Impact of First Mile Access Improvements on Small-Scale Farming in Kenya and Tanzania

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1.Introduction

The "First Mile" is a reference to the primary segment of transport that includes the first stage in the movement of goods and services in rural areas. In the case of this research the First Mile links farmer's from their farm to the nearest produce collection or consolidation point, or local market. The term first mile is used figuratively to describe the first movement of produce from the farm, but in reality it can be a few metres up to several kilometres, depending on the remoteness of the farm. The road infrastructure in this first transport segment in many low income countries often consists of earthen access roads or tracks that are inaccessible to four wheeled vehicles. This specific link is also referred to as the 'Last Mile' in terms of movement of goods and services from their urban source to their rural destination. For example, in the context of this research fertilisers or pesticides could be produced in urban factories and transported to farms, and the Last Mile could be a bottleneck for the delivery and make the products more expensive for the farmer. Poor road conditions were cited in the World Development Report (World Bank, 2008) as a reason for the high marketing cost of agricultural produce and of inputs such as fertilisers.

Means of transport on the first mile vary from human porterage, animal carts, bicycles and motorcycles, to tractors, pickups and small trucks. The transport used is frequently a function of the type and condition of the road. These modes of transport and the condition of the road can have a significant influence on the quality of agricultural products by the time they reach their destination. For delicate and perishable produce, the first mile is a critical part of the journey to market where crop damage and wastage is highly likely to occur due to the poor condition of the road pavement.

2. Background

The issue of 'First Mile' has previously been researched by IFRTD, with two pilot studies in Kenya (Njenga et al, 2014) and Tanzania (Njenga et al, 2015). These studies confirmed that the first transport segment from the farm is critically important to the performance of the whole agricultural supply chain. The standard of road and its condition affect the transport costs and influence the profitability and livelihoods of the farmer. The pilot studies referenced above indicated the need for larger studies to confirm the planning and policy implications of these initial findings.

Transport efficiency is also important for reducing post-harvest losses, as highly perishable crops are vulnerable to long periods in the heat. Many crops such as tomatoes, mangoes, soft fruits and bananas can be bruised and lose value through transportation over rough roads or loading/handling at collection points.

Agriculture remains a significant part of many developing economies. In Sub-Saharan Africa the sector employs 62% of the population and generates 27% of the GDP (Livingston et al, 2011). According to the Food and Agriculture Organisation (FAO) (2012), agricultural growth involving smallholders, especially women, is most effective in generating employment for the poor and reducing extreme poverty and hunger.

Rural access and transport services play a central role in enabling agricultural development (Banjo et al, 2012), but when it is not operating efficiently it is the most serious bottleneck (Salami et al, 2010). A recent systematic review of more than 50 worldwide studies showed that the extension of rural road networks has positive effects on the welfare of rural populations. Economic and social gains have been demonstrated and any negative effects were found to be minimal (Hine et al, 2016).

It should however be recognised that there are many other factors that influence agricultural production and the livelihoods of farmers. The research discussed in this paper focuses on transport along the first mile, but has also considered other factors

such as exploitation and the formation of farmer's associations.

As a result of the problems noted above, there is a growing awareness that rural infrastructure, including the location and standards of roads to markets, needs to be planned in conjunction with transport services, in order to reduce transport costs and crop wastage, to gain the maximum advantage for rural farmers, transporters and the ultimate consumers of the produce.

The First Mile is recognised as the part of the chain which has the most problems, is the most expensive when expressed in tonne/km terms and provides the biggest transport constraints to the development of agriculture. These initial movements usually take place on local tracks and may involve non-motorised transport, making them more expensive, for example head loading has been found to be in the order of up to 30 times more expensive per tonne/km than moving goods by truck (Hine et al, 2016).

The dynamics of transport on the first mile and the effect it has on farmers' livelihoods and ultimately on poverty, is not well understood. This research aimed to explore this aspect of the transport chain and make recommendations for practical application and policy consideration.

3. Methodology

Research was carried out in Kenya and Tanzania. Two sites were selected in each country, specifically looking at smallholder farmers who were producing for the market, rather than large-scale farms. The sites selected had similar challenges that small-scale farmers experience in getting agricultural produce from the farms to the market.

In Kenya the sites were in Meru County and Machakos County, with both having French beans as the main crop. Meru County has a mix of good soils and favourable climatic conditions. Machakos is semi-arid, but good soils allow irrigated agriculture as well as drought resistant crops. French beans are largely grown as an export crop and require high market compliance standards. They need to be transported as quickly as possible to collection centres and cooled if they are not transported on to market immediately.

In Meru the available access roads were washed out as a consequence of inadequate design and are no longer accessible to vehicles. Manual transport, such as headloading and backloading, is prevalent on these roads, but is expensive (Hine et al, 2016). In Machakos the access roads are generally in reasonable condition, with some variation depending on the season. A combination of animal carts, motorcycles/bicycles, small trucks, pickups, wheelbarrows and headloading are used for transporting the crops.

In Tanzania the study was carried out in Matola and Madeke districts, both in the Southern Highlands. In Matola the main crop is potatoes, which suits the high altitude and cooler conditions. In Madeke pineapples are grown, which thrive at a slightly lower altitude. This is a hilly area with temperate climate for most of the year.

In Matola the farm access roads are mainly of earthen construction with minimal design. The surface is vulnerable to rainfall and the roads quickly become impassable during the rainy season. The situation in Madeke is similar. Both areas lack formal collection points, so farmers bring their produce to the main road for collection. Transport is a combination of ox carts, motorcycles, animal carts and headloading to the roadside collection points.

The study investigated several issues, including road condition, farm production, transport services, gender and the potential cost benefit analysis of extending motorable roads closer to the farm.

It was important to determine the condition of the roads, so that any crop damage could be related back to the suitability of the infrastructure. Condition surveys were carried out on all the study roads using a variety of means such as:

- Traditional visual surveys using a drive-through methodology.
- DashCam videos of the roads, assessed in the office by the project engineer.

• Road roughness was measured in terms of International Roughness Index (IRI).

Farm production and transport services data was collected using specifically designed and tested survey procedures, with a combination of quantitative and qualitative approaches (Table 1). Quantitative data was collected using household questionnaires for farmers, transport service operators, and market / collection point feedback. Having identified and mapped the survey area a cluster sampling approach was employed. This was developed by the project staff and survey managers in liaison with local key informants, and implemented by the enumerators. The survey procedure ensured that, smallholder farmers with good accessibility, and poor accessibility, were both surveyed. An equal balance of men and women were invited to participate in the focus group discussions. The market traders and transporters were recruited from the transport routes, collection points and local markets used by the farmers.

The questionnaires captured information such as crops grown, quality and price, means of transport, costs and conditions of accessibility in the first mile. More than 700 questionnaires were completed, along with nine key informant interviews and five focus group discussions.

4. Findings

Production and net income data for Kenya and Tanzania are shown in Tables 2 and 3[1] . In both research locations in Kenya the farm sizes were relatively small. Despite their higher yields, farmers in Meru were at a considerable disadvantage because the prices they received, per kg, were around

Survey instruments	Kenya		Tanzania		Total
	Meru	Machakos	Matola	Madeke	
Farmer's Questionnaire	126	129	132	139	526
Transporter's Questionnaire	35	35	90	26	186
Market, seller / farmer's produce data Questionnaire	4		10		14
Collection point / market general data Questionnaire	5		4		9
Key informant interviews	6		3		9
Focus Group Discussions	2		5		5

Table 1: Survey Sizes and Survey Procedures Used, Showing the Number of Responses for Each Survey Instrument

	Area farmed in Acres	Yield kg	Yield/ acre kg/acre	Price received US cents/ kg	Net income US$	% of harvest spoiled	%of harvest sold as 2nd quakity or spoiled
Machakos Mean Median	1.2 1.0	1,350 700	1,297 800	70 60	366 268	9%	9%
Meru Mean Median	0.4 0.25	1,005 900	3,596 2,725	34 30	171 144	3%	4%

Table 2: Production and Income of Farms, for French Beans in Machakos and Meru areas of Kenya

1. Note rates of exchange used are: US$1 = 100 Kenya Shillings (KSh) = 2245 Tanzania Shillings (TSh)

half of those in Machakos. There was only one commercial buyer for export in Meru, whereas there were several in Machakos.

Farms in Tanzania were significantly larger (see mean area farmed in Tables 2 and 3), and incomes higher, although crop spoilage and selling at below 'best quality' was much higher compared with Kenya. 'Best quality' is the crop that demands the highest price, but the assessments of crop quality in these locations are largely subjective. Second quality is a crop that demands a lower price than best quality, but the scale is not well defined.

Data on the modes of transport and transport costs for the first-mile are presented in Tables 4 and 5 for Kenya and Tanzania respectively. Due to the hilly terrain and lack of suitable roads and tracks in both Meru and Madeke, head/back loading was by far the dominant means of first mile transport. In contrast, a range of modes could be used in both Machakos and Matola. The loads reported in the tables were for a consignment, and not necessarily the loads carried in one trip (It is unlikely that loads of 50 kg or 90 kg would be carried by a porter on one trip).

	Area farmed in Acres	Yield kg	Yield/ acre kg/acre	Price received US cents/ kg	Net income US$	% of harvest spoiled	%of harvest sold as 2nd quality or spoiled
Matola/Potatoes							
Mean	1.9	8,093	3,997	13	631	24%	5%
Median	2	4,350	3,600	13	294		
Madeke/Pineapples							
Mean	4.4	59,073	15,452	10	4,741	32%	22%
Median	3	30,870	12,000	9	1,939		

Table 3: Production and Income of Farms, Potatoes and Pineapples in Matola and Madeke areas of Tanzania

	Machakos				Meru
	Head/ back load	Motor-cycle	Donkey cart	Donkey	Head/back load
Observations	50	23	11	7	82
Mean Load, kg	52.8	141.3	231.3	112.5	65
Mean Distance, km	1.43	1.8	1.35	2.2	1.53
Mean US cents /kg	1.49	1.14	0.74	1.2	1.11
Mean US cents /kg-km	2.03	1.39	0.65	0.63	0.95

Table 4: Types of First Mile Transport for Green Beans in Kenya

	Madeke, Pineapples	Matola, Potatoes			
	Headload	Headload	Motor cycle	Donkey cart	Ox cart
Observations	126	53	34	30	14
Mean Load, kg	37.1	91.9	85.7	101.9	123.4
Mean Distance, km	0.34	0.67	1.44	1.78	2.15
Mean US cents/kg	1.51	0.84	1.04	1.11	1.11
Mean US cents/kg-km	20.9	5.38	1.95	1.79	0.88

Table 5: Types of First Mile Transport for Pineapples and Potatoes in Tanzania

Transport data	Potatoes	Pineapples		
	Truck	Truck	Motorcycle	Pickup
Load, kg	10,512	3,505	103	813
Distance, km	582	195	31.5	108
Charge US$	517.6	177	9.8	66.8
US cents/kg	4.92	5.05	9.5	8.2
US cents/ kg-km	0.0085	0.026	0.3	0.076

Table 6: Examples of Longer Distance Transport of Farm Produce in Tanzania

Examples of longer distance transport for Tanzania, to the market and beyond, are given in Table 6. The efficiency and low costs associated with truck transport is very apparent when taking heavier loads and travelling longer distances.

In all the study locations it was found that road condition is too poor for four-wheeled motorised transport services. As can be seen in Table 5, human porterage, animal transport and motorcycles are the most common means of transport. Head and back loading are the most expensive means of transport per tonne/km. Depending on its load and trip distance, it was found that a fully loaded truck, on a long distance route, might charge as little as one per cent of the typical costs of human porterage, or ten per cent of a motorcycle, when expressed in terms of costs per tonne/km.

The analysis shows that the cost of first mile transport has a considerable impact on the net incomes of the farmers, with more significance in Tanzania (pineapples and potatoes) than Kenya (French beans). Using two different methods of analysis for the Tanzanian data, multiple regression and simple tabulation of average results, it was estimated that transport costs and spoilage on the first mile, accounted for around 30% to 40% of net farmer incomes. While in Kenya, they accounted for around 10% to 15% of net farmer incomes.

The study also found that the average area farmed by men was significantly larger than that farmed by women. Women's farms tended to be closer to the collection point than for men, but their first mile transport costs were higher, despite using similar modes of transport. Yields per acre were lower for women in three locations, however for Madeke pineapple farming, women achieved 58% higher yields. Overall, in each location women's net incomes were substantially less than for men.

5. Cost benefit analysis

In order to test whether it would be economically viable to extend roads closer to the farm, a cost benefit analysis was undertaken. The Madeke pineapple producing area was chosen for this because it had the most perishable crop and accessibility to the farms was low with signifi-

	Less than 0.5 km to collection point	More than 0.5 km to collection point
Number of farmers surveyed	95	36
Average distance to collection point	0.15 km	0.97 km
Total distance of farms to collection point	14.38 km	34.85 km
Average transport charge for head / backloading	1.48 US cents/kg	1.56 US cents/kg
Average revenue per kg of pineapples	10.3 US cents/kg	8.64 US cents/kg
Average crop losses	12.7%	10.7%
Average farm size	4.1 acres	5.66 acres
Average net income per farm	5,880 US$	4,499 US$
Average net income per acre	1,425 US$	1,020 US$

Table 7: Data on Pineapple Farms in Madeke, Tanzania, based on their proximity to the collection point

cant potential for road improvement. The analysis is inevitably tentative because of the uncertainty in predicting how farmers, and the transport and marketing system, will respond to the changes. Therefore a number of assumptions have had to be made.

The area selected produces one third of all pineapples grown in Tanzania. The total length of farm access roads is 16 km, of which only 5 km is accessible all year. The data has been analysed in terms of the distance to collection point, as shown in Table 7.

Most farms are close to the collection point (on average 0.15 km), but 27% are on average 1 km away. Despite the six fold difference in average distance, the head/backloading transport charges only increased by 6% per kg. While at the same time the selling price of pineapples was 16 % less, and the net incomes per acre were 28% less, for the farms closest to the collection points. These results confirm previous regression analysis in this project which showed that farms with higher initial transport costs were negatively correlated with lower incomes. However, the reason for lower farm incomes for remote farms is almost certainly the result of a number of factors in addition to the direct costs of transporting produce.

The Focus Group interviews confirmed that it was the custom for head/backloading charges not to substantially increase with distance, despite the increased effort. One possible explanation of the small difference in transport charges (i.e. 6% difference for a six fold difference in distance) is that the same farm workers did both harvesting and transport and that while nominally they may be paid the same, or little different, for transport (between a near and remotely located farm) effectively the remotely located farm either had to pay more for harvesting and other farm activities, or gained less from the farm labour as a consequence. This would have a knock-on effect of reducing net farm incomes for the remotely located farm as a result.

A set of road maintenance and upgrade interventions were suggested that would enhance accessibility in the area by rehabilitating the roads and in some cases reducing gradients to make them accessible to a wider range of vehicles. The interventions are designed to provide year-round basic access, particularly on the 16 km of access roads. These were costed using average local rates for typical road maintenance interventions in the area. A full programme of investment in roads of TSh 1,158.5 M (or US$ 32,250 per km) was assumed to occur for rehabilitation in 2019. After this, annual routine maintenance of TSh 15 M (or US$ 420 per km) was assumed with a larger periodic maintenance effort of TSh 129 M (US$ 3,600 per km) in 2024 and 2029.

It would be reasonable to assume interventions on a scale that would reduce the average distance to an all-season motorable road to 0.5km from the more remote farms, reducing the previous average by 0.5 km from 1.0 km. For transporters to regularly access roads to collect produce there needs to be good all-year round access that the farmers, transporters and wholesalers have confidence in. The decision to base the CBA on a revised distance from farm to accessible road to 0.5 km was based on the fact that this would be a reasonable intervention for the local road organisation to make.

An elasticity was derived as the proportionate change in net incomes per acre divided by a proportionate change in transport charges, i.e.

The elasticity of net income per acre to transport charge

$$= (-0.284/1) / (0.057/1)$$
$$= - 4.98$$

Hence a 1% decline in transport charges is associated with a 5% increase in farm incomes. However, it should be noted that other factors besides transport costs may also have played a part in reduced incomes of the more remote farmers. For the purposes of the CBA, it is also recognised that part of the predicted rise in farmers' incomes, following any intervention, may also be because of better bargaining power, and so possibly at the expense of the incomes of middlemen, transporters and buyers. It is therefore suggested that

an elasticity of -2.5 is used for evaluation purposes.

Whilst the overall manpower required to transport pineapples from the farm will reduce by 35%, following the existing marketing arrangements overall transport for head/backloading charges will fall by only 2.2%, or US cents 0.032 per kg. At the same time it may be expected that there will also be a small increase in freight charges as the truck has to travel the extra distance to pick up the more remote loads, so overall truck freight charges would increase by US Cents 0.007 per kg. Therefore an overall fall in transport charges of 1.7% combined with an elasticity of -2.5 would, assuming a robust causal relationship, be associated with an overall rise in net incomes of 4.25%.

In the calculation it is assumed that overall incomes will rise by 2% per year in the area (both with and without the investment) as further land is devoted to pineapple farming. It is also assumed that if the interventions take place in 2019, then in 2020 only half the full benefits are assumed to occur, with the main full benefits occurring from 2021 onwards. A fifteen year planning time horizon was used in the analysis.

The results of the Cost Benefit Analysis are shown in Table 8. It can be seen that, according to the calculations the investment is very worthwhile.

Total investment costs:	US$ 516,000
Net present value:	U$ 1.37 M
IRR:	47%
Discounted Benefit-Cost ratio[2]: (Discount rate 12%)	2.65

Table 8: Results of Discounted Benefit-Cost Calculation

2 If the ratio is above 1 then discounted benefits are greater than discounted costs, and the investment becomes worthwhile. For a BCR of 1 the NPV will be zero and the IRR will be 12%.

6. Discussions/Recommendations

The findings and analysis were presented to stakeholders throughout the project. A summary of the main discussions and recommendations is given below:

6.1. Extend motorable roads closer to farms:

The results of the research show clearly that the most cost-effective transport on the first mile is by truck. In Tanzania it was estimated that the cost to transport by truck per tonne/km is around one tenth of that by motorcycle and often much less than this compared with head and backloading. To take advantage of truck transport there needs to be both vehicle accessibility and effective load consolidation.

The cost of transport could be reduced and farmers' incomes increased if larger vehicles could be brought closer to the farm. However, trucks can only be used if the access roads are suitable, i.e. if they are wide enough, not too steep and the surface is suitable for heavy vehicles. There would also need to be an effective maintenance regime in place and operational so that reliable access could be guaranteed in all except the most exceptional circumstances.

6.2. Introduce or strengthen farmer's associations / cooperatives:

From focus group discussions it is clear that the areas where farmers do not have any type of association, they receive a lower price for their crops. Forming a farmers' association would strengthen the farmers' position and could allow them to negotiate better prices for their produce. The earlier pilot study of First Mile transport of onions in Kenya found that farmers' associations were active in helping to consolidate loads and organise the timing of truck transport to maximum advantage (Njenga et al, 2014).

In addition there could be benefits in lobbying as a cooperative for improved road access. The farmers in Meru expressed a keen interest to become involved in infrastructure provision to their farms; at present they are paying a premium for headloading and backloading their produce to the collection point, but there would be

a significant saving if trucks could ply the access roads.

It would be necessary for the association to liaise closely with the local engineering department, initially to consult over the work necessary to rehabilitate the roads, but also to participate in training on how the roads need to be maintained.

6.3. Community participation in road rehabilitation and maintenance:
There was interest expressed during interactions with local communities to become involved in the provision and maintenance of the road infrastructure to farms. However, they are reluctant to get too involved without technical training. This is however a subject that warrants further investigation as a potentially cost effective and sustainable solution.

Several countries in Africa have a history of using the lengthworker system of maintenance. This usually involves tasks such as clearing drains and culverts, removing debris and filling small depressions and potholes with locally available material.

If a community system were to be used for road maintenance, it could be appropriately managed through a farmer's association. Farmers could use simple farm tools for the works and ox-carts to transport materials. To support farmers a simple manual for spot improvement and maintenance could be prepared and circulated, with the support of local technicians who could impart some basic training, such as the supplement published in the Organic Farmer magazine in Kenya (Beusch et al, 2008).

6.4. Adding value at the farm
In the second Tanzania country workshop there was a suggestion that value could be added at the farm by taking on some simple processing tasks of the produce. In the Madeke area of Tanzania, which predominantly produces pineapples, the government had set up a processing facility to dry pineapples for packaging within the pineapple growing area. Ultimately this did not succeed, but it would have made sense because of the remoteness and long distances for transport, the poor road conditions and the vulnerability of the crop. Transport costs of the processed product would ultimately be cheaper because the produce being transported is smaller in volume and lighter in weight.

7. Conclusions

The research has increased understanding of the dynamics of transport on the first mile and the effect it has on farmer's livelihoods and ultimately on poverty reduction. The results have indicated that it is cost effective to upgrade roads from farm to collection point and reduce the first mile distance, in order to minimise transport costs and reduce wastage of crops being transported slowly on poor roads. This information should be disseminated widely so that policy makers have all the information necessary to make decisions that can positively impact on farmer's productivity and food security.

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