Education and Road Connectivity: Empirical Evidence from Tanzania

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Abstract

Road access has been proven to open opportunities in reaching new or diversified employment activities that generally generate more revenues. At the same time, receiving education provides specific skills valuable to enter in these activities. Using the Kagera Health and Development Surveys (KHDS) the paper discusses the determinants of per capita consumption growth between 1991 and 2004 in Tanzania. The objective is to assess the impact of road connectivity improvements on distribution earnings according to education.

The results show that the distribution of earnings in the Kagera region moved in favor to those that achieved a post-primary level of educated in communities as long as road connectivity did not deteriorate sharply. The results call for a cautious and joint design of roads and education investments. Roads impacts may be underestimated (resp. overestimated) if investments are implemented in very low (resp. high) education attainment regions.

Key words: Consumption Growth, Road Connectivity, Education, Tanzania
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Introduction

Across the 1.8 billion people residing in rural regions of developing countries, around two-thirds are located in less favored or low potential areas (CPRC, 2004). The existence of lagging behind and disfavored areas in terms of economic development is at the core of the issue of inequality. Indeed, people from these areas are more likely to be poor and subject to chronic poverty (Bird, Higgins and Harris, 2010). Such regions are called spatial or geographic poverty traps, as Bird et al (2010) explain*: "Location goes a long to explain why people that live there are poor".*

Poverty traps can be defined as areas where capital endowments of all kinds (natural, physical, human, social..) are low and poverty is high. Such areas can be disfavored due to their geographic location, being isolated from political and economic centers and thus poorly integrated to the national and international markets. Ecological disadvantages can also weaken the economic potential of an area through lower agricultural or natural resources. These characteristics are referred to as "first nature" geography while the spatial distribution of public and social services and infrastructures is called "second nature" geography. It concerns for instance education and health facilities, administrative and social institutions, transport and communication networks…

The present paper focuses on these second nature characteristics using the case of the Kagera region in Tanzania to address the following question: Does road connectivity affect earnings distribution according to education? Among diverse impacts, road connectivity is showed to influence the diversification of activities and income sources. More generally transport infrastructure development can open new employment opportunities (Jacobs and Greaves, 2003), and in rural areas outside the traditional

agricultural farming sector. Similarly, education has been proven to improve the access to more income generating non-farm activities (Knight, Shi and Quheng, 2009). The paper tests if the positive effect of education on poverty reduction is reinforced by an enhancement in road connectivity. Indeed, roads facilitate access to larger and farer markets and also to new or more diversified employment opportunities. Being educated can help benefiting from these opened opportunities of greater earnings, thanks to specific skills acquired at school.

The analysis is performed on the Kagera Health and Development Surveys (KHDS), conducted five times in Tanzania between 1991 and 2004. The Kagera region, located in the north-western corner of Tanzania is a good example of a geographic poverty trap. In terms of first nature characteristics, being bordered by Lake Victoria in its eastern part could represent an advantage. However, remote from the capital Dar Es Salaam and the coastal area, sharing borders with countries prone to conflicts (Burundi, Rwanda and Uganda), the region is in fact not well integrated. Consequently poverty in this rural agricultural-based region declined only slowly compared to Dar Es Salaam or other coastal areas since the 90s.

The relation between education and road connectivity in determining earnings has been poorly (if at all) studied. Previous studies usually introduce both education and road access indicators in their analyses. The evidence is not conclusive. Jalan and Ravallion (2002) show that road density has a highly significant positive effect on consumption growth, using data on China. Their estimations use four proxies for education: illiteracy rate, proportions of adults and kids with primary school, proportion of kids with secondary education. Only the latter has a significant (positive) impact on household consumption growth. Gibson and Rozelle (2003) discuss the determinants of

poverty in Papua New-Guinea. They show that poverty increases with the time to the nearest road, while it is lower for households whose head is literate. Minot, Baulch and Epprecht (2006) demonstrate that lower poverty in Vietnam is associated with high road density. Here again an education impact is also highlighted. In the case of Uganda Deininger and Okidi (2003) find that both connectivity and education help to reduce poverty but there is no impact on income growth from the connectivity indicator. On the contrary Dercon (2004) assesses the determinants of consumption growth in Ethiopia and finds substantial externalities from road infrastructure, however no significant impact from education. De Vreyer, Herrera and Mesplé-Somps (2005) do not find any impact from infrastructures or education in the Peruvian case. Escobal and Torero (2003) also focus on Peru. Their results show a positive and significant impact of school rate attendance on the per capita expenditure growth rate but they do no control for road connectivity.

Contrary to the above literature, Yamauchi et al (2011) highlight a complementarity effect for schooling and roads using an interaction term between a post-primary education variable for the household head and the change in the average road quality at the sub-district level. They provide an analysis on household income growth and non-agriculture labor supply in the Indonesian case, which shows that roads and schooling are complementary in determining both the income growth and the labor supply to the non-agricultural sector.

The present paper adapts their specification and choice of indicators to KHDSs' specificities, but goes deeper in the analysis. Firstly, the definition of education is not restricted to post-primary education. Five alternative segmentations of individuals according to their instruction achievement are used. They compare educated

(irrespective of the obtained grade) to non educated people; people who achieve primary education to non educated people; people who achieve post-primary education (secondary or higher) to non educated people and people that reach a primary grade in education, people who achieve post-primary education (secondary or higher) to non educated people only, people who achieve post-primary education (secondary or higher) to people that reach a primary grade in education only. Secondly, Yamauchi et al (2011) perform their analysis on non-migrants individuals, underlying that their estimates are potentially affected by selection. The same issue applies here but is controlled for: the existence of a selection bias is analyzed with a Heckman two-step procedure.

Interestingly, while the focus in education policies is on primary education and basic literacy (see the Millennium Development Goals[2]) the main result of this work concerns post-primary education as opposed to primary education. Between 1991 and 2004, the distribution of earnings in the Kagera region moved in favor to those that achieved a post-primary level of educated compared to primary grades in communities that experienced an improvement in their road connectivity or at least not a huge deterioration. In this case, no additional advantage of post-primary education appears. This leads to the conclusion that basic knowledge is not sufficient to reach new employment and activities opportunities opened by road connectivity.

These results can be important for policy makers and development practitioners. The expected impact of road connectivity improvement on consumption may be overestimated if implemented in very low education attainment regions. On the contrary the effect may be overestimated in high education attainment areas. Roads and

[2] http://www.un.org/millenniumgoals/education.shtml

education investments should be thought and designed to take this effect into account.

The following section reviews the literature on roads, education and development. Section 3 and 4 describe the data and the empirical strategy, respectively. Section 5 presents the empirical results and their interpretation. Section 6 discusses the robustness of the results. Section 7 summarizes the results and opens discussion on policy recommendations.

2. Roads, Education and Development

21. Roads and Development

The literature on roads and poverty can be divided in three parts. Firstly, road connectivity and the subsequent reduced transport costs ease the access the both input and output markets. Productivity thus increases thanks to the larger availability of inputs and their reduced prices. Khandker, Bakht and Koolwal (2009) show that road development allowed to significantly reduce the price of fertilizer in Bangladesh. Minten and Stifel (2008) show that crop yields for the three major staple items in Madagascar (rice, maize, and cassava) are lower in isolated relative to non-isolated areas.

Improved access to output markets leads to a rise in income thanks to greater opportunities of sales or higher prices. Gibson and Rozelle (2003) explain that "the rate of price decline is around seven percent for each extra hour to the nearest transport facility" in Papua New-Guinea. Escobal and Ponce (2002) find that roads rehabilitation in Peru entailed an income increase. Khandker et al (2009), show that road development leads to higher agricultural production, higher wages, and higher output prices. Jacoby and Minten (2009) calculate that a sharp decrease in transport costs associated with a new road would increase the income of the remotest households by almost half.

However, Ruijs, Schweigmann and Lutz (2004) find that the direct effect of transport costs reductions on food prices, such as cereals, requires some nuance and tempered expectations in the case of Burkina Faso, notably due to the organization of markets.

Transport infrastructure can also reduce poverty by creating employment and new job opportunities (Jacobs and Greaves, 2003). The construction and maintenance of a road are labor-intensive operations and can provide job opportunities to people in the close area. However, these projects are only occasional and cannot represent a long term strategy for reducing poverty. But the provision of roads entails a greater and/or cheaper availability of labor markets. For example, Mu and van de Walle (2007) show that road projects in Vietnam increased employment opportunities by 11% for unskilled labor. The literature also provides insights on the relationship between road access and the diversification of income sources. First, diversification outside the agricultural sector is widely considered as a way to escape from poverty. In fact, while the majority of the poor live in rural areas where the main activity is agriculture, there is strong evidence that nonfarm activities are a major source of income and employment for the poor in developing countries. Smith et al. (2001) show that road rehabilitation projects in Uganda extended job opportunities in the service sector. In Tanzania, this kind of project developed job opportunities for non-agricultural employment (Lanjouw, Quizon and Sparrow, 2001). Mu and van de Walle (2007) have similar results: households affected by a road project are less likely to rely on agriculture or forestry as their main source of revenues and switch to the service sector. Gollin and Rogerson (2010) show that large subsistence agriculture sectors are promoted by a lack of transportation infrastructure in Uganda. Diversification can also be thought as a multiplication of income sources. On this point the mechanism is twofold. On the one hand, diversification in remote areas is a

way to satisfy the local demand for multiple goods and services (Barrett, Reardon and Webb, 2001; Block and Webb, 2001). Facing transaction costs, it is more profitable for households living in poorly connected regions to diversify their activities so as to satisfy their own demand. But better connectivity to markets develops multi-activities since opportunities to diversify are greater. An illustrative example is found in Gibson and Rozelle (2003).

Finally roads facilitate provision of basic needs such as health and education. Poor people usually suffer from inadequate access to human capital facilities that are essential to escape from poverty. Actually Njenga and Davis (2003) point out "poverty reduction needs more than economic mechanisms to be effective". Roads appear as a complementary input for these provisions of human capital formation facilities to be effective in their poverty reduction objective (Gannon and Liu, 1997). Road projects evaluations provide evidence on the roads' human capital impact. Rural roads rehabilitation in Vietnam improved primary school completion rates and enhanced the treatment of broken bones (Mu and van de Walle, 2007). Road development in Bangladesh led to higher girls' and boys' schooling (Khandker et al, 2009).

22. Education and Development

Human capital is defined as all the attributes of workers that potentially increase their productivity in all or some productive tasks. It is catalytic for economic development as it represents an output, a goal[3] and an input. As such the importance of education is a long lasting subject in the development economics literature.

At the macro level, the inclusion of education in growth theories dates back to

[3] See the Millenium Development Goals

the 1980s with Romer (1986, 1990) and Lucas (1988). Their adaptation of Solow (1956, 1957) loses the main characteristic of the neoclassical growth model. The constant returns to scale property collapses thanks to two main changes: the total output depends on the average level of human capital in the economy and human capital is endogenous. As a consequence, human capital is characterised by spillovers and externalities. In the context of poverty traps, the Kremer (1993) O'ring theory provides a clear illustration of why and how multiple equilibria co-exist. The key feature of this model is complementarities among inputs which give rise to positive assortative matching. In the end it explains why some countries/firms/families have it all (skilled people, high wage and high-quality production) but not others.

Many empirical researches dealt with the impact of education on economic growth (Barro 1991; Mankiw, Romer and Weil 1992; McMahon 1999; Benhabib and Spiegel 1994, 2005). Unfortunately the results are not consensual and for some authors this setting cannot contribute much about the education-growth relation[4].

At the micro level, the literature focuses on estimating the social rate of return of education investments. This consists in measuring benefits from education, usually with the difference in earnings between more and less educated workers and to compare it to the cost of education (expenditures on schooling and the opportunity cost of being at school rather than working). The alternative Mincerian earnings function is used to estimate the private returns to education (Mincer 1974). The log of an individual income is regressed on an education variable, usually the numbers of years in school, and other individual controls. In the context of developing countries where earnings can be difficult to assess in surveys, this specification is widely used replacing earnings by

[4] Psacharopoulos and Patrinos (2011) record for instance Topel (1999); Pritchett (2006); Banerjee and Dufflo (2005); Durlauf, Johnson and Temple (2005).

consumption expenditures. Contrary to the macro level, the micro analysis generally emphasizes a large and robust impact of education on development across studies.

The seminal paper of Sachs et al (2004) on the African poverty trap issue lists all the development dimensions on which education can play. Based on the Millennium Development Goals, the presented strategy to cut off poverty stresses that education can act on around 10 objectives. On income poverty, apart from the human capital effect described previously, education can lead to lower the fertility rates leading to a higher growth per capita. It also opens new employment opportunities, in particular higher education that promotes innovation and ideas. As the first achievement of education, literacy improves the management of nutritional needs and farm production. This can contribute to reach the hunger objective. The same holds for higher education and the following increase in number of agricultural extension workers. The achievement of the primary education objective relies on other kinds of education. First, maternal education is a strong determinant of primary enrolment. Incentives to complete primary and secondary education are also greater if higher education is available. On gender equality, education provides more employment opportunities for women as well as improved decision-making and finally their empowerment. On child and maternal mortality, the effect of education comes from secondary education and adult literacy programs. The first reports the age of marriage, increases contraception use, care seeking for child illnesses and the access to prenatal care and safe delivery; secondary education also lowers fertility rates. Adult literacy programs increase awareness of the causes and prevention of child and maternal mortality. Education and literacy programs increase awareness of ways to prevent and treat HIV/AIDS, malaria and tuberculosis. They also increase access to essential medicines and improve their appropriate use. Supply of

health workers is provided thanks to higher education. Basic education and higher education are finally crucial for the water and sanitation by improving hygiene and providing trained workers in water supply and sewer infrastructure. More broadly, education possibly produces better institutions and encourages modern attitudes in population.

3. Data

The data used in this paper stem from the Kagera Health and Development Surveys (KHDS). The data are adapted from the World Bank's Living Standards Measurement Study (LSMS) questionnaires but differ in that they constitute a longitudinal household survey. Originally conducted by the World Bank and Muhimbili University College of Health Sciences (MUCHS), the first objective was to analyze the impact of adult mortality and morbidity on the welfare of individuals and households in the Kagera region in Tanzania. Indeed, this specific region located on the western shore of Lake Victoria, sharing borders with Uganda, Burundi and Rwanda, is at political and economic crossroad that is also at the epicenter of the AIDS epidemic in East Africa.

The KHDS sampled 912 households from 49 communities in all six districts that composed Kagera before 2000[5]. Households, community leaders, health facilities, schools, and market vendors were queried in 6-7 month intervals for up to four survey periods between 1991 and 1994. In 2004 a new wave was conducted with the objective to interview the members of the original households interviewed between 1991 and 1994. The sample of households to be interviewed theoretically consisted of any

[5] Before year 2000, the Kagera region comprised six districts: Bukoba Urban, Bukoba Rural, Muleba, Karagwe, Ngara,and Biharamulo. Thereafter Bukoba Rural was divided into two: Bukoba Rural and Misenyi, Biharamulo was also divided into two districts: Biharamulo and Chato.

household in which household members from the 1991-1994 sample resided in 2004. The KHDS 2004 is designed to provide data to understand economic mobility and changes in living standards of the sample of individuals interviewed 10-13 years ago. This new sample consists of over 2,700 households from the 832 households actually interviewed in the 90s, which were recontacted. Around 50% of the recontacted households did not move from their original communities. 18% moved to a nearby community while 20% move to another place in Kagera. Only 10% moved to another place in Tanzania. 2% went to Uganda.

The survey is made of six different questionnaires, while the present analysis concentrates on three of them[6]. The first is a household questionnaire used to measure individual and household well-being, mortality, and use of service[7]. The data on individual education at baseline stems from this part as well as data on individual characteristics used as controls in the regressions presented in Section 5. It also records consumption expenditures[8]. Per capita consumption expenditures are defined following Beegle, Dercon and de Weerdt (2010): "*The consumption aggregate includes home produced and purchased food and non-food expenditure. The non-food component includes a range of non-food purchases, as well as utilities, expenditure on clothing/personal items, transfers out and health expenditures. Funeral expenses and health expenses prior to the death of an ill person were excluded".* A price questionnaire was also conducted to

[6] A health questionnaire records data on health facilities' characteristics such as the personnel, the equipment, the services, immunizations, family planning, inpatient services, … A school questionnaire is used to complete the analysis on demand for schooling. A last questionnaire documents the prices, types of facilities, services, and referral practices of traditional healers.

[7] It encompasses information on demographic characteristics, health status, symptoms, health-seeking behavior and medical expenditures, nutritional status, mortality and related expenditures, human capital, enrollments and education expenditures, fertility and contraceptive use, time use in the labor force, other productive and health-related activities, income levels and sources, assets and durable goods, including housing, farm and business assets, consumption expenditure (by component), savings, debts, transfers and receipt of assistance, characteristics of non-resident parents and children, including their mortality.

[8] The data can be found directly at http://www.edi-africa.com/research/khds/introduction.htm

measure prices of key consumption goods throughout the survey area and over time. Based on these data, price indexes were computed and used to deflate monetary consumptions from the household questionnaire. I use them to adjust the consumption monetary level. Finally, a community questionnaire provides information on demographic characteristics, economy and infrastructure, education, health, agriculture and culture. This questionnaire provides the information on road connectivity at the community level. Specifically this question is asked in the community questionnaire in 1991 and 2004: "Does a motorable road pass by this community?". The question is used to construct $Connect_{tk}$, a dummy variable indicating if a motorable road passes by the community k at date t (t=1991 and 2004). For each community a 'neighborhood' is then defined, consisting in the five nearest communities based on their GIS data[9]. The neighborhoods are used to fill the formula from Yamauchi et al (2011):

$$Connect_t(N) = (\Sigma_k \, Connect_{tk})/6$$[10]

$Connect_t(N)$ is the mean probability that a motorable road passes by communities of neighborhood N at date t. Finally, the change in the average road connectivity of community k is defined as follows:

$$\Delta Connect_k = Connect_{2004}(N) - Connect_{1991}(N)$$

$\Delta Connect$ is used as a proxy for changes in road connectivity experienced by the Kagera communities over the 1991-2004 period.

[9] Available upon request from the World Bank.
[10] The sum is divided by six as a neighborhood consists in one community PLUS the five nearest.

4. Empirical Framework

The following equation on consumption growth at the individual level between the baseline period[11] and 2004 is estimated with Ordinary Least Squares (OLS). The sample is restricted to individuals older than 15 at baseline.

$$\Delta \ln C_{ik} = \alpha + \theta_1 \, Educ_i^0 + \theta_2 \, \Delta Connect_k + \theta_3 \, interaction_{ik} + \gamma \, X_i^0 + \beta \, X_k^0 + \delta_d + \delta_j + \varepsilon_{ik} \qquad eq(1)$$

where *i* stands for 'individual' ; *k* for 'community' and *0* indicates the baseline period. δ_d and δ_j are respectively district and initial household fixed effects. The second allows controlling for any initial household level heterogeneity that may affect the growth of consumption. The inclusion of fixed effects allows controlling for an omitted variable bias that potentially spurs the results, as they take into account district and household unobservables that would determine jointly consumption growth, the non random placement of roads and the localization choices of people. The issue of reverse causality can be considered here of less concern as the change in roads occurs at a more aggregated level.

Per capita consumption expenditures (as defined in Section 3) at baseline and in 2004 are used to create the per capita consumption growth, by taking the difference of the two logs[12]. The education variable, $Educ_i^0$, is a dummy coded as 1 if the individual has received education in school, whatever the level; 0 otherwise.

As explained by Wooldridge, we cannot simply look at the coefficient θ_1 of the education variable. In fact this coefficient measures the earnings differential between

[11] The baseline period covers four years from 1991 to 1994. For each individual the baseline date for consumption corresponds to the last year he was interviewed.

[12] There is ONE observation per individual; the estimation is performed under a cross-section analysis with one time-varying independent variable *ΔConnect*.

educated and non educated people when the variable *ΔConnect* =0 i.e. when the average probability that a motorable road passes by the community remains the same between 1991 and 2004. On the contrary I am interested in the impact of schooling when the road connectivity measured at the community level varies. This refers to the impact of roads on the earnings distribution according to education in the Mincer point of view and I expect θ_3 to be positive[13]. Indeed roads facilitate access to larger and farer markets and also to new or more diversified employment opportunities. Thanks to the instruction they received at school, educated people may have an additional advantage to reach these opened opportunities of activities generating more revenues. A first simple example is that it is easier to succeed in a very simple trade activity related to road connectivity (for instance to sell fruits or food along the road) if you own a basic knowledge in mathematics and reading. However the effect may be less clear in case of deterioration. The naïve idea would be that the impact turns to be negative but it could simply become insignificant as educated people lose the access to these income generating activities.

Finally X_i^0 and X_k^0 are individual and community baseline characteristics. At the individual level, the regression controls for the age, gender, relation to the head of the initial household, parents education and chronic illness that are all related to consumption growth rate. At the community level, the regression controls for the number of health and education facilities, the proportion of households with access to credit, the proportion of households whose main activity is agriculture, distance to the district capital and if the community is urban. Table 4a sums up the variables and their definition. Table 4b shows descriptive statistics.

[13] This could also be interpreted as a complementarity effect between education and schooling as in Yamauchi et al (2011).

Table 4c presents mean comparison tests of per capita consumption growth between people that received education and people who did not, stratified by the status of road connectivity evolution: deterioration, no change, improvement. Very interestingly, the table shows that on average per capita consumption growth is significantly higher at the 1% level for those who received education when facing an improvement in road connectivity or no change. Education is thus likely to represent an advantage for consumption growth. On the contrary the difference is not significant for a deterioration of connectivity.

5. Empirical Results

51. Education

Table 5a presents the results from estimating eq (1) using Ordinary Least Squares (OLS), clustered at the community level. As explain by Wooldridge, we cannot simply look at the coefficient of *Educ*. In fact this coefficient measures the effect when the variable $\Delta Connect=0$ i.e. when the average probability that a motorable road passes by the community remains the same between 1991 and 2004. On the contrary the paper seeks to analyze the impact of schooling when the community road's connectivity varies. Wooldridge also explains that the estimated coefficients of *Educ* and the interaction must not be taken separately. What matters is the joint significance of each of the component of the interaction term and the interaction term, that is to test that H_{0A}: $\theta_1=0$, $\theta_3=0$ and H_{0B}: $\theta_2=0$, $\theta_3=0$. Based on the p-value associated to H_{0A} the null hypothesis that θ_1 and θ_3 are jointly not significant cannot be rejected. On the contrary the p-value associated to H_{0B} leads to reject the null that θ_2 and θ_3 are jointly not significant. So being educated does not provide any extra consumption growth compared to people

that did not received education at school. However, road connectivity has a significant impact *per se*: an increase in connectivity of one standard deviation increases per capita consumption growth by 2.817 standard deviations leading to an extra (2.817*0.0785 =) 0.22 percentage point.

It is very likely that no relation emerges between education and road connectivity in determining consumption due to the precise definition of education here. Indeed, it does not account for the type of instruction and thus encompasses heterogeneous levels of education, which also could explain the not significant direct impact of being educated.

52. Primary Education

In Table 5b, the education variable is replaced by the dummy *Primary* coded 1 if the individual received primary education, 0 if the individual did not received education. Focusing on primary education is relevant concerning first the idea that even reading or counting can be an advantage when road connectivity opens new job opportunities such as trade. It is also of major interest in the context of the Millennium Development Goals whose second objective is to achieve universal primary education.

Based on the p-values associated to H_{0A} and H_{0B}, there is no relation between primary education and the change in road connectivity in the determination of consumption growth. Two interpretations can be made. First, it may be that changes in road connectivity did not manage to create more generating income activities. The poverty traps literature points that particular areas may not have the natural, geographic or economic endowments to ensure their development. Second, a low level of instruction may not be sufficient to benefit from an upgrade in the connectivity to the

motorable road network. Basic knowledge acquired in the first grades at school is possibly not the one needed to reach new employment and diversification opportunities. Surprisingly the impact of *ΔConnect* is here significantly negative[14].

53. Post-Primary

Table 5c presents the results using *Post-Prim1* as the education variable. *Post-Prim1* is coded 1 if the individual achieved a post-primary level of education, 0 if he did not received education or attained a primary level of instruction. The coefficient of *Post-Prim1* corresponds to the effect of education on consumption growth when no change in the road connectivity is measured: post-primary education gives an extra 6.03 percentage point to consumption growth compared to primary or no education. Contrary to the preceding tables, here the p-values associated to the test of H_{0A} and H_{0B} both lead to reject the null hypotheses. A significant relation of between education and road connectivity is thus expected. Actually the gain in earnings for people that reached a post-primary level of education compared to those who have no education or a primary level is +10.3 percentage points for the maximum change in connectivity. For a change in road connectivity valued at his mean, the effect is +5.84 percentage points. This is a slightly lower effect than the one reported for a zero change in road connectivity as the mean for *ΔConnect* corresponds to a decrease in road connectivity (-0.00713). So when road connectivity decreases the combined effect of post-primary educated and road connectivity is weaker. For a larger deterioration of road connectivity the relation turns to collapse: the effect is not statistically different from zero for *ΔConnect* valued at its minimum. So in communities where the mean road connectivity

[14] A potential explanation builds on results from the next sub-section.

improved or at least did not change, the distribution of earnings shifted in favor to individuals that achieve a post-primary (secondary or higher) level of education. This could explain the surprising significant negative coefficient of *ΔConnect* in Table 5b, which restricts the sample of estimation to individuals without education or with only a primary grade. On the contrary the distribution was unaffected in communities that experienced a decrease in their road connectivity. In this case, no additional advantage of post-primary education appears.

Post-Prim1 considers non educated people and those who achieved a primary grade as equivalent. To deal with the heterogeneity of the reference group, two other post-primary education indicators are used. Table 5d first presents the results using *Post-Prim2*. It is coded 1 if the individual achieved a post-primary level of education, 0 if he attained a primary level of instruction. A one standard deviation increase in *ΔConnect* increases per capita consumption growth by (2.444*0.0785=) 0.19 percentage points. People that achieved a post-primary education level experience a 5.49 percentage point higher per capita consumption growth compared to those who attained a primary level of education, in the case of a zero change in the community probability to be passed by a motorable road. Valued at the mean level of road connectivity, the effect is slightly lower: it represents a +5.31 percentage point for consumption growth of post-primary educated people compared to consumption growth of primary educated people. Valued at the maximal value of the road connectivity indicator, the effect is set at an extra 9.77 percentage points for consumption growth. As previously no significant impact appears when *ΔConnect* is valued at its minimum.

Finally, Table 5e presents the results using the last post-primary education variable *Post-Primary3.* This variable compares the effect of post-primary education to

the no education: *Post-Primary3 is* coded 1 if the individual achieved a post-primary level of education, 0 if he did not received instruction. The impact of the change in road connectivity for a one standard deviation from the mean is (5.026*0.0785=) 0.39 percentage point. However, no relation exists between change in road connectivity and post-primary education compared to no education, emphasizing that the effects reported in Table 5c are in fact driven by the comparison between post-primary and primary education.

So over the 1991-2004 period, post-primary education represented an advantage over primary education in determining per capita consumption growth in the Kagera region in Tanzania where road connectivity improved or did not deteriorate. On the contrary, no similar benefit appeared for primary education compared to receiving no instruction. Basic knowledge and skills acquired in primary school are certainly not sufficient to allow reaching new employment and activity opportunities opened up by the improvement in road connectivity.

6. Robustness Checks

61. Selection Bias

The preceding estimates are potentially biased since they do not integrate individual migration in while « the migration process can differentially affect both the numerator and the denominator to calculate per-capita income » (Yamauchi et al, 2011). Moreover using the KDHS Beegle et al (2010) showed that migrants experienced 36 percent higher consumption growth compared to those who stayed in their original communities. I use the Heckman's (1979) two-step estimation procedure to estimate the parameters of the consumption growth equation (1) and control for the selection bias.

ΔlnC_{ik} is observed only if individual *i* did not leave his initial community between the baseline period and 2004. The complete model can be written as:

$$\Delta \ln C_{ik} = \alpha + \theta_1 \text{ Education}_{i0} + \theta_2 \Delta \text{Connect}_k + \theta_3 \text{ interaction}_{ik} + \gamma X_i^0 + \delta_d + \delta_{j0} + \varepsilon_{ik} \quad \text{eq(1)}$$

$$\text{Selection}_{ik} = \beta Z + \mu_{ik} \quad \text{eq(2)}$$

ΔlnC_{ik} is observed only if $Selection_{ik}$ =1. $Selection_{ik}$ is a dummy variable indicating if individual *i* stayed in community *k* between the baseline period and 2004; 0 if *i* leaved his original community over the period. *Z* is a set of variables including all regressors from eq(1) PLUS four exclusion variables.

The definition of exclusion variables stems from Beegle et al (2010). Indeed, they provide a consumption growth analysis to assess the impact of migration. To prevent from an endogenous bias they implement a 2SLS procedure and provide statistics tests to ensure the validity of their instruments. I thus use these instruments as exclusion variables here. The first is the interaction between the distance to the regional capital and whether the person is male and aged 15 at baseline. It acts as a pull-factor and measures the opportunities available. As a push factor they use the mean deviation of rainfall between 1991 and 2001 from the local average, interacted by being male and aged 15. Finally as migration depends on social and familial norms, they add two dummy variables: for being the head or spouse of the household head at baseline, for being a child of the head at baseline. Close relative of the household head are less likely to move[15]. Table 6a reports the results using *Post-Prim1* as the education variable. Consumption growth estimation is presented in column (1) and the selection in column

[15] The regressor that controls for the relation with the household head at baseline is thus dropped from the regression.

(2). The results are comparable to Table 5c with a additional consumption growth comprised between 6 and 10 percentage point. Also notice that the inverse Mills ratio is not significant at conventional level. The sample restricted to non movers to build the analysis in Section 5 thus does not create a selection bias. The same conclusion applies using *Post-Prim2* as the education variable[16].

62. Neighborhood Definition

The second sets of robustness checks deal with the definition of the neighborhood used in Section 3 to define *ΔConnect*. The variable is re-constructed for two measures of the neighborhood, using the 3 and 4 nearest communities. Table 6c presents the results using *Post-Prim1* as the education variable. Column (1) is for a neighborhood with the three nearest communities, column (2) for the four nearest communities and column (3) corresponds to the "benchmark" regression in Table 5c, column (4). Results compare generally the same across the regressions. In particular the impact of post-primary education compared to primary or no education is around 6 extra percentage points on consumption growth. Table 6d shows the respective results for *Post-Prim2* and leads to the same conclusion that the results are robust to the size of the neighborhood.

63. Sample Size

Finally, the robustness of the results is questioned according to the distribution of earnings at baseline, proxied by the log of per capita expenditures at baseline. The sample is therefore restricted to individuals whose baseline consumption belongs to the

[16] Results for the other education variables lead to the same conclusion and are available upon request.

second and third quartiles, to ensure that the results are not driven by extreme values. Table 6e shows the results with *Post-Prim* and the restricted sample in column (1), and the "benchmark" regression from Table 5c in column (2). Once again the results are comparable in terms of magnitude of the impact and its significance.

7. Conclusion

The issue of spatial or geographic poverty trap represents a challenge for development policies. Bird et al (2010) links the relevance of the topic to its scale, its multiple dimensions, and the fact that poverty can co-exist with economic growth and a decreased in aggregate poverty headcount. The Kagera region in the north western part of Tanzania is good example of such lagging areas. In this primarily rural and agricultural based region, poverty did not decline as fast as it did Dar Es Salaam the capital or in the coastal and more connected areas of the country.

The paper analyzes the effect of education on per capita consumption growth and its relationship with road connectivity through the question of whether a change in road connectivity affects the distribution of earnings according to the level of education. The issue of sample selection bias potentially arising from restricting the study on people that did not move over the survey period is controlled for thanks to a Heckman two-step procedure, but it proves to be out of concern. For a change in road connectivity between zero and its maximal value, the impact of post primary education goes from +6.03 to +10.3 percentage points for per capita consumption growth rate. The distribution of earnings shifted in favor of post-primary educated people in communities that experienced a zero change or an improvement in road connectivity but was not affected where connectivity deteriorated. Coupled with the lack of a significant

advantage of primary education over non education, it seems that basic knowledge and skills acquired in primary school are certainly not sufficient to allow reaching new employment and activity opportunities opened up by the improvement in road connectivity.

These results call for a hand-in-hand design of roads and education investments. Integrating the effect highlighted in this work in development policies may help to achieve a poverty reduction more efficiently than if roads and education were taken separately. Indeed, the expected impact of road connectivity improvement on consumption may be overestimated in very low education attainment regions. On the contrary it could be underestimated if road connectivity improvements occur in high education attainment areas. A naive recommendation should be to invest for roads only in regions where post-primary education is spread. But to reach post-primary grades, one must first achieve primary education cycle. So primary AND post-primary education investments should not be separated, they belong to the same investment package. It appears that road connectivity could also help here at this stage, as it should facilitate access to education facilities.

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Tables Section 4

Table 4a: Definition of variables

Name	Definition	Effect on ΔlnC
	Per Capita Consumption Growth between baseline and 2004	
ΔlnC	Difference of (ln) per capita consumption expenditures	
Educ	Dummy: Education versus no education	+
Primary	Dummy: Primary education versus no education	+
Post-Prim1	Dummy: Post-primary education versus no education or primary education	+
Post-Prim2	Dummy: Post-primary education versus primary education	+
Post-Prim3	Dummy: Post-primary education versus no education	+
ΔConnect	Change in Road Connectivity	+
Interaction	ΔConnect*Educ/Primary/Post-Prim1(2,3)	+
ChronicIll	Chronic illness dummy	-
Male	Male dummy	?
Close	Close to the head dummy	+
MotherEduc	Mother Education, years	+
FatherEduc	Father Education, years	+
Age	Age, years	+/-
NbClasses	Number of primary classes	+
NbHealth	Number of health facilities	+
Credit	Households with access to credit (%)	+
Agr	Households whose main activity is agriculture (%)	-
DistDC	Distance to district capital (km)	-
Urban	Urban dummy	+

Table 4b: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
ΔlnC	3544	7.796	0.6115	-10.109	-4.974
Educ	3544	0.762	0.4258	0	1
Primary	3459	0.756	0.429		
Post-Prim1	3544	0.0240	0.153	0	1
Post-Prim2	2701	0.0315	0.175	0	1
Post-Prim3	928	0.0916	0.289	0	1
ΔConnect	3437	-0.00713	0.0785	-0.167	0.167
ChronicIll	3543	0.291	0.454	0	1
Male	3544	0.466	0.500	0	1
Close	3544	0.789	0.408	0	1
MotherEduc	3544	0.569	1.651	0	11
FatherEduc	3544	1.967	3.311	0	13
Age	3544	33.157	17.458	15	87
NbClasses	3544	8.466	3.195	5.265	21
NbHealth	3544	0.363	0.659	0	3
Credit	3544	0.0728	0.0717	0	0.298
Agr	3544	0.840	0.109	0.303	0.953
DistDC	3544	23.687	18.421	0.95	65.64
Urban	3544	0.189	0.392	0	1

Table 4c: Per Capita Consumption Growth Comparisons

Consumption Growth (Mean)	Change in Road Connectivity ΔConnect		
	Deterioration	No Change	Improvement
Received Education (1)	-7.977	-7.725	-7.789
Did not received Education (2)	-7.876	-7.493	-7.523
Difference= (1) - (2)	0	+ ***	+ ***

Tables Section 5

Table 5a: Per Capita Consumption Growth, *Educ*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC	(4) ΔlnC
Educ	-0.258*	-0.260	-0.0151	-0.0135
	(0.151)	(0.156)	(0.114)	(0.0115)
ΔConnect	-0.390	-0.530	-1.730	2.817***
	(0.979)	(0.900)	(1.227)	(0.265)
Interaction	no	0.164	1.860	0.113
		(1.324)	(1.302)	(0.177)
Baseline Individual Controls	no	no	yes	yes
District Fixed Effects	no	no	no	yes
Original HH Fixed Effects	no	no	no	yes
Observations	3,437	3,437	3,436	3,436
H_{0A} , P-value				0.4198
H_{0B}, , P-value				0.0000

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Educ*: coded 1 if achieved any level of instruction, 0 if no education

Table 5b: Per Capita Consumption Growth, *Primary*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC	(4) ΔlnC
Primary	-0.248	-0.249	-0.00930	-0.0120
	(0.152)	(0.156)	(0.113)	(0.0115)
ΔConnect	-0.412	-0.530	-1.753	-0.536**
	(0.979)	(0.900)	(1.233)	(0.217)
Interaction	no	0.139	1.834	0.129
		(1.327)	(1.319)	(0.182)
Baseline Individual Controls	no	no	yes	yes
District Fixed Effects	no	no	no	yes
Original HH Fixed Effects	no	no	no	yes
Observations	3,361	3,361	3,361	3,361
H_{0A}, P-value				0.4604
H_{0B}, , P-value				0.0024

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Primary*: coded 1 if achieved a primary level of instruction, 0 if no education

Table 5c: Per Capita Consumption Growth, *Post-Prim1*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC	(4) ΔlnC
Post-Prim1	-0.431***	-0.429***	-0.178**	0.0603**
	(0.0929)	(0.0985)	(0.0773)	(0.0237)
ΔConnect	-0.195	-0.196	-0.210	3.691***
	(0.971)	(0.972)	(0.713)	(0.225)
Interaction	no	0.0478	1.641*	0.259*
		(0.986)	(0.883)	(0.149)
Baseline Individual Controls	no	no	yes	yes
District Fixed Effects	no	no	no	yes
Original HH Fixed Effects	no	no	no	yes
Observations	3,437	3,437	3,436	3,436
H_{0A}, P-value				0.0473
H_{0B}, P-value				0.0000
Post-Primary Education Impact				
If ΔConnect = mean				0.0584**
				(0.0229)
If ΔConnect = min				0.0171
				(0.0178)
If ΔConnect = max				0.103**
				(0.0452)

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim1*: coded 1 if achieved a post-primary level of instruction, 0 if no education or primary education.

Table 5d: Per Capita Consumption Growth, *Post-Prim2*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC	(4) ΔlnC
Post-Prim2	-0.372***	-0.366***	-0.176**	0.0549**
	(0.0979)	(0.103)	(0.0719)	(0.0245)
ΔConnect	-0.385	-0.391	0.277	2.444***
	(1.119)	(1.123)	(0.601)	(0.328)
Interaction	no	0.243	1.469*	0.257
		(0.960)	(0.795)	(0.157)
Baseline Individual Controls	no	no	yes	yes
District Fixed Effects	no	no	no	yes
Original HH Fixed Effects	no	no	no	yes
Observations	2,595	2,595	2,594	2,594
H_{0A}, P-value				0.0907
H_{0B}, P-value				0.0000
Post-Primary Education Impact				
If ΔConnect = mean				0.0531**
				(0.0237)
If ΔConnect = min				0.0121
				(0.0202)
If ΔConnect = max				0.0977**
				(0.0465)

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim2*: coded 1 if achieved a post-primary level of instruction, 0 if primary education.

Table 5e: Per Capita Consumption Growth, *Post-Prim3*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC	(4) ΔlnC
Post-Prim3	-0.624***	-0.615***	-0.210	0.0850
	(0.168)	(0.161)	(0.131)	(0.0638)
ΔConnect	-0.487	-0.530	-0.432	5.026***
	(0.849)	(0.901)	(0.803)	(0.289)
Interaction	no	0.382	1.391	0.460
		(1.499)	(1.323)	(0.824)
Baseline Individual Controls	no	no	yes	yes
District Fixed Effects	no	no	no	yes
Original HH Fixed Effects	no	no	no	yes
Observations	918	918	917	917
H_{0A}, P-value				0.1236
H_{0B}, P-value				0.0001

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim3*: coded 1 if achieved a post-primary level of instruction, 0 if primary education.

Tables Section 6

Table 6a: Heckman Sample Selection Correction, *Post-Prim1*

VARIABLES	(1) ΔlnC	(2) Selection
Post-Prim1	0.0583*** (0.0122)	-1.168*** (0.280)
ΔConnect	11.76*** (0.467)	-74.35 (0)
Interaction	0.251* (0.145)	-0.424 (3.271)
Baseline Individual Controls	yes	yes
District Fixed Effects	yes	yes
Original HH Fixed Effects	yes	yes
Km from reg. capital * male * age15		-0.00424 (0.00287)
Head or spouse		0.982*** (0.255)
Child of head		0.863*** (0.260)
Average rainfall deviation * age 15		-0.102 (0.119)
		-0.00424
Observations	4,285	4,285
Censored observations	849	849
Uncensored Observations	3,436	3,436
Inverse Mills ratio	0.0111	
NO SELECTION	(0.0136)	
Post-Primary Education Impact		
If ΔConnect = mean	0.0565*** (0.0118)	
If ΔConnect = min	0.0166 (0.0225)	
If ΔConnect = max	0.100*** (0.0311)	

Heckman's two-step efficient estimates per capita consumption growth
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim1*: coded 1 if achieved a post-primary level of instruction, 0 if no education or primary education.

Table 6b: Heckman Sample Selection Correction, *Post-Prim2*

VARIABLES	(1) ΔlnC	(2) Selection
Post-Prim2	0.0519*** (0.0131)	-1.077*** (0.284)
ΔConnect	11.83*** (0.518)	-75.32 (0)
Interaction	0.244 (0.152)	-0.347 (3.278)
Baseline Individual Controls	yes	yes
District Fixed Effects	yes	yes
Original HH Fixed Effects	yes	yes
Km from reg. capital * male * age15		-0.00539 (0.00350)
Head or spouse		1.020*** (0.307)
Child of head		0.983*** (0.280)
Average rainfall deviation * age 15		-0.118 (0.115) -0.00539
Observations	3,307	3,307
Censored observations	713	713
Uncensored Observations	2,594	2,594
Inverse Mills ratio **NO SELECTION**	0.017 (0.0162)	
Post-Primary Education Impact		
If ΔConnect = mean	0.0501*** (0.0127)	
If ΔConnect = min	0.0112 (0.0234)	
If ΔConnect = max	0.0926*** (0.0328)	

Heckman's two-step efficient estimates per capita consumption growth
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim2*: coded 1 if achieved a post-primary level of instruction, 0 if primary education.

Table 6c: Neighborhood Definition Robustness Check, *Post-Prim1*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC
Post-Prim1	0.0568***	0.0601***	0.0603**
	(0.0207)	(0.0202)	(0.0237)
ΔConnect	2.257***	3.165***	3.691***
	(0.161)	(0.189)	(0.225)
Interaction	-0.00546	0.168	0.259*
	(0.159)	(0.132)	(0.149)
Baseline Individual Controls	yes	yes	yes
District Fixed Effects	yes	yes	yes
Original HH Fixed Effects	yes	yes	yes
Observations	3,543	3,543	3,436
H_{0A} , P-value	0.0159	0.0172	0.0473
H_{0B} , P-value	0.0000	0.0000	0.0000
Post-Primary Education Impact			
If ΔConnect = mean	0.0568***	0.0609***	0.0584**
	(0.0206)	(0.0206)	(0.0229)
If ΔConnect = min	0.0582	0.0265	0.0171
	(0.0366)	(0.0241)	(0.0178)
If ΔConnect = max	0.0555	0.0936**	0.103**
	(0.0516)	(0.0405)	(0.0452)

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim1*: coded 1 if achieved a post-primary level of instruction, 0 if no education or primary education.
(1) uses a neighborhood of the 3 nearest communities, (2) uses a neighborhood of the 4 nearest communities, (3) is the estimate (4) reported in Table 5c.

Table 6d: Neighborhood Definition Robustness Check, *Post-Prim2*

VARIABLES	(1) ΔlnC	(2) ΔlnC	(3) ΔlnC
Post-Prim2	0.0518**	0.0559**	0.0549**
	(0.0218)	(0.0214)	(0.0245)
ΔConnect	1.805***	2.116***	2.444***
	(0.215)	(0.264)	(0.328)
Interaction	-0.0319	0.167	0.257
	(0.186)	(0.144)	(0.157)
Baseline Individual Controls	yes	yes	yes
District Fixed Effects	yes	yes	yes
Original HH Fixed Effects	yes	yes	yes
Observations	2,700	2,700	2,594
H_{0A} , P-value	0.0419	0.0409	0.0907
H_{0B} , P-value	0.0000	0.0000	0.000
Post-Primary Education Impact			
If ΔConnect = mean	0.0519**	0.0567**	0.0531**
	(0.0217)	(0.0217)	(0.0237)
If ΔConnect = min	0.0598	0.0224	0.0121
	(0.0441)	(0.0270)	(0.0202)
If ΔConnect = max	0.0439	0.0894**	0.0977**
	(0.0578)	(0.0430)	(0.0465)

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim2*: coded 1 if achieved a post-primary level of instruction, 0 if primary education.
(1) uses a neighborhood of the 3 nearest communities, (2) uses a neighborhood of the 4 nearest communities, (3) is the estimate (4) reported in Table 5d.

Table 6e: Sample Size Robustness Check, *Post-Prim1*

VARIABLES	(1) ΔlnC	(2) ΔlnC
Post-Prim1	0.0756**	0.0603**
	(0.0292)	(0.0237)
ΔConnect	1.405***	3.691***
	(0.0885)	(0.225)
Interaction	0.348**	0.259*
	(0.167)	(0.149)
Baseline Individual Controls	yes	yes
District Fixed Effects	yes	yes
Original HH Fixed Effects	yes	yes
Observations	1,821	3,436
H_{0A} , P-value	0.0398	0.0473
H_{0B} , P-value	0.0000	0.0000
Post-Primary Education Impact		
If ΔConnect = mean	0.0675**	0.0584**
	(0.0268)	(0.0229)
If ΔConnect = min	0.0176	0.0171
	(0.0234)	(0.0178)
If ΔConnect = max	0.134**	0.103**
	(0.0521)	(0.0452)

OLS estimates of per capita consumption growth, robust to community clustering
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Education variable is *Post-Prim1*: coded 1 if achieved a post-primary level of instruction, 0 if no education or primary education.
(1) uses a sample restricted to the second and third quartile of $\ln(C)_{baseline}$, (2) is the estimate (4) reported in Table 5d.

Appendix

The public road network in Mainland Tanzania is classified as National roads and District roads. Table 3a presents details on the lengths.

Table 3a. : Tanzania Road Network Length

	Quality		
Road Class	Paved km (% Total 1)	Unpaved km	TOTAL 1
Trunk Roads	5,130 (40,1%)	7,655	12,786
Regional Roads	702 (3,5%)	19,523	20,225
District, Urban, Feeder, Roads	745 (1,3%)	57,291	58,037
TOTAL 2	6,578 (7,2%)	84,470	91,049

The National road network includes:

- Trunk roads :national route that links two or more regional headquarters; or an international through route that links regional headquarters and another major or important city or town or major port outside Tanzania
- Regional roads: secondary road connecting a trunk road and a district or regional headquarters; a regional headquarters and district headquarters

The District network includes

- Collector roads: road linking a district headquarters and a division centre; road linking a division centre with any other division centre; route linking a division centre with a ward centre; road within an urban area carrying through traffic which predominantly originates from and destined out of the town and links with either regional or a trunk road

- Feeder roads: road within urban area that links a collector road and other minor road within the vicinity and collects or distributes traffic between residential, industrial and principal business centres of the town; village access road linking wards to other wards centres
- Community roads: within the village or a road which links a village to another.

Fig 3a shows the road network in the region in 2008. While relatively developed, differences in the density of the network appear among the districts: The Bukoba and the Ngara districts benefit from the densest networks; followed by the Muleba and the Karangya districts presenting both areas with no secondary roads. But the most interesting is the Biharamulo district: while opening the region to the rest of the country, its road network is the least developed for secondary roads, emphasizing the fact that this is just a passage area to reach the rest of Tanzania.

About 80% of the main network is in good or fair condition, which corresponds to the mean recorded in eastern Africa (Gwilliam et al, 2008).

Fig3a: Kagera Road Network