison with the earlier NTL-based assessment, the results suggest that the corridor delivered meaningful accessibility gains and improvements in wages, alongside reallocation toward industry particularly among men. While broad-based job creation is not statistically established in this design, the pattern of effects is consistent with structural transformation. Men appeared to benefit more than women in terms of industrial employment, highlighting the need for targeted interventions to ensure women benefit equitably from these investments moving forward.

The findings from the assessment promote recommendations to build on the positive effects of the road investment by complementing future investments with measures that strengthen their long-term employment and social impact. It calls for using the accessibility analysis to prioritise the siting and upgrading of hospitals and secondary schools in districts with the largest service gaps, and for continuing investment in feeder roads and public transport to improve connectivity between settlements, markets, and workplaces. To support access to better jobs, particularly for women, the report highlights the importance of financing skills development and TVET programmes aligned with the types of employment generated by road investments. Development partners are encouraged to promote multi-sectoral project design that links transport to training, SME support, and social services, and to adopt employment-intensive approaches in maintenance to sustain local job creation over time.

Résumé exécutif

Ce rapport présente une deuxième évaluation de l'impact sur l'emploi (EmpIA) de la phase 2 du projet de corridor routier de Nacala (NRCP) en Zambie, réalisée avec la Banque africaine de développement (BAD) et cofinancée par l'Union européenne (UE), la Banque européenne d'investissement (BEI) et l'Agence française de développement (AFD). Le tronçon Luangwa-Mwami a été mis en œuvre dans le cadre du projet national de réhabilitation de la route Great East Road. S'appuyant sur une précédente évaluation STRENGTHEN2 qui utilisait les lumières nocturnes (NTL), cette étude exploite les données de l'enquête sur la population active (LFS) pour analyser l'emploi, les changements sectoriels, les salaires et les heures de travail, et utilise les systèmes d'information géographique (SIG) pour évaluer les changements dans l'accès aux infrastructures sociales.

Nous combinons la modélisation SIG des temps de trajet avec une analyse des différences dans les différences au niveau des quartiers basée sur l'enquête sur la population active (LFS) en utilisant des effets fixes et une ventilation par sexe. L'identification compare les quartiers situés à moins de 2,5 km de la route réhabilitée aux quartiers situés le long de routes non traitées dans la province orientale. L'analyse de l'accessibilité révèle une amélioration de l'accès aux hôpitaux et aux écoles secondaires à la suite de la réhabilitation des routes. Les temps de trajet motorisés vers les hôpitaux ont diminué de 20 minutes, et on estime que 17 800 personnes supplémentaires vivent désormais à moins de 30 minutes en voiture d'un hôpital (soit une augmentation d'environ 1 point de pourcentage de la couverture). Les effets sur les écoles primaires et les établissements de santé primaires sont moins importants, ce qui reflète une couverture de base déjà élevée. Les tendances observées dans les districts mettent en évidence des écarts persistants, en particulier dans les zones plus rurales telles que Chipata et Sinda, qui pourraient justifier des investissements complémentaires dans les infrastructures et la prestation de services.

À partir des données de l'enquête sur la population active, l'analyse économétrique ne détecte pas de changement statistiquement significatif dans l'emploi total, mais révèle des changements spécifiques à certains secteurs. Pour les hommes, l'emploi dans l'industrie a augmenté de 4,3 %, ce qui correspond à un meilleur accès à des opportunités plus productives. L'agriculture affiche une légère baisse non significative. Les salaires ont augmenté de 6,5 à 8,3 % pour l'emploi total, masculin et féminin, ce qui indique une amélioration de la qualité des emplois et du potentiel de revenus. Le nombre d'années de scolarité est positivement associé à l'emploi dans les services et à des salaires plus élevés, ce qui souligne le rôle du capital humain.

Dans l'ensemble, et par rapport à l'évaluation précédente basée sur le NTL, les résultats suggèrent que le corridor a permis d'améliorer considérablement l'accessibilité et les salaires, tout en favorisant la réaffectation vers l'industrie, en particulier chez les hommes. Bien que la création d'emplois à grande échelle ne soit pas statistiquement établie dans cette conception, le schéma des effets est conforme à la transformation structurelle. Les hommes semblent avoir davantage bénéficié que les femmes en termes d'emploi industriel, ce qui souligne la nécessité d'interventions ciblées pour garantir que les femmes bénéficient équitablement de ces investissements à l'avenir.

Les conclusions de l'évaluation encouragent à tirer parti des effets positifs des investissements routiers en complétant les investissements futurs par des mesures qui renforcent leur impact social et sur l'emploi à long terme. Elles préconisent d'utiliser l'analyse de l'accessibilité pour donner la priorité à l'implantation et à la modernisation des hôpitaux et des écoles secondaires dans les districts où les lacunes en matière de services sont les plus importantes, et de poursuivre les investissements dans les routes de desserte et les transports publics afin d'améliorer la connectivité entre les zones d'habitation, les marchés et les lieux de travail. Afin de favoriser l'accès à de meilleurs emplois, en particulier pour les femmes, le rapport souligne l'importance de financer des programmes de développement des compétences et d'enseignement et de formation techniques et professionnels (EFTP) adaptés aux types d'emplois générés par les investissements routiers. Les partenaires de développement sont encouragés à promouvoir la conception de projets multisectoriels qui relient les transports à la formation, au soutien aux PME et aux services sociaux, et à adopter des approches à forte intensité de main-d'œuvre dans le domaine de l'entretien afin de soutenir la création d'emplois locaux à long terme.

1. Introduction

The STRENGTHEN2 project is a joint initiative of the European Union (EU) and the ILO that aims to promote employment impact assessment (EmpIA) of infrastructure investments, for the creation of more and better jobs in sub-Saharan Africa. The Nacala Road Corridor Project (NRCP) is aimed at providing transport linkages to the port of Nacala for Malawi, Mozambique and Zambia, whilst improving accessibility for communities to markets and social services. The project was split into three phases, with two phases currently completed and one ongoing. Phase 2, which covered 360 kilometres (km) of road works from Luangwa to Mwami, is the focus of this report.

The project was completed in 2017 and financed by the African Development Bank (AfDB). It forms part of the Great East Road Rehabilitation project, which was co-financed between the European Commission (EC), AfDB, European Investment Bank (EIB) and Agence Française de Développement (AFD). The previous EmpIA using NTL data to measure the long-term economic and employment impacts unveiled a strong positive impact of the road rehabilitation on luminosity around the road. It was estimated that NTL luminosity increased by 25 per cent in administrative units that were within 2.5 km of the road project, compared to those that were close to roads that did not receive improvement, two years after completion of the project. It was estimated that this produced an increase in local-level GDP of 12 per cent; taking into account the elasticity between lights/GDP and GDP/employment, this equated to an increase of 6.7 per cent in employment.

This previous assessment built upon a base of research and numerous studies by the STRENGTHEN2 project, which has been applying spatial data to measure the long-term impacts of these infrastructure investments in Africa, spanning transport corridors to rural road projects (Game and Kang, 2023a; Game and Kang 2023b). Drawing on this body of work, it can be summarized that the application of NTL data to measure the long-term economic and employment effects is valuable, particularly in countries that lack available LFS data. It provides a useful proxy to identify spatial patterns of economic growth and employment over time. However, there are only so many insights that can be generated from the NTL data and it does not allow for underlying employment dynamics to be measured, such as shifts between sectors or changes in wages. This analysis aims to apply the LFS data to address these gaps and offer a comparison to the NTL methodology, which highlighted an increase in economic activity and employment. In addition to this, it allows for a more nuanced understanding of who is benefiting from road investments, by disaggregating employment outcomes by gender. This EmpIA goes a step further and applies GIS data to analyse how the road rehabilitation impacted the project's objective of improving access to social infrastructure at district level, by assessing travel time to health and education facilities for the surrounding population.

2. Country situation analysis

Zambia is a landlocked country in Southern Africa, bordered by Angola, Botswana, the Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, and Zimbabwe. It covers an area of approximately 752,612 square kilometres and experiences a predominantly subtropical climate, with three distinct seasons: a hot dry period, a rainy season, and a cool dry season. As of 2022, Zambia's population was estimated at 19.7 million and is projected to reach 28.3 million by 2035 (ZamStats, 2022; UNFPA, 2025). A significant proportion of the population is under the age of 35, accounting for 77.9 per cent, while children aged 0 to 14 comprise 42 per cent (ZamStats, 2022).

Over the past decade, Zambia has navigated a series of macroeconomic challenges, alongside global and regional shocks. From 2015 to 2018, real GDP growth averaged 3.6 per cent but declined to 1.4 per cent in 2019 and declined further by 2.8 per cent in 2020, due largely to the COVID-19 pandemic and associated economic disruptions. Since 2021, however, the country has embarked on a path of economic recovery, with average annual growth reaching 4.8 per cent between 2021 and 2024. Concurrently, inflationary pressures have eased, with inflation declining from a high of 22 per cent in 2021 to an annual average of 14.6 per cent in 2024 (IMF, 2024). Fiscal consolidation efforts have contributed to improvements in public finances, with the fiscal deficit narrowing from 14.5 per cent of GDP in 2020 to 8.2 per cent in 2022, and further to 6.6 per cent in 2023, supported by higher revenues in the mining sector (AfDB, 2024a). Despite these gains, Zambia continues to face significant public debt vulnerabilities. Total debt as a share of GDP increased from 35 per cent in 2014 to 141 per cent in 2023 (IDA & IMF, 2024).

In this context, while Zambia has recorded progress in industrial growth over the past decade—particularly between 2010 and 2018—the structure of the economy remains concentrated in a limited number of sectors. In 2023, wholesale and retail trade contributed the largest share to GDP at 20 per cent, followed by mining and quarrying at 15 per cent, and construction at 11 per cent. In contrast, manufacturing and agriculture, though central to livelihoods and national output, accounted for 9 per cent and 7 per cent of GDP, respectively (ZamStats, 2024).

The current structure of the economy is also closely intertwined with the state of national infrastructure, which plays a defining role in shaping sectoral performance and regional development. As of 2023, Zambia had an installed electricity generation capacity of 3,705 MW, of which 85 per cent was hydro-based. Despite this capacity, access to electricity remains uneven, with national coverage at 54 per cent, comprising of 80 per cent in urban areas and only 34 per cent in rural areas (ZamStats, 2024). These disparities mirror the spatial concentration of economic activity and service delivery. At the same time, improvements in transport infrastructure have supported internal connectivity and trade flows. Zambia's road quality score of 40.6 in the 2019 Global Competitiveness Index exceeded the regional average for the Southern African Development Community (WEF, 2019), reflecting efforts to strengthen logistical networks and physical access to markets.

This infrastructure divide has significant implications for labour market outcomes, where uneven access to services and regional disparities contribute to high informality and unemployment. As of 2023, Zambia's working-age population (aged 15 years and above) was estimated at 11.6 million, with a labour force of 4.5 million and a participation rate of 39 per cent (ZamStats, 2023). Of the approximately 4 million employed persons, the employment-to-population ratio stood at 34.3 per cent. However, the labour market is heavily skewed toward informality, with 75.6 per cent of total employment in the informal sector, and only 24.4 per cent employed in formal enterprises and institutions, where workers benefit from social protection coverage. This pattern is particularly evident in sectors such as agriculture, forestry and fishing where 92.6 per cent of the employed population works informally, and wholesale and retail trade, which records 93.1 per cent informal employment (ZamStats, 2023).

The extent of informality and the challenges faced by the labour market are further reflected in high unemployment rates, especially among youth and females. The national unemployment rate in 2023 was estimated at 12 per cent, with slightly higher unemployment among women (12.6 per cent) compared to men (11.5 per cent). Among young people, the unemployment rate reached 26.4 per cent for both genders (ILO, 2023). Additionally, when considering the combined rate of unemployment and potential labour force—a broader measure of labour underutilization—the figure stood at 39.4 per cent, with higher rates for females (45.5 per cent) compared to males (34.5 per cent), and substantially higher rates in rural areas (49.6 per cent)

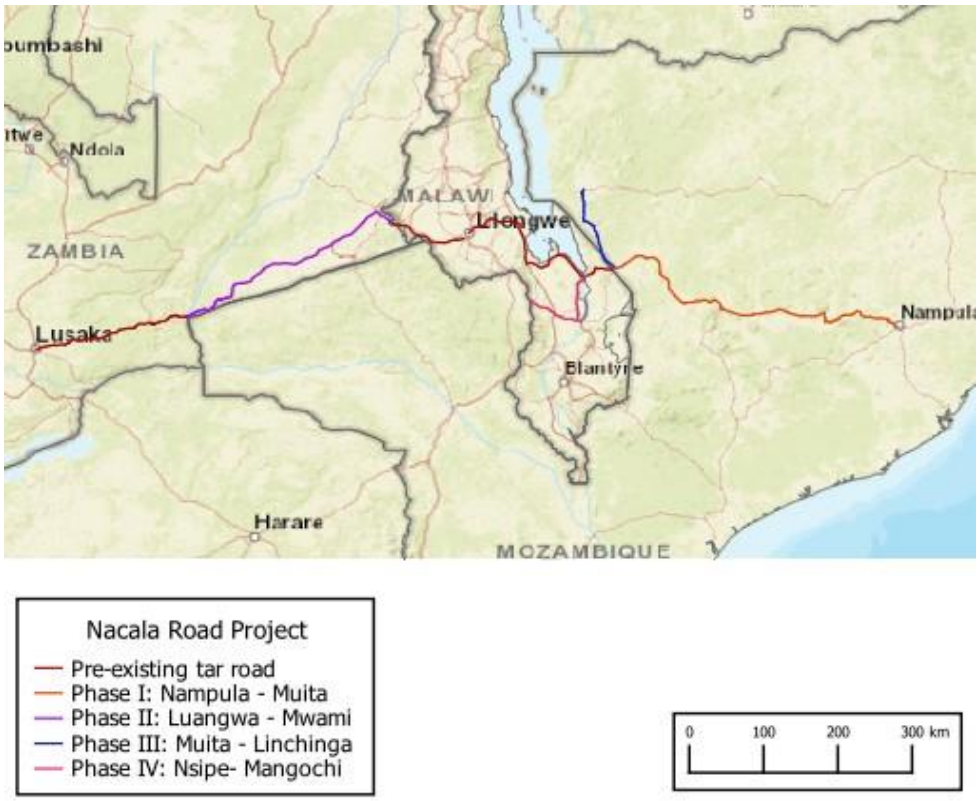
compared to urban areas (31.3 per cent) (ZamStats, 2023). These figures underline how regional disparities, driven by both infrastructure gaps and economic factors, significantly shape the labour market outcomes in the country. Formal firms and wage employment remain concentrated in Lusaka and along the Copperbelt corridor, while weak transport connectivity and higher travel and job-search costs constrain diversification and wage work in rural districts (World Bank, 2018).

Zambia's long-term development vision is articulated in Vision 2030, which is operationalized through successive medium-term National Development Plans (NDPs). The draft Eighth National Development Plan (8NDP) outlines four Strategic Development Areas: economic transformation and job creation; human and social development; environmental sustainability; and good governance (MoFNP, 2025). Building on the foundations of the Seventh National Development Plan, the 8NDP identifies infrastructure as a key enabler of inclusive and sustainable growth. Priority areas include the rehabilitation and integration of transport systems—encompassing road, rail, air, and water networks, as well as reforms in the energy sector to reduce transmission losses and attract private investment.

3. Project description

The NRCP contains a total of 1,033 km of road works across Malawi, Mozambique and Zambia and the construction of two one-stop border posts. The project is implemented through multiple phases (Figure 1). Two additional phases (4 and 5) are currently ongoing and provide further rehabilitation and trade facilitation. The corridor aims to provide Malawi, Mozambique and Zambia with transport links to the port of Nacala in Mozambique, improving transport services through the reduction in transport and delay costs at border crossings. The project also aims to improve sustainability of investments by controlling axle loads and improving the accessibility of the communities in the zone of influence to markets and social services. The project is co-financed between the EC, AfDB, EIB and AFD. The NRCP operationalises the eighth NDP (2022-2026) objective of economic transformation and job creation by reducing travel costs and improving connectivity to allow the population to access more and better jobs.

▶ Figure 1. Nacala road transport corridor project phases



Sources: Main roads: OSM (2022); Zambia country boundary: GADM (2012).

Table 1 summarizes phases of the NRCP: Phase 1 consists of the realization of 361 km of road in Malawi and Mozambique, Phase 2 consists of the realization of 360 km of road in Zambia and Phase 3 consists of the realization of 175 km of road in Malawi and Mozambique with two single-border posts.

▶ Table 1. Breakdown of the road works phases of the Nacala Road Corridor Project

Phase	Length (km)	Completion Date	Financing
Multinational – phase 1 (Loan to Mozambique and Malawi)	361	Ongoing (planned completion 2026)	AfDB, Governments of Malawi and Mozambique
Multinational – phase 2 (Loan to Zambia)	360	December 2017	AfDB and Government of Zambia
Multinational – phase 3 (Loan to Mozambique)	175	December 2024	AfDB and Government of Mozambique

Source: AfDB (2024b).

The present assessment focuses on Phase 2 of the project, which was completed in December 2017. The NRCP Phase 2 comprised three road sections covering 360 km in total. The AfDB was responsible for 114.7 km of this length–Nyimba to Petauke (67.7 km) and Petauke to Sinda (47 km). In addition, further outputs were market sheds, community boreholes, capacity development, HIV/AIDS and TB awareness, tree planting and compensation for project affected persons (PAPs). The project duration was almost six years. The Luangwa-Mwami stretch of the road runs through predominantly rural districts of Eastern Province, Nyimba, Petauke, Sinda, Katete and Chipata, linking the provincial hub to the Mwami/Mchinji border. Local economies in these districts are centred on smallholder agriculture.

From the final evaluation of the project, the development objective of improving the accessibility of the communities to social services and markets was realized. The travel speeds estimated at the appraisal exceeded the 71.1 km/h for medium trucks and 94.5 km/h for passenger vehicles targeted to be achieved at project completion. Travel times also reduced with the increased speeds. This decreased the vehicle operating cost by 13.1 per cent for heavy vehicles and 14.9 per cent for light vehicles. The road safety awareness campaigns were also found to be effective in decreasing the number of accidents, from 929 in 2013 to 70 at completion, a 92 per cent reduction (AfDB, 2017).

The final evaluation also found that the project led to an increase in income levels for both men and women through direct employment during construction. On average, the project engaged 360 unskilled workers of whom 30 (or 8.3 per cent) were women. This was well below the target of 20 per cent female employment. The employment generated an income of US$0.51 million per month, which was injected into the local economy. Of this, US$0.043 million per month accrued to women. Other economic activities such as provision of food for construction workers, hospitality services and roadside vending offered additional income-generating opportunities for the communities along the project route (AfDB, 2017). Due to the project, additional sources of income were realized for women through sales of food items to construction workers. The provision of nine borehole water points in selected communities served an estimated 1,800 households. Finally, the project included construction of three simple market structures, and women were the major beneficiaries of this activity since it improved the conditions under which women could sell their produce. On-the-job training of unskilled labour has improved the potential of the project workers to find employment with the same contractor or with other employers.

4. Data

A variety of spatial data were downloaded and processed to conduct the assessment of access to social infrastructure and for measuring the employment effects. These were combined with the LFS data in the econometric analysis. The different data sources and processing required are outlined below.

4.1. Labour force survey (LFS)

Zambia's LFS is a nationwide household survey conducted by ZamStats in collaboration with the Ministry of Labour and Social Security (MLSS). It aims to collect comprehensive data on the labour market activities of eligible individuals in selected households across the country. Since its inception in 1986, the LFS has been carried out every one to three years. The primary objective of the LFS is to measure the size of the labour force and its characteristics, such as age, sex, industry, employment sector, education, and more. The survey utilizes a two-stage stratified cluster sampling design. In the first stage, enumeration areas (EAs) are selected with Probability Proportional to Estimated Size (PPES) using the number of households as the size measure. In the second stage, households are selected from an updated list within each sampled EA using systematic random sampling (SRS). The sampling is designed to include both urban and rural areas, with different groups in each area being surveyed each quarter. By combining data from all four quarters, more detailed insights can be provided at the provincial level and for other specific regions.

This assessment utilizes Zambia's LFS from four time points, 2014, 2017, 2019 and 2021. The sampling frame for these surveys was based on the 2010 Census of Population and Housing, which provided detailed information on provinces, districts, constituencies, wards, and the number of households and population for each EA. Since the same households are not re-interviewed in every survey round, the LFS data does not qualify as a panel dataset. To ensure representativeness over time, household-level data has been aggregated to the ward level (administrative level 3). Wards are administrative subdivisions within constituencies and the smallest administrative unit used in Zambia. This aggregation establishes the ward level as the unit of analysis for the statistical exercise conducted in this assessment. Aggregating to the ward level ensures that the data is representative, on average, for the same administrative unit across the different survey years.

Zambia's LFS data was further restricted to a specific geographic area for the purpose of this assessment. The sample comprises of 54 administrative units (wards) in 10 districts. The treatment group consists of 33 administrative units (1,672 respondents) within a 2.5 km distance from the road improvement. The control group consists of 21 wards (1,010 respondents) along a comparable road, which has not been improved during this time frame, but which had a similar baseline level of employment and education to the treatment group. The maximum survey period is four years, with 55 per cent of treated units and 33 per cent of control units surveyed in all four years. However, 91 per cent of treated units and 76 per cent of control units have been surveyed in more than two years. As a result, the analysis is based on an unbalanced panel at the ward level, covering 2,682 individuals across 54 wards over the period 2014-2021.

The LFS provides detailed information on socio-economic background, including age, gender, and years of schooling, which are utilized as covariates in the analysis to account for their potential influence on the outcomes. The main variables of interest used in the analysis are employment status, sector employment, working hours, and hourly income. To ensure the analysis targets the relevant population, the sample is restricted to individuals aged 15 to 65 years, aligning with the ILO's definition of the working-age population (WAP).

While the gender distribution is balanced among treated units, control units exhibit a slightly higher proportion of female respondents, at 52 per cent. Table 2 provides a comparison between treated and control units during the pre-rehabilitation period, disaggregated by gender. The average age is comparable between treated and control units and consistent across genders. On average, male respondents have achieved more years of schooling than female respondents. A significant gender disparity is evident in all employment categories. In treated units, 30 per cent of the working-age population is employed, compared to 25 per cent in control units. In both groups, approximately 3 per cent are unemployed, and 70 per cent are outside the

labour force. Women are disproportionately represented among those not in the labour force, with approximately 80 per cent compared to 60 per cent among men. Additionally, men work more hours on average than women, and individuals in control units tend to work slightly longer hours than those in treated units. The average hourly wage is similar across treated and control units; however, men have higher earnings in control units, while women exceed men's hourly wages in treated units. The difference and standardized mean difference (SMD) was calculated for the total values of variables. The columns indicate that pre-treatment characteristics are broadly comparable across the two groups. Standardized mean differences are small (generally <0.1), which indicates that the treated and control samples are well balanced.

▶ Table 2. Comparison of characteristics between the treatment and control group wards

	Treatment			Control			Comparison	
	Total	**Male**	**Female**	**Total**	**Male**	**Female**	**Difference**	**SMD**
Average age (years)	31.04	31.02	31.05	31.28	31.58	31.00	-0.24	0.006
Average school years (years)	6.14	6.79	5.48	5.67	6.24	5.15	0.47	0.089
Employed (%)	0.30	0.39	0.21	0.25	0.34	0.17	0.05	0.01
Unemployed (%)	0.03	0.04	0.02	0.03	0.04	0.02	0	0
Out of labour force (%)	0.67	0.57	0.78	0.72	0.63	0.81	-0.05	-0.006
Agriculture (%)	0.43	0.43	0.42	0.46	0.43	0.53	-0.03	-0.005
Industry (%)	0.13	0.17	0.07	0.13	0.18	0.04	0	0
Services (%)	0.44	0.40	0.51	0.41	0.39	0.43	0.03	0.005
Average working hours (h)	36.19	37.97	32.80	38.22	40.26	34.58	-2.03	-0.084
Average hourly wage (ZMW)	10.96	10.11	12.63	10.87	12.89	7.17	0.09	0.039

Note: SMD (Total) is the standardised mean difference. For percentage indicators, SMD uses the Bernoulli variance; for continuous indicators, SMD is computed from individual data.

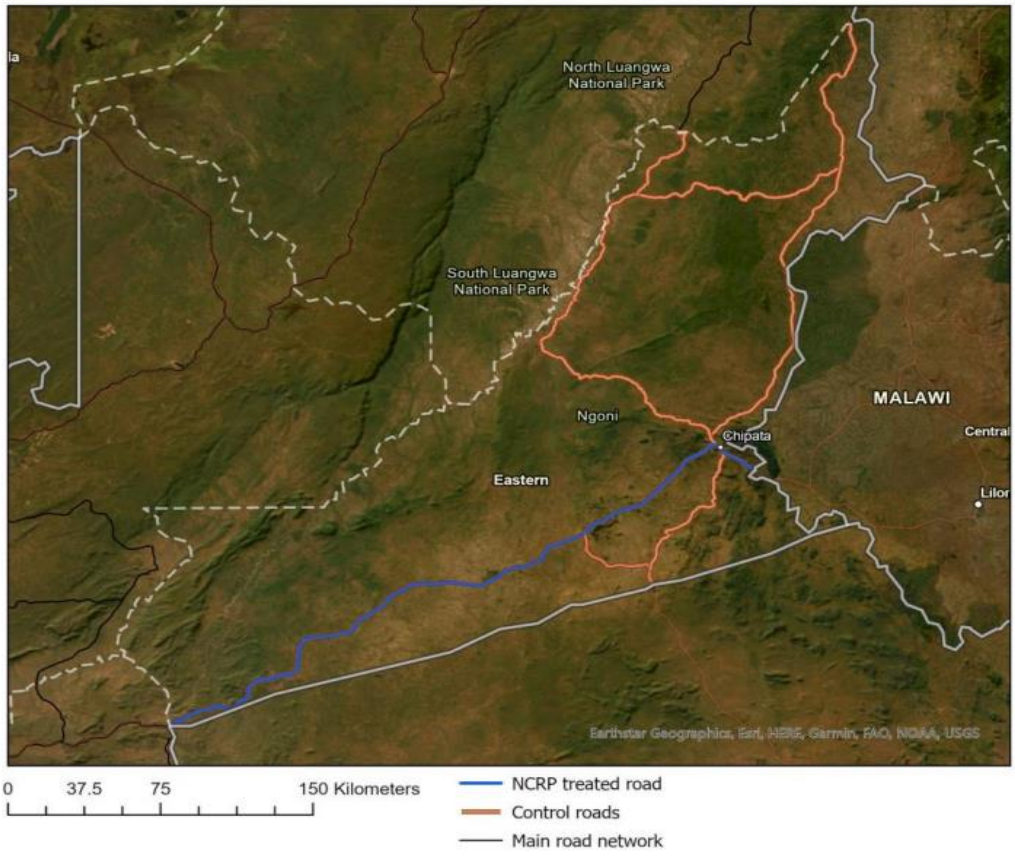
Source: Zambia Labour Force Survey, 2017. Sample based on working age-population aggregated to the ward level.

4.2. Geospatial data

A range of geospatial data was used in the analysis, with details of the open-source datasets that were applied in Table A.1 in the Annex. AfDB provided the location of the completed section of road under Phase 2 of the project. Administrative units (wards) that fell within a 2.5 km buffer around this road were selected as the treatment group and compared to administrative units within such a buffer around primary or secondary roads in the surrounding area, within the Eastern province of Zambia; these were selected as the control group (Figure 2). These other roads had received no treatment for the years of focus in the study (2014-21). Given the geographical proximity between the treatment and control wards, potential spillover effects cannot be ruled out. Reductions in transport and border-delay costs along the corridor may benefit nearby control areas via commuting, trade links, or reallocation of firms and workers. If control areas gain from the project, the estimated results will have a downward bias. On the contrary, if activity relocates from nearby controls into treated wards, the contrast could be biased upward. In attempt to mitigate this, wards located at the end points of corridors were excluded from the analysis. End points can concentrate new activity and services, and their benefits can diffuse quickly to nearby areas, so omitting them could mitigate some of the potential bias, however residual spillovers along feeder links may remain so results should be interpreted with this in mind.

For the analysis on access to social infrastructure, travel times were calculated using a combination of geographic datasets: landcover, elevation, roads, rivers, other permanent water bodies, health facilities, and schools. Details on temporal and spatial resolution of the data can be found in Table A.1, information on the travel time calculations are described below.

▶ Figure 2. Treated and control roads used in the analysis



Sources: NCRP road: AfDB (2017); Control roads: OSM (2022).

5. Methods

5.1 Accessibility analysis

This section describes the analysis that was undertaken to assess to what extent the project met the objective of improving access to social services for the surrounding population. Although it should be made clear that this only addresses geographic, physical access to infrastructure and does not take into account alternative barriers to access, such as those of a socioeconomic or cultural nature.

Gridded travel times were estimated at 100 by 100 meter resolution using Accessmod version 5, a World Health Organization tool for estimating geographic accessibility (Ray and Ebener 2008). Walking and motorized journey modes were calculated. Appropriate speeds from previous studies were applied to landcover types for walking speeds towards social amenities (Alegana, Tatem, and Gething 2012). Rivers and other permanent water bodies were included as a barrier to geographic access except when there was a road or bridge across it. Elevation was used to moderate walking speeds towards amenities as fatigue is present when travelling on uneven terrains and land cover under the premise that walking on bare ground/paved surface warrants faster walking speeds. Travel times were estimated for access to schools and health facilities. Models were run for primary schools, secondary schools, primary health facilities (clinic, health centre, health post, rural health centre and rural health post) and secondary health facilities (hospitals).

The AfDB project completion report captures the baseline speed for trucks (56.7 km/h) and passenger cars (68.3 km/h) and for post-project, 80 km/h for trucks and 120 km/h for passenger cars. Therefore, 63 km/h mean speed was applied to all trunk roads as the pre-scenario, including the treatment road, for the motorized travel model. An average speed of 100 km/h was applied to the treatment as the post-scenario and 63 km/h to all other trunk roads, assuming the other trunk roads were not improved. For walking speeds, 5 km/h speed was applied to all roads pre-improvement and then 5.5 km/h to the treated road to account for the improvements. The travel times were calculated for up to 360 minutes (6 hours). Results are presented by analysing population coverage within 0-15 minutes travel time from services and 15-30 minutes travel time (excluding those within the 0-15 minutes category). The travel speeds for all road and landcover types are in table A.2 in the Appendix.

5.1.1. Calculating changes in travel time

Four travel time models were calculated for each amenity type of primary schools, secondary schools, primary health facilities and secondary health facilities. For instance, for a primary school, walking and motorized models are estimated for the baseline travel speed (before) and the post-project (after). Therefore, 16 models were estimated, 8 for schools and 8 for health facilities. For each amenity, e.g. secondary health facilities (hospitals), the ‘after’ travel models are subtracted from the corresponding “before” model to estimate the change in travel time. The median travel times were calculated for each district using the travel time models and district administrative boundaries for the Eastern Province. Median travel times were chosen because the mean estimates could be affected by extreme values.

5.1.2. Calculating population coverage

Gridded population estimates from WorldPop (WorldPop and ZamStats 2024), containing the count of persons per 100 x 100-meter area were used to calculate the number and percentage of persons near defined travel limits of health facilities and schools. The geographic coverage for key population groups was estimated by combining the gridded travel time models with the gridded estimated population and summarised using administrative boundaries. Travel to health facilities was estimated for the whole population. Different population subgroups were used to produce estimates for primary and secondary schools, to include school-age children. The population coverage estimates were produced at reasonable travel limits (15 minutes and 30 minutes) for health facilities and schools. Population coverage was also estimated at the district levels, to observe gaps in coverage.

5.2. Econometrics to estimate employment impacts

This section describes the empirical strategy and specification that was applied to measure the employment effects of roads. The data and specification is inspired by the previous work of Yamauchi (2016), and a previous assessment of a feeder roads project in Rwanda using similar methodology (Game, Kucera and Neza 2025). It was important to try to replicate the previous assessment that used NTL data as much as possible, to compare the two methods and capture employment impacts that could not be included in the NTL analysis, which utilized the NTL satellite data as a proxy for GDP and translated this into employment. Yamauchi looked at observations at the household level, using village fixed effects to examine impacts of roads in Indonesia. Due to the nature of the LFS survey for Zambia and as highlighted above, the unbalanced panel that is used in this analysis is constructed at the ward level. These estimates capture local effects, comparing treated wards within 2.5km of the rehabilitated road to those untreated. They exclude spillovers across the country that could occur due to the facilitation of trade and increased mobility from the project. Increases may reflect a spatial reallocation of labour rather than net new jobs.

All of the regressions were disaggregated by gender to assess the impact on employment, employment by sector, wages and working time. The below specification was applied:

$$Yi,t = \alpha + \beta 1 Treatedit + \beta 2 Zit-j + \lambda i + nt + \epsilon i+t$$

Where Y is employment, or the log of wages or working time, $Treated$ is the treatment variable that has a value of 1 if the ward fell within the 2.5 km buffer around the rehabilitated road under the project, from the year 2018. λi are village fixed effects and nt are annual fixed effects. $\beta 2$ controls for household characteristics that could impact the employment outcomes, including average age and number of schooling years (level of education) obtained. Using village and time fixed effects, coefficient estimates are driven by change over time within villages. By using village fixed effects, the analysis tries to address the aspects of endogeneity regarding non-random placement of investments that can be considered fixed over time, as well as partly addressing omitted variable bias.

6. Results

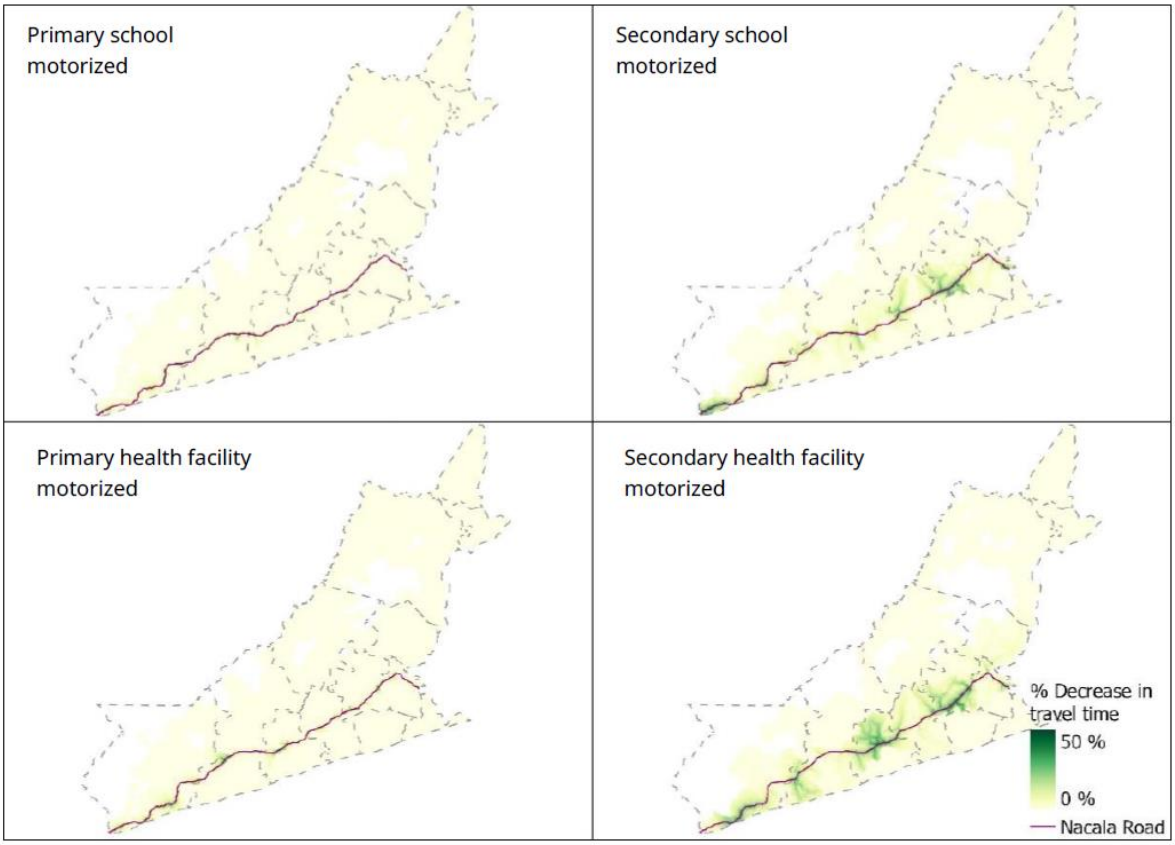
6.1. Access to social infrastructure

6.1.1. Changes in travel time

There were 633 primary schools in the Eastern Province compared to 47 secondary schools. For primary schools, the maximum decrease in walking travel time to the nearest school was 9 minutes, while motorized travel showed a 5-minute change. As expected, secondary schools were fewer and farther away. The maximum decrease in walking time to secondary schools was 29 minutes, while motorized distance was 20 minutes. Figure A. 3 in the Annex highlights changes in walking and motorized travel time.

There were 297 primary health facilities (clinic, health centre, health post, rural health centre and rural health post) in the Eastern Province and only 12 secondary health facilities (hospitals). Compared to primary health facilities, travel time to hospitals saw a significant decrease in journey times (Figure A.4 in the Annex). Walking journeys to primary health facilities decreased by a maximum of 15 minutes compared to 9 minutes for motorized journeys. Walking to secondary schools was reduced by a maximum of 27 minutes compared to the 20-minute maximum reduction by motorized journeys. Large areas of districts intersecting with the Nacala road saw reductions in travel time to hospitals, which had the most pronounced decrease after road improvements, followed by secondary schools as seen in Figure 3.

Figure 3. Per cent decrease in travel time for motorized travel to schools and health facilities



Source: Author's research.

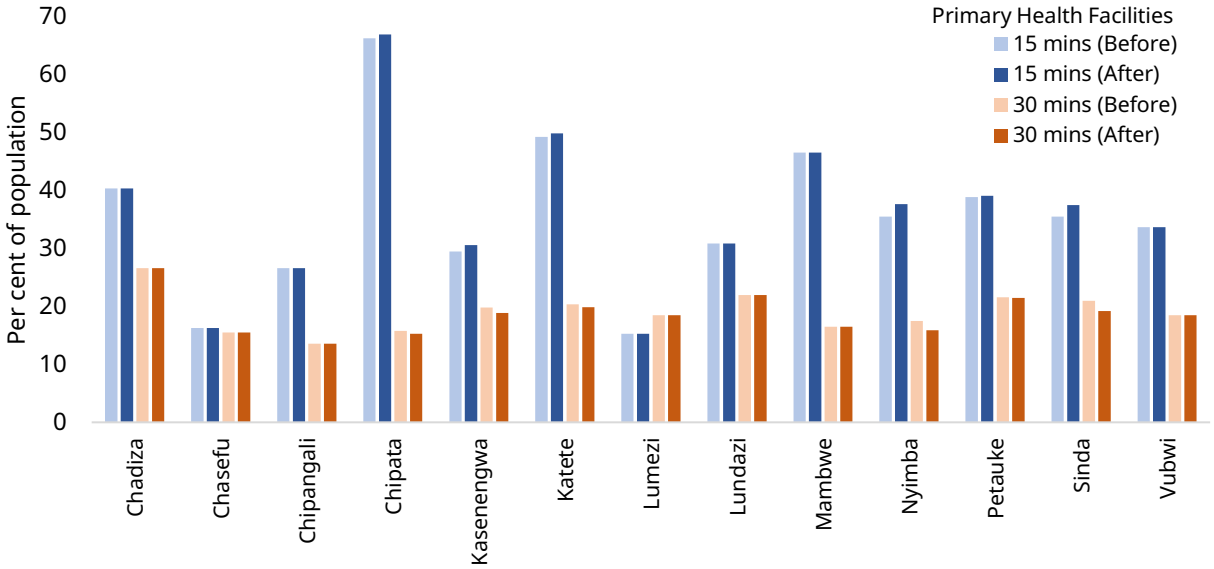
At district level, the majority of districts where the rehabilitated road passes have motorized travel times to primary health facilities within an hour compared to longer walking distances. The median walking and motorized travel times to the primary health facilities did not change before or after the road improvements. However, there were changes in geographic access to hospitals at district-level. Chipata district had the highest change in the median travel time with a 4 minute reduction. Among districts with the treated road passing through, Nyimba has the longest travel time to health facility, with journey time to a hospital at approximately 3 hours. Differences in travel time for primary and secondary schools were minimal before and after the road improvements. Figures breaking down changes in travel time by district can be found in the Annex (Figures A.5 and A.6).

6.1.2 Population coverage

There was an estimated 1 percentage point increase in population coverage access to hospitals (secondary health facilities) for motorized journeys within 15 and 30 minutes. The 1 percentage point increase in coverage within 30 minutes impacts approximately 17,872 persons, while 14,825 persons benefit from the 0.8 percentage point increase for 15-minute travel. More than half of the population travels an hour or more to reach a hospital. In most districts where there is a change in population coverage to health facilities, the percentage of people within 15 minutes of health facilities increased post-road improvements. Consequently, the percentage of persons within 15 to 30 minutes of health facilities decreased. Most districts had at least one-third of their population living 15 minutes away from a primary health facility (Figures 4 and 5). Coverage to primary health facilities was generally high within 15 minutes, ranging from 15.3 per cent in Lumezi to 67 per cent in Chipata. The biggest change (2.2 percentage points, 1419 persons) for primary health facilities was in Nyimba district. In Sinda district, coverage within 15 minutes increased by 2 percentage points, benefitting an estimated 3,340 people.

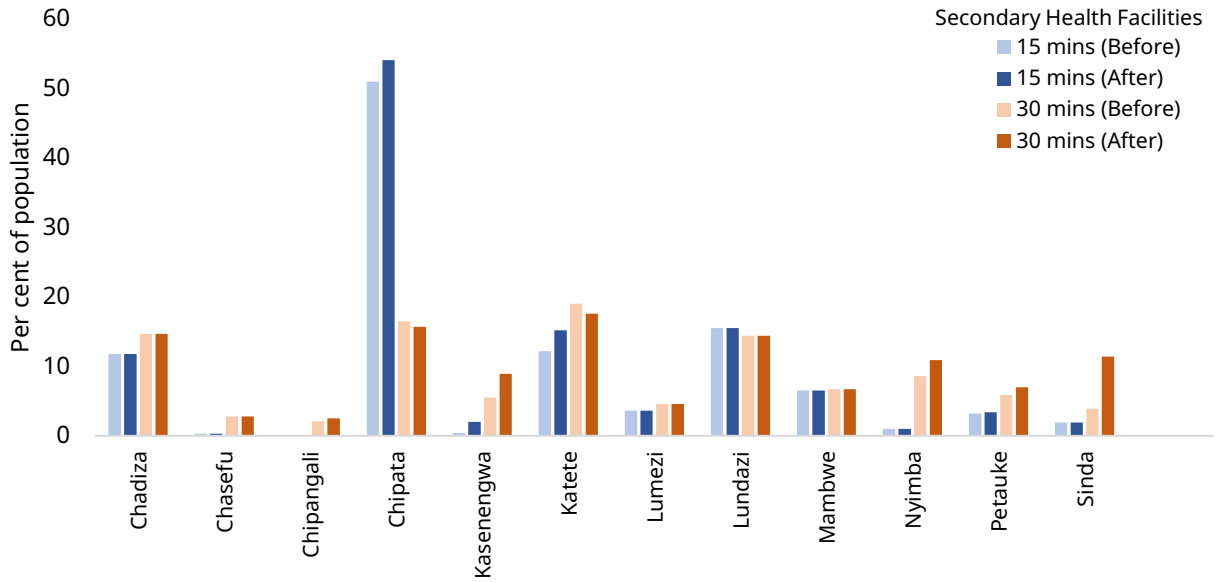
Population coverage by district for hospitals was poor. Most districts had below 20 per cent coverage within 15 minutes and 30 minutes of travel to hospitals. Chipata district had the best coverage (54.1 per cent) within 15 minutes of travel after road improvements (3.1 per cent increase for 7,479 persons). Similar to coverage for primary health facilities, Sinda district saw a 7.5 per cent increase in coverage to secondary health facilities within 30 minutes of travel, increasing geographic access for an estimated 12,335 persons.

▶ **Figure 4. Population coverage of motorized access to primary health facilities by district**



Source: Author's research.

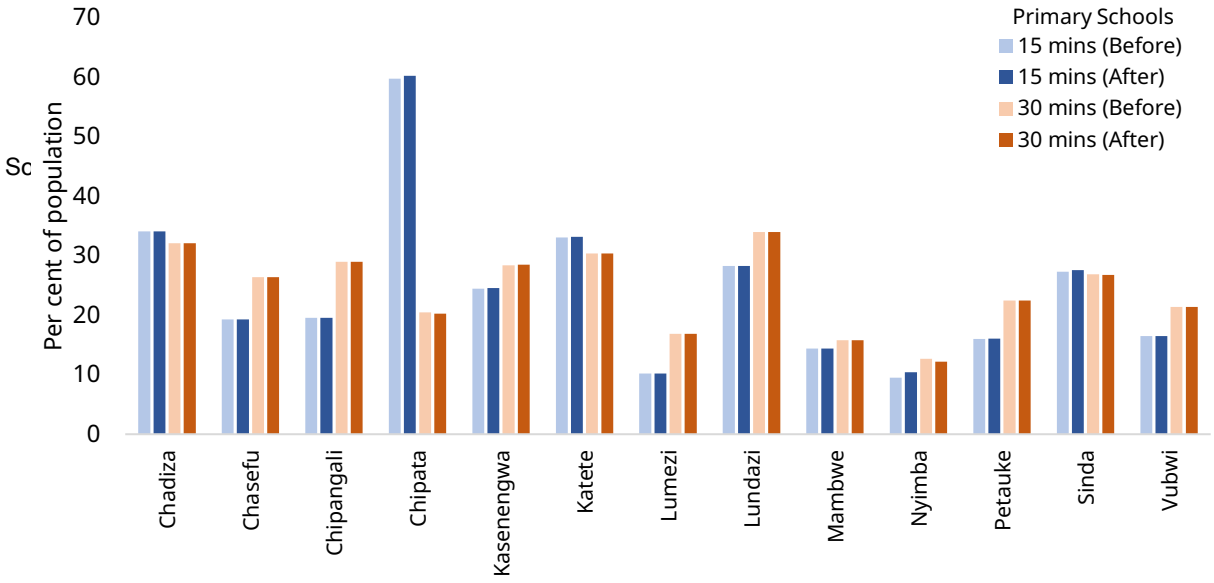
▶ **Figure 5. Population coverage of motorized access to secondary health facilities by district**



Source: Author's research.

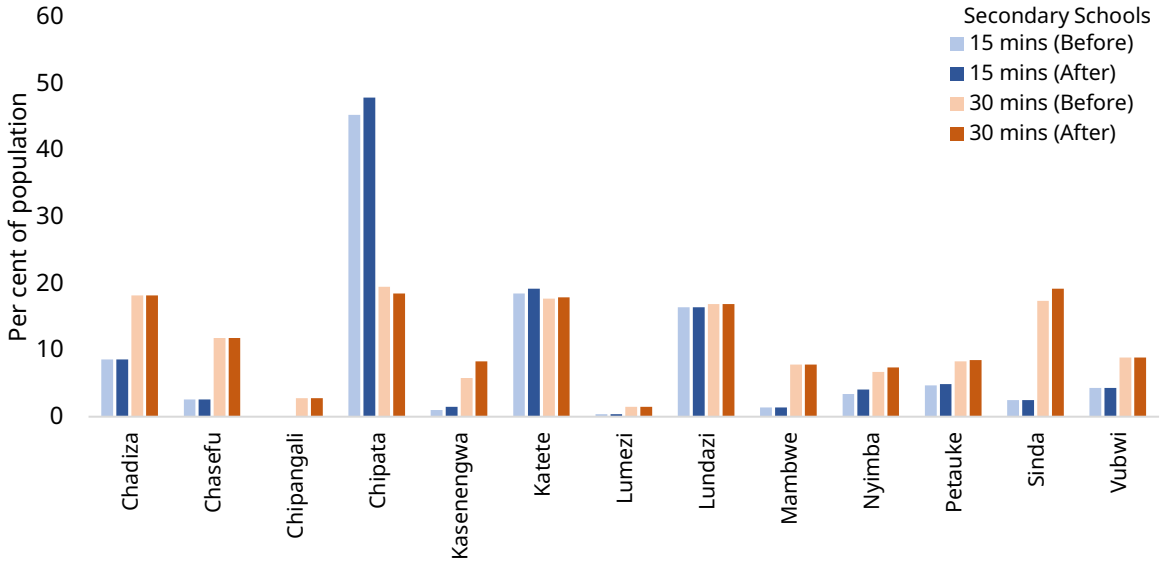
About a quarter of the population lived within 15 or 30 minutes of a primary school. Few districts observed marginal changes, generally less than 1 per cent, in population coverage to primary schools (Figure 6). In Chipata, coverage for 15 minutes travel increased from 59.8 per cent to 60.3 per cent to cover 254 additional school-age children. On average, about 4 out of 10 children could reach a primary school within 15 or 30 minutes. Geographic access to secondary schools was lower than primary schools as most districts had less than 10 per cent of secondary school-age children within 15 and 30 minutes motorized travel to secondary schools (Figure 7). Again, Chipata had the best population coverage because almost half (47.9 per cent) of their secondary school-age children could reach a school within 15 minutes after road improvements, by 2.6 per cent for 875 children.

▶ Figure 6. Population coverage of motorized access to primary schools by district



Source: Authors' research.

▶ **Figure 7. Population coverage of motorized access to secondary schools by district**



Source: Authors' research.

6.2. Impacts on employment

The previous results of the NTL study indicated an increase in GDP and employment at the local level, in areas that benefitted from the road project compared to the control areas that did not. The results showed that NTL luminosity increased by 25 per cent in those treated administrative units, two years after completion. It was estimated that this produced an increase in GDP at the local level of 12 per cent and an increase in employment of 6.7 per cent. When examining the results from the LFS analysis on employment in Table 3, the effect on total employment is positive but not statistically significant. This limits the strength of conclusions regarding overall job creation. However, the disaggregated results by sector provide more insight.

The data categorizes employment into three main sectors: Agriculture, Services and Industry, Tables 4-6 present the regression results of these, respectively. Employment in agriculture produced negative coefficients across all categories, although these were not statistically significant. This was also the case for employment in the Services sector (Table 5). Employment in the Industry sector presented a more robust impact, with an increase in male employment in the sector. When exponentiating the coefficient, with (exp(X)-1), it is estimated that for male employment in wards that benefitted from the road project, employment in the Industry sector increased by 4.3 per cent. This result is statistically significant at the 5 per cent level.

These findings suggest that the road project increased the expansion of industry-related employment, this could potentially be in male-dominated sectors such as construction and transport. Although not statistically significant, a decrease in agricultural employment indicates that the road rehabilitation contributed to a reallocation of labour, for men, to the industry sector, indicating signs of structural transformation. This breaks down the result from the NTL study, that estimated a 6.7 per cent increase in employment but was unable to provide details on which sector this increase occurred in.

Employment in services highlighted a positive, statistically significant relationship with years of schooling, indicating that people are more likely to be employed in the services sector who have a higher level of education. For employment in agriculture, people with less years of schooling were more likely to be employed in the agricultural sector.

▶ Table 3. Regression results of total employment, split by gender

Employment			
	Total	**Male**	**Female**
Treated	0.057	0.117	-0.070
	0.224	0.187	0.258
Age	0.020	0.015	0.003
	0.033	0.021	0.030
Schooling	-0.047	-0.050	-0.005
	0.066	0.046	0.074
Constant	2.794**	2.368***	2.363**
	1.198	0.795	1.147
Observations	179	179	179
R^2	0.663	0.688	0.563
Adjusted R^2	0.495	0.533	0.346

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

▶ Table 4. Agricultural employment results, split by gender

Employment in Agriculture			
	Total	**Male**	**Female**
Treated	-0.246	-0.133	-0.223
	0.288	0.242	0.281
Age	0.027	0.015	0.015
	0.043	0.027	0.033
Schooling	-0.299***	-0.197***	-0.179**
	0.085	0.060	0.080
Constant	3.587**	2.695**	2.399*
	1.543	1.033	1.249
Observations	179	179	179
R^2	0.592	0.585	0.476
Adjusted R^2	0.389	0.379	0.216

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

▶ Table 5. Services sector employment results, split by gender

Employment in Services			
	Total	**Male**	**Female**
Treated	0.075	-0.007	0.053
	0.209	0.202	0.200
Age	0.017	-0.003	0.010
	0.031	0.022	0.024
Schooling	0.191***	0.133***	0.140**
	0.062	0.050	0.057
Constant	0.070	0.548	0.124
	1.121	0.859	0.893
Observations	179	179	179
R^2	0.782	0.727	0.759
Adjusted R^2	0.674	0.591	0.640

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

▶ Table 6. Industry sector employment results, split by gender

Employment in Industry			
	Total	**Male**	**Female**
Treated	0.338	0.042**	-0.045
	0.227	0.218	0.122
Age	0.003	0.021	-0.010
	0.034	0.024	0.014
Schooling	0.048	0.001	0.044
	0.067	0.054	0.035
Constant	0.719	0.032	0.555
	1.217	0.928	0.543
Observations	179	179	179
R^2	0.574	0.568	0.465
Adjusted R^2	0.362	0.354	0.200

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

6.3. Wages and working time

The regression analysis indicates a significant positive effect of road rehabilitation on wages across all groups (total, male and female). Individuals in wards benefitting from the road rehabilitation experienced an average 6.5 per cent increase in total wages, with male wages rising by 7.2 per cent and female wages by 8.3 per cent, when exponentiating the coefficients. All results were statistically significant at the 5 per cent level. These results suggest that road improvements not only enhanced labour productivity but also increased access to jobs with higher wages. This could further indicate a shift from agriculture to jobs in the industry sector, where wages tend to be higher. Higher wages were associated with an increase in years of schooling. Table 8 presents results for impacts on working time. Results were not statistically significant and the positive effect was small.

▶ **Table 7. Regression results for total wages, split by gender**

Wages			
	Total	**Male**	**Female**
Treated	0.065**	0.072**	0.083**
	0.307	0.312	0.416
Age	0.002	-0.013	0.012
	0.045	0.035	0.051
Schooling	0.267***	0.170**	0.181
	0.084	0.079	0.110
Constant	0.121	0.152	0.385
	1.627	1.358	1.840
Observations	146	170	147
R^2	0.604	0.483	0.507
Adjusted R^2	0.347	0.213	0.191

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

▶ **Table 8. Regression results for total working time, split by gender**

Working time			
	Total	**Male**	**Female**
Treated	0.037	0.001	0.008
	0.119	0.124	0.195
Age	-0.016	-0.015	-0.005
	0.017	0.014	0.023
Schooling	0.064*	0.034	0.059
	0.032	0.031	0.051
Constant	3.908***	4.052***	3.637***
	0.617	0.538	0.839
Observations	165	176	165
R^2	0.576	0.508	0.495
Adjusted R^2	0.345	0.265	0.218

*Note: *p<0.1; **p<0.05; ***p<0.01*

Source: Authors' research.

6.4. Comparison to NTL assessment

Results from the previous assessment using NTL data indicated a clear increase in local economic activity and employment in areas benefitting from road rehabilitation under the NRCP. This analysis provides a more detailed view of employment changes across sectors and gender groups. The effect on total employment in Table 3 is positive but not statistically significant, although the magnitude of the coefficient aligns with the NTL results, it still makes it difficult to draw firm conclusions on the overall increase in employment. However, the results at sector level and wages reveal shifts that complement the NTL findings. The LFS analysis adds nuance to the NTL results by highlighting that economic activity is likely being driven by industrial job growth and rising incomes rather than a large-scale increase in employment.

The LFS and NTL analyses present a broadly consistent narrative, road rehabilitation under the NRCP contributed to local economic development through increased employment, particularly in the industry sector and enhanced job quality, through an increase in wages. While the NTL analysis captures aggregate changes in economic activity, the LFS provides critical insights into how these changes affect specific groups, sectors, and dimensions of employment.

7. Conclusion

7.1. Summary of impacts on access to social services

The accessibility analysis presents how the project has contributed towards improving access to health and education facilities for the benefitting population at the district-level. The improved road will reduce transport costs and support the movement of goods and services. Reductions in travel time will also be seen for emergency services. Despite these positive effects, it should be taken into consideration that the model used to calculate travel times does not include traffic conditions that could impact true travel time. The population may also use alternative vehicles, such as bikes which could affect speed. The analysis only covers the physical accessibility to health facilities and schools but does not capture other variables that could affect reaching these services, such as social, cultural or economic barriers.

The analysis highlights that travel times to hospitals have fallen by up to 20 minutes for motorized travel, with an estimated additional 17,800 people now within a 30-minute drive of a hospital. Secondary schools also saw improvements, which could increase enrolment and attendance rates, particularly for children who face greater barriers due to long travel distances. While the improvements for primary schools and primary health facilities were less pronounced, due to increased number and coverage of these facilities, the district-level analysis highlights areas where gaps in service provision persist, even after road upgrades. This points to the need for targeted investments in these areas, particularly in rural districts like Chipata and Sinda.

From a policy perspective, these findings highlight the role of road rehabilitation in supporting equitable physical access to essential services. Improved access to healthcare can reduce maternal and child mortality, while shorter travel times to secondary schools can increase educational attainment, feeding into long-term employment outcomes. Policymakers can use this evidence to prioritize road maintenance and infrastructure planning, through the construction of additional facilities in underserved areas.

7.2. Summary of employment impacts

The LFS analysis, using a difference-in-differences approach with ward-level fixed effects, indicates that road rehabilitation has influenced the structure and quality of employment in wards that benefitted from the rehabilitated road compared to those wards that did not. While total employment was shown to increase through the previous assessment with NTL data, this effect was not statistically significant in this analysis, making it difficult to attribute broad-based job creation to the NCRP. However, industry employment, particularly for men, increased by 4.3 per cent, suggesting that improved connectivity facilitated access to jobs in higher productivity sectors. These results could be indicative of structural transformation. For female workers, the lack of a significant increase in employment in industry might reflect gender barriers in accessing industrial jobs, which often require specific skills, training, or physical mobility that may not be equally available to women in rural areas. These results underscore the importance of integrating infrastructure development with complementary measures, such as vocational training, to maximize the impact on female employment.

Across treated wards, total wages and wages for both men and women increased between 6.5 – 8.3 per cent. These substantial increases suggest that improved road infrastructure increases access to economic opportunities that provide higher wages, which aligns with the increase observed in employment in the industry sector. This result suggests that infrastructure investment can contribute to improving employment quality by improving access to the labour market and decent jobs.

Education levels, represented as years of schooling were included as one of the control variables in the analysis. The results reveal that years of schooling have a positive impact on wages and employment in the services sector, with a negative relationship between years of schooling and employment in the agricultural sector. The findings highlight the role of education in supporting economic mobility, particularly in higher productivity sectors.

7.3. Recommendations

This analysis, together with the previous assessment, highlights the long-term influence of road investments on both economic and social outcomes, which are impacts that are often complex and difficult to capture. By combining geospatial data with labour force survey data analysis, this study demonstrates an innovative, evidence-based approach to assessing the broader effects of infrastructure projects. While the LFS data allows for further examination of outcomes at the ward level, the absence of true panel data and certain measurement inconsistencies limit the precision of some employment estimates. This analysis highlights data gaps and potential areas for improvement in future survey rounds and can feed into the ongoing collaboration between the ILO and ZamStats. This reinforces the importance of applying diverse data sources and methodologies to fully understand the long-term impacts of infrastructure investments.

The results can be interpreted to inform recommendations on increasing the impact of transport investments on employment and on economic and social outcomes for the benefiting population. This assessment confirms that the road generated meaningful improvements in physical access to services and jobs, reflected in wage gains of 6.5–8.3 per cent and a shift of male employment into industry, alongside important gender and spatial disparities that persist. The accessibility analysis shows residual gaps in geographic access, particularly for 30-minute hospital access and for secondary schools, with Chipata and Sinda standing out. From a planning and policy perspective, these results highlight the need for integrated programming in which road rehabilitation is complemented by investments in education, health, skills development and market linkages to amplify the effects of these infrastructure projects.

The recommendations below set out how to increase the impact of transport investments for roads and corridors, while taking into account the findings on employment and accessibility. These are framed from a government policy perspective and include implementable actions that can be adopted by development partners, including donors and implementing agencies.

Government of Zambia

- Use the findings from the analysis of access to social infrastructure to target the siting and upgrading of hospitals and secondary schools in districts with the largest deficits (e.g. Chipata, Sinda), to support access to services that will promote better jobs over time.
- Continue investment in transport corridors and complement with feeder roads and public transport to improve connectivity of settlements to the corridor and the labour market.
- Support women's access to industry jobs through skills development by financing TVET programmes aligned to jobs that road investments are creating.

Development partners

- Promote multi-sectoral project design that links transport infrastructure to other development projects, including components of training, SME support and improved social services.
- Increase job creation by putting in place long-term road maintenance strategies, adopting employment-intensive approaches to target local labour and increase long-term employment near the road.
- Set clear coverage targets for improvements in access to social infrastructure, use this analysis to finance targeted access works in areas where gaps remain (feeder roads, public transport, pedestrian access etc.).
- Include apprenticeships and training in works and maintenance contracts, with a focus on women and youth participation which could support an increase in employment for these groups.

These recommendations aim to deepen job creation and inclusion beyond the positive impacts already observed. Increases in wages and an increase in employment in the industry sector for men suggest the investment has supported a shift to more productive, better-paid jobs in the long-term. More should be done to extend these gains to women and address some of the geographic gaps in access to social services that support long-term employability. Findings from this study can be used to guide the planning and targeting of future transport corridor investments, to improve access and promote long-term decent job creation.

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Annex

Table A.1. GIS data sources used in analysis

Dataset	Year	Source
Roads	2023	OSM, AfDB (treated section)
Landcover	2022	ESA
Elevation	2008	SRTM
Population	2023	Worldpop
Schools	2021	GRID3
Health Facilities	2023	GRID3
Water bodies	2023	OSM
Rivers	2012	ICGSM

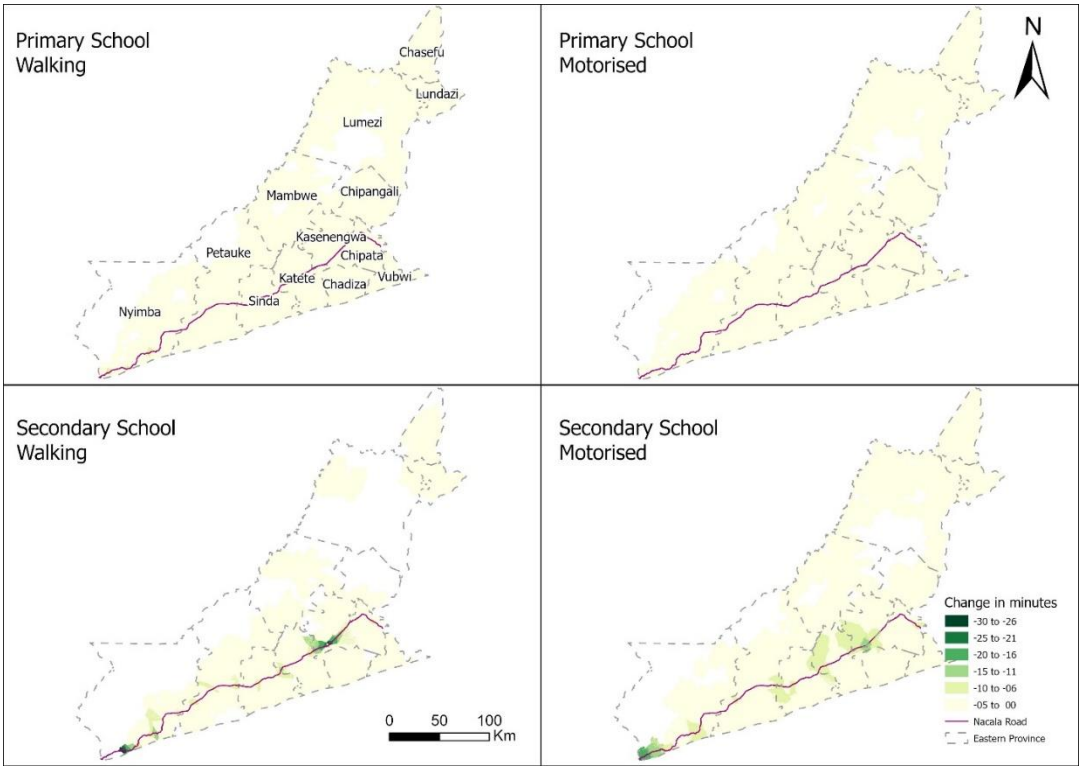
Source: Authors' research.

Table A.2. Assigned travel speeds for accessibility analysis

Feature	Motorized travel model (km/h)	Walking travel model (km/h)
Tree cover	2	2
Shrub	4	4
Grassland	4	4
Cropland	4	4
Built up	5	5
Bare sparse vegetation	4	4
Permanent water bodies	0	0
Herbaceous wetland	2	2
Tertiary link	30	6
Tertiary	30	6
Secondary link	30	6
Secondary	40	6
Primary link	30	6
Primary	60	6
Trunk link	30	6
Trunk	63	6
Trunk Nacala before road improvements	63	6
Trunk Nacala after road improvements	100	6.5

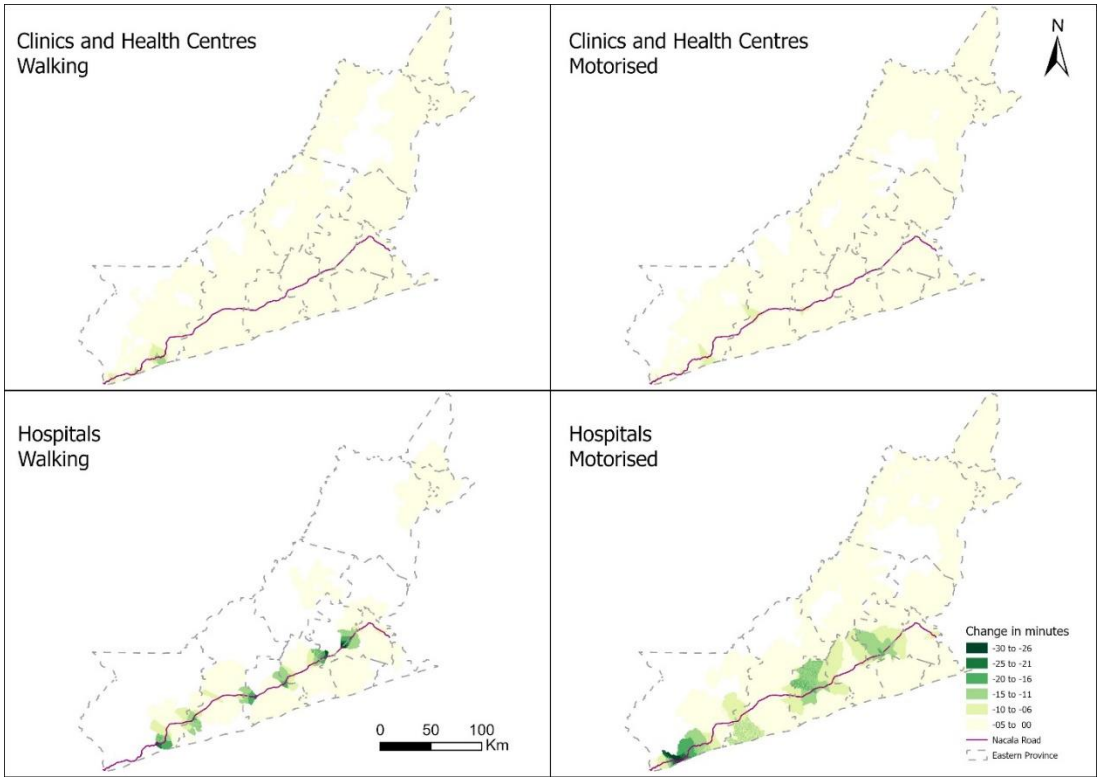
Source: Authors' research.

▶ Figure A.3. Changes in motorized and walking travel time to schools



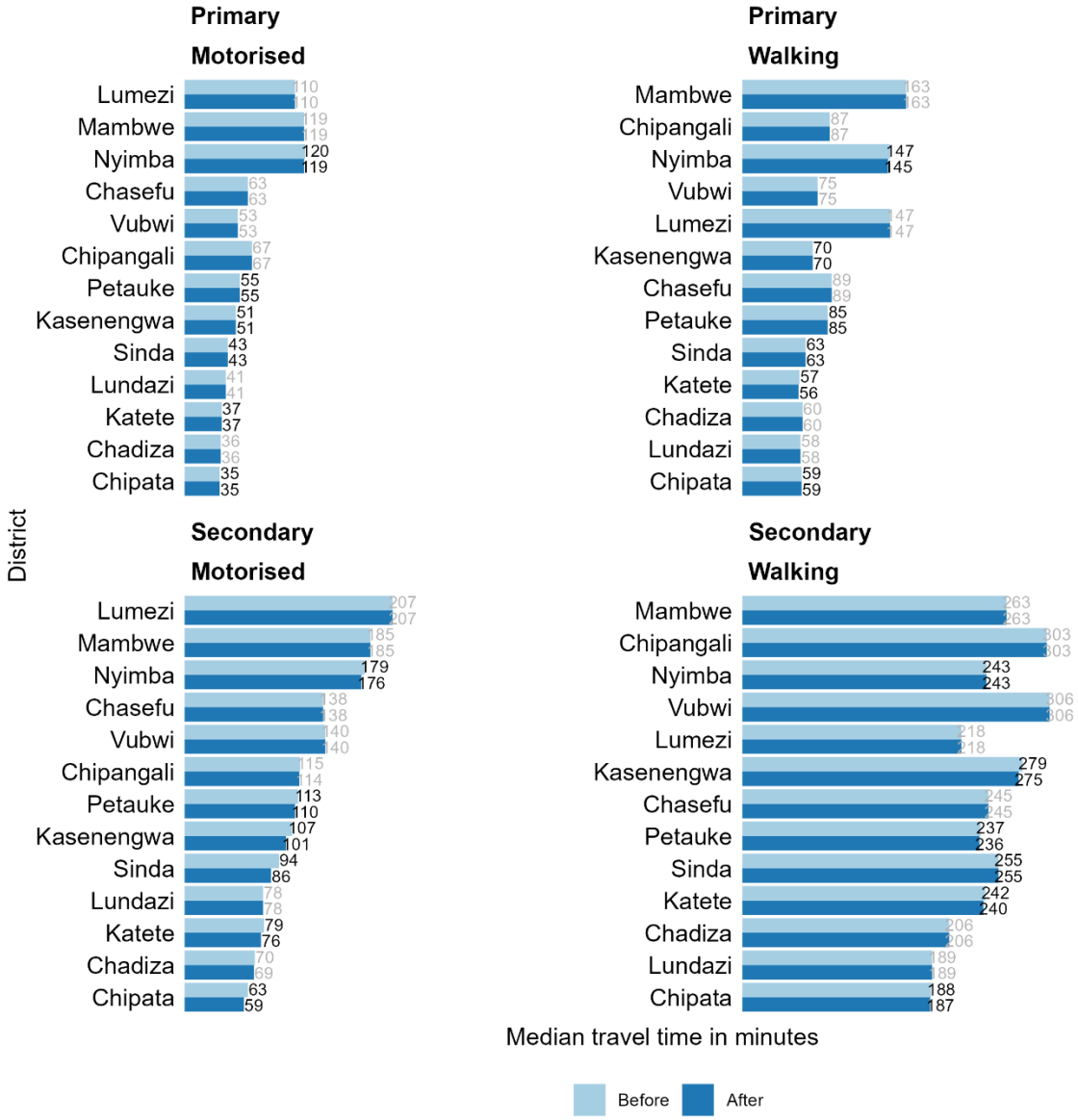
Source: Author's research.

▶ Figure A.4. Changes in motorized and walking travel time to health facilities



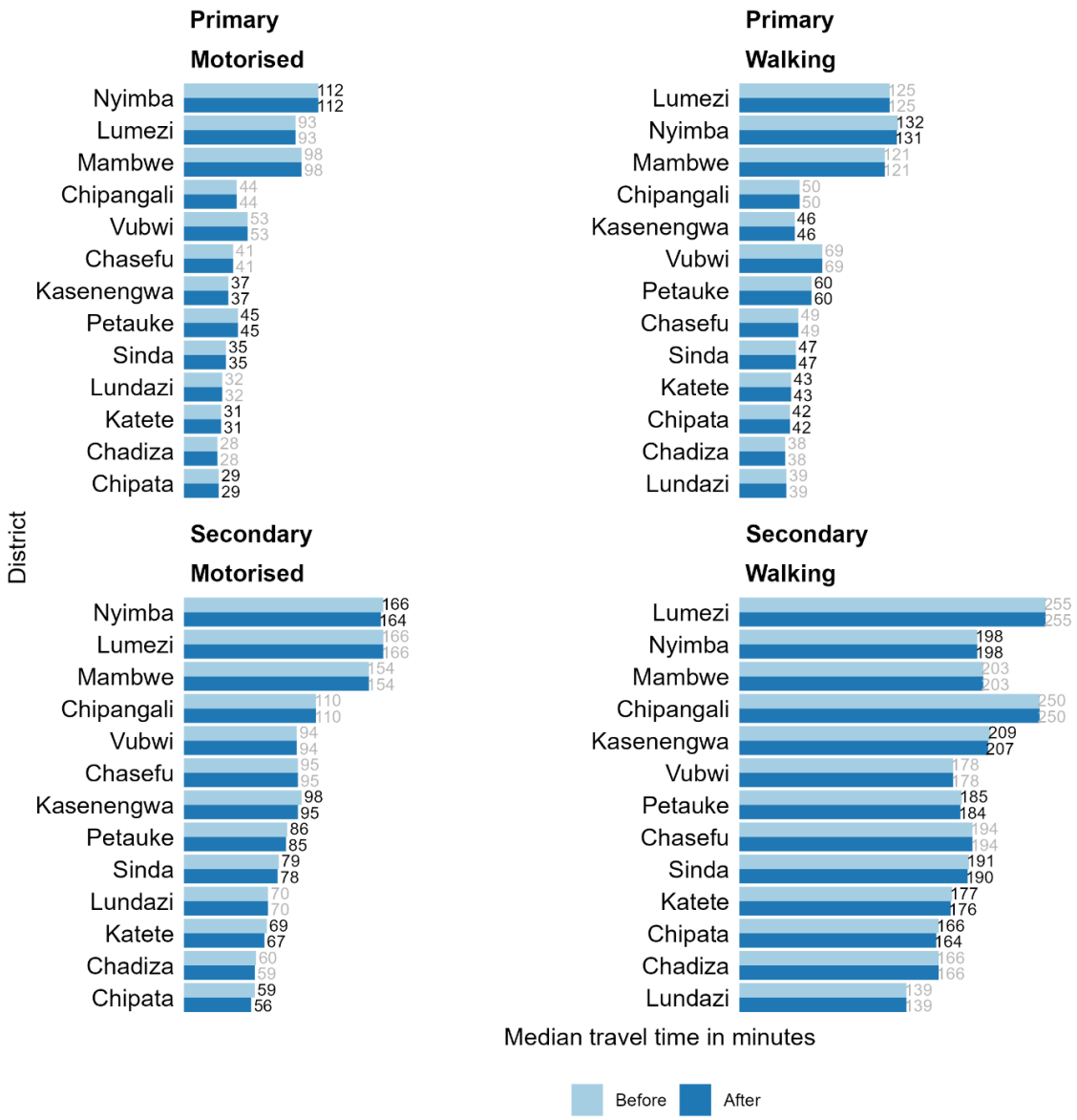
Source: Author's research.

Figure A.5. Median motorized and walking travel time to health facilities by district



Source: Author's research.

▶ Figure A.6. Median motorized and walking travel time to schools by district



Source: Author's research.

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