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Economic Analysis and Prioritization of Feeder Road Rehabilitation: Incorporating Vehicle Operating Costs, Passenger Time and Producer Surplus Transport Costs Savings –the Case of Southwestern Uganda

by

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ABSTRACT

Development studies demonstrate that agricultural projects and programmes which exclude basic infrastructures in their design often fail to translate incremental production into sufficient incomes for the intended beneficiaries. Creation of supplementary infrastructure is an important factor in poverty reduction strategies. Both the Government of Uganda and donors – the International Fund for Agricultural Development (IFAD) and the African Development Fund (ADF) have realized this and have incorporated basic infrastructure, including feeder road rehabilitation, in the design of the Area-based Agricultural Modernisation Programme proposed to be implemented in the southwestern Uganda and which is being co-financed by these institutions. However, due to capital rationing, it is not possible to include all the roads that require rehabilitation in the investment proposal. An acceptable and practical methodology was therefore imperative to be able to analyse all the feeder roads prescreened and submitted to the donors for financing of their rehabilitation. Given the low traffic volumes associated with roads of this nature, most of the current methodologies which rely on traffic count data are not adequate to address the issue. The objective of this paper is to review the current practices as being used by the international donor agencies, in the context of an agricultural based rural feeder road rehabilitation component in the Southwestern Uganda, with a view to establishing a more practical methodology for feeder road selection, ranking and prioritization. There is no dearth of theoretical underpinnings of the principles. Yet the practice in the field is often the weak link. The paper is intended to assist the work of development and project economists to address the problem of choice among competing investment options, under capital rationing, with regards to feeder road prioritization for rehabilitation.

RÉSUMÉ

Les études sur le développement démontrent que les projets et programmes agricoles qui, dans leur conception, ne tiennent pas compte des infrastructures de base, n'arrivent souvent pas à traduire la production additionnelle en revenus suffisants pour les bénéficiaires cibles. La création d'infrastructures supplémentaires est un facteur important dans les stratégies de lutte contre la pauvreté. Le gouvernement ougandais et les bailleurs de fonds, en l'occurrence le Fonds international de développement agricole (FIDA) et le Fonds africain de développement (FAD) l'ont compris et ont inclus l'infrastructure de base dont la réfection des routes de desserte dans la conception du Programme de modernisation agricole par région à réaliser dans le sud-ouest de l'Ouganda, programme cofinancé par lesdites institutions. Cependant, en raison des contraintes budgétaires, il n'est pas possible d'inclure dans l'investissement proposé toutes les routes qui demandent à être rénovées. Une méthodologie acceptable et pratique s'imposait donc pour l'étude de toutes les routes de desserte présélectionnées pour rénovation et dont le financement a été proposé aux bailleurs. Les routes de ce genre affichent des volumes de trafic faibles et, de ce fait, les méthodologies actuelles fondées sur les données de comptage routier ne sont pas adaptées à la situation. Le présent document vise à examiner les pratiques actuelles en usage dans les organisations internationales dans le contexte d'une agriculture axée sur la rénovation de routes de desserte dans le sud-ouest de l'Ouganda en vue de la mise en place d'une méthodologie plus pratique de sélection, de classement par catégorie et par ordre de priorité. A cet égard, les théories foisonnent mais la pratique sur le terrain demeure souvent le point faible. Le présent document a pour objet d'aider les économistes du développement et les économistes-projets à faire le choix entre des options d'investissement antagonistes, sur toile de fond de contrainte budgétaire, pour déterminer les routes de desserte à rénover en priorité.

Economic Analysis and Prioritization of Feeder Road Rehabilitation: Incorporating Vehicle Operating Costs, Passenger Time and Producer Surplus Transport Costs Savings – the Case of Southwestern Uganda.*

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1. Introduction

With support from the International Fund for Agricultural Development (IFAD) and the African Development Fund (ADF), the Government of Uganda (GOU) is implementing an Area-based Agricultural Modernisation Programme (AAMP) in the southwestern Uganda. The objective of the programme is to raise the income of more than 300,000 households or about 1.5 million persons living in the 10 districts comprising the region, through a process of agricultural modernisatiom (shifting from subsistence to commercial farming), community mobilization (through empowerment, training and interest group promotion) and rural infrastructure development (improvement in rural feeder roads, community access roads and other infrastructure, including irrigation, livestock, marketing facilities and storage). The African Development Fund has agreed to finance the rural feeder road rehabilitation component of the programme. This will comprise improvement on about 700 km of over 2,680 km requiring rehabilitation in the region. These roads deteriorated due to various causes in the past, including civil unrest, lack of resources for development and insufficient institutional framework. Routine and periodic maintenance were considered un-economical. Improvement in basic access roads in the rural areas is acknowledged as one of the important steps towards poverty alleviation. Improvement in feeder roads have been known to provide incentives for agricultural commercialization and monetization of the rural sector through better access to more competitive marketers and traders and improved farm gate prices for most commodities (depending on their demand elasticities), increased export of farm produce outside the region, reduction in passenger times and motorized vehicle operating costs and costs of transportation of surplus produce. All these in turn stimulate further production at the farm level, with a consequent boost in total food production capacity (Ojukwu, 1992).

Given limited external financing available and the absorptive capacity of both the GOU and the district local administrations in terms of marching counterpart funds, it becomes imperative that some sort of selection process and prioritization be employed to, apart

[1]The paper was based on an initial concept paper and outcome of an appraisal mission of the Uganda Area-based Agricultural Modernisation Programme during February, 2000.

[2]Chiji Ojukwu is a Principal Agricultural Economist in the Agriculture Division of the Country Operations Department, East. His thanks go to L.I. Umeh, Manager, Agriculture Division, Country Department East and colleagues Sam Onwona, Micah Ajijo, Ben Kanu and Esther Kasalu-Coffin who reviewed the initial concept paper that was used for the mission, and to Dougou Keita and Paul Barnstein, members of the mission, and to Fred Were of the Ugandan Ministry of Works, Housing and Communication and all the Chairmen, District Engineers and Economists who participated in the stakeholders workshop and provided most of the data used in this paper.

from ensuring equity in spatial distribution among districts, also ensures that only those roads whose rehabilitation will maximize returns to investment are retained for improvement. This methodology was applied in the selection of district roads included for rehabilitation under the Area-based Agricultural Modernisation Programme in the southwestern Uganda.

2. **Concept and Issues**

The underlying concept is that the resources that a country has for road improvement expenditures are always insufficient for the total needs, and thus an economic evaluation is necessary to determine the optimal allocation of the available resources, the priority and timing of individual road improvement. A number of literature abound, especially those published by the World Bank, enunciating methodologies for design and appraisal of rural transport infrastructure. One of the earliest publications was that by Beenhakker and Chammari (1979). This approach compares the aggregate benefits accruing from farmers in the project's road zone of influence and the transport costs savings accruing to non-agricultural traffic under the "with project" situation, with the total costs of road rehabilitation and maintenance and complimentary agricultural investments. This methodology was used extensively in Nigeria for selecting rural feeder roads for rehabilitation under the multi-state agricultural development projects (MSADPs) implemented during the 1980s[3]. One of the drawbacks of this methodology is the problem of isolating the exact effects of the rural feeder road. It tends to aggregate all benefits irrespective of the contributing factors, such as agricultural technology or cultural practices and farm management. It also limits the number of crops that can be included in the analysis.

In a more recent Infrastructure notes, Liu (2000) working in Andhra Pradesh, India, tries to aggregate savings in vehicle operating costs (VOC) and rural road user travel time (TTC), even as the author admits the unsuitability of the methodology due to low traffic volumes associated with rural access roads. Thus Schelling and Liu (2000) suggest complimenting the analysis with a participatory cost-effectiveness approach. This approach is data intensive and requires the existence of a rural road master plan. The World Bank paper on Design and Appraisal of Rural Transport Infrastructure does indeed recommend that for roads with traffic volume of less than 50 vehicles per day, the analyst should use the cost-effectiveness criteria, while for traffic volumes of 50 to 200 per day, it recommends the use of the Road Economic Decision Model. But this may not necessarily be so as most rural roads can hardly achieve an average daily traffic (ADT) of more than 50 vehicles. This would therefore mean the exclusion of all such rural roads from the economic appraisal methodology.

In this paper, we can illustrate based on a recent study in the southwestern Uganda that it is indeed possible to undertake a simplified economic analysis of individual rural feeder roads by a combination of the VOC, TTC and the producer surplus transportation costs

[3] During the implementation of the MSADPs, each participating state was mandated to submit to the World Bank for approval on annual basis a report of prioritized rural roads selected for implementation.

savings (PSTC). It should be noted that the value of agricultural production is not included in the analysis as in the Beenhakker and Chammari approach. Even though the road rehabilitation will facilitate access of farmers to agricultural input and extension services and thus impart the level of incremental production, the proposed methodology takes these as given, and only focuses on benefits that will accrue outside the direct production line.

3. **Application of the Methodology**

The first step in the analysis is to receive a shortlist of pre-screened roads from each of the districts. The criteria for including roads in the shortlist is as follows[4]:

- road must pass through and/or give access to agricultural productive areas, with additional advantage if road passes along potential commercially active areas;
- road must be linked in the road network;
- the road must be classified to be in bad condition;
- road should not be under funding by other donors or government agencies;
- the road must be located within the project area or its zone of influence directly serves sub-counties selected as beneficiaries in the agricultural development;
- road must be technically feasible and within a cost level not exceeding US$15,000 per kilometer; and
- road must be within the scope of the district to maintain adequately after rehabilitation[5].

The suggested economic analysis of individual rural feeder road involves the aggregation of (1) savings accruing from motorized vehicle operating costs, (2) value of passenger time savings and (3) producer surplus transportation costs savings, in a with and without improvement scenario, and comparing these benefits with the associated costs of (4) initial road rehabilitation and the (5) periodic and (6) routine maintenance over a 20-year period. Benefits (1) and (2) will require traffic count data from motorized vehicles – trucks, buses, motorcycles, pick-up vans, etc, while benefit (3) will require transport costs of non-motorized vehicle such as bicycle. The general data requirement to undertake the analysis is as given in Annex 1.

[4] These criteria were agreed at a stakeholder workshop. It is important that if this study is to be replicated elsewhere, a workshop of all the districts be held to agree on similar criteria.

[5] In the case of Uganda, district roads are maintained through planned fund guarantee from the central government or what is called conditional funding.

Estimating Costs

In estimating typical road improvement costs, the following assumptions have been applied:

- The civil works will involve full rehabilitation along existing alignments, and will consist of road side and cross drainage works, construction of embankment for swampy sections, reshaping and re-surfacing of carriageway with gravel and reconstruction of broken bridges. The design will follow the guidelines set by the Ministry of Works, Housing and Communications (MWHC). Annex 2 gives the design characteristics for rehabilitation of rural feeder roads.

- The cost of rehabilitating 1 km of rural feeder road has been estimated as not more than US$15,000. Cost estimate will include a 10% physical contingency. The unit cost estimates are provisional. Full survey and engineering estimates, followed by competitive bidding will be undertaken prior to the implementation of each road work and this is expected to result in more realistic, market-based, costing of civil works;

- According to the GOU 1999 Rural Road Strategy Report, US$3,700 (or 25%) of the capital cost will be used for periodic maintenance[6]. This is assumed to take place every 5 years after construction and 5 years after every other periodic maintenance. Routine maintenance is assumed to occur every year, except in the first year of capital investment and the years when periodic maintenance is undertaken.

- Routine maintenance costs have been estimated at US$300 or 2% of capital costs for the year following full rehabilitation; rising to 3% in PY3; 4% in PY4 and 5% in PY5. The circle repeats after each periodic maintenance.

Estimating Benefits

Three types of benefits are estimated: (i) benefits accruing as a result of motorized vehicle operating cost savings; (ii) benefits accruing to commuters as a result of road travel time savings; and (iii) benefits accruing to non-motorized vehicle (bicycle) as a result of 50% of the agricultural surpluses being hauled to market by bicycle and the resultant savings on the cost of transportation following improved roads (Motorized vehicles – cars, pick-up and trucks – are expected to haul the balance 50%[7]. However, only bicycle has been included in the analysis to avoid double counting since the reduction in motorized vehicle operating costs will also be transferred to reduced transport costs to non-agricultural vehicle users). For estimation of the various benefits, the following assumptions have been made:

- assume 312 (26 days in a month) days per year traffic period;

[6] See the AFRICON 1999 Report

[7] Without road improvement, it is assumed that almost 100% of the produce will be transported using bicycles (or by head portage). With project, it is assumed about 50% of the produced will still be hauled using bicycles, but at reduced fares. It is the savings in the fares of the 50% multiplied by the volume hauled that is captured as benefit due to the road improvement.

- assume 5% annual growth rate of traffic after rehabilitation. For the purposes of this analysis, the growth rate is assumed to peak in Project Year 6 [8].

- For commuter time savings, assume a return trip (road length x 2)[9]. Time savings have been converted to person-days and valued at their opportunity costs factored by the shadow wage rate. Eight hours are assumed to constitute a worked day.

- For estimation of benefits accruing as a result of producer surplus hauled by bicycles, the following additional assumptions are made:

- Road Zone of Influence is assumed as 1 km either side and either end of road;

- Assume 70% of the arable land cultivated annually[10].

- For the Uganda case a typical high altitude montane farm model is assumed[11]. Other farming systems may be assumed under different road analysis.

- For the montane high altitude model, major crops are beans (30% area), banana (15%), maize (10%) and irish potato (45%). This assumption will vary from place to place as for the rest of the road analysis. Loss in consumer surplus (family consumption plus waste) assumed between 30% to 50% for the typical crops. This will vary from crop to crop and as to whether cash or food crop in individual road analysis. For typical cash crops, only percentage associated with waste may be assumed.

- Costs of transportation on the roads are as estimated by the mission and compares with the WARDROP Report[12]. Assume no price changes for the final consumer in the local market.

Cost-Benefit Analysis

All financial costs and benefits are duly shadow priced to convert them to their economic costs and benefits. By use of an excel spreadsheet, the layout is as given in Annex 3. The spreadsheet is divided into 5 Sections. Section A gives the road's basic data and parameters for the economic analysis, including road name and length, initial capital cost of

[8] VOC data are based on HDM-IV programme (as contained in the MOLG Report Manual for Evaluating District Roads), adjusted to PY2000 constant prices; Traffic count data are taken for our typical model on one of the roads in Ntungamu District. The data compare favourably with those estimated in the WARDROP Report for MOLG p.47 for least traffic roads, and is in line with traffic count group 3 (11 – 20 veh/day). See MOLG Manual 11.

[9] Change in transport costs between bad (typical operating speed of 20 km/hr) and good road condition (operating speed of 60 km/hr), ie Before and After Rehabilitation, taken from WARDROP Report p.69, and compares with mission observation.

[10] As agreed at the Stakeholder workshop held at Mbarara on 17 February, 2000

[11] See IFAD Appraisal Report, Appendix 14 p2. Also yield estimates are based on the IFAD estimates under improved condition and mission estimates.

[12] Impact assessment of Rural Feeder Roads Rehabilitation and maintenance Programme, Final Report, MOLG, November, 1999.

rehabilitation, annual rate of traffic growth, standard conversion factor and shadow wage rate.

Section B gives the estimation of benefits based on VOC savings for the first project year. Information requirement here includes the Average Daily Traffic (ADT) for the motorized vehicles that ply the road, the road length which cascades from Section A, the differential VOCs from the improved and non-improved road respectively and the derived savings per kilometer.

Section C is similar to Section B except that the basis of the analysis is the estimation of time savings by commuters. Data requirement here includes vehicle differential speed on the improved and non-improved road respectively, average vehicle occupancy rate and return road length.

Section D estimates benefits from producer surplus transport cost savings through the transportation of major commodities grown in the roads zone of influence. Data required here include the list of the major crops grown, expected yield levels, hectarage allocated to each crop, percentage of farm under cultivation in the zone of influence, percentage loss in consumer surplus and storage losses and the differential costs of transportation on both the improved and non-improved road.

Section E aggregates the economic costs and benefits and estimates the economic internal rate of return (EIRR), the net present value (NPV) and the NPV-capital investment ration (NPV/K) which is the basis of ranking.

Results of the Analysis

The economic internal rate of return (EIRR) for the road model over 20 years is estimated at 38% and is very robust when compared with the opportunity cost of capital for Uganda of 12%. The model produces an NPV of USH. 347.8 million and an NPV/K of 1.56. Sensitivity analyses (Annex 4) show that the rate of return would decrease to 34% and 29% if benefits are down by 10% and 20% respectively. The EIRR will reduce to 34% and 31% if costs are up by 10% and 20% respectively. A 2-year delay will reduce the EIRR to 22%. It will take a simultaneous 20% reduction in benefits and 40% increase in costs to reduce the EIRR to 18%, which is an unlikely scenario. When the Average Daily Traffic (ADT) is reduced to only 5 vehicles a day, the EIRR is still robust at 33%. If however, only 30% of the arable land were to be cultivated (Uganda national average is 30%, according to the PMA Report[13]), the EIRR will drop to 16%.

[13] Plan for Modernisation of Agriculture: Eradicating Poverty in Uganda, MAAIF and MFPED, 3 January, 2000, p.9

District Feeder Roads Prioritization

Based on the above model, each of the pre-screened roads submitted by 8 of the 10 districts present at a stakeholders workshop have been individually analysed and then ranked in descending order of their NPV/K[14] until the allocated kilometers for each district is attained. The result of the analysis showing the ranking of prioritized roads is given in Annex 5. Only those roads returning an EIRR equal to or greater than 12% are retained for rehabilitation and included in the project costs. The EIRR of the individual roads retained ranges from 14% to 54%.

4. **Conclusion**

The objective of the feeder road rehabilitation component is to provide all-weather and all-year road access and to reduce agricultural input and output transport costs. Other benefits include the derived transport operating cost savings accruing to non-agricultural traffic users and the reduction in time for commuters compared to without project situation. These objectives put together have enabled the analysis of a representative road rehabilitation model, taken from a high altitude montane environment in the Southwestern Region of Uganda. The investment package is computed by comparing total benefits accruing to an improved road with total costs of road rehabilitation and assumed maintenance regimes (routine and periodic). This methodology is then utilized to analyse all the shortlisted roads submitted by each district. Those producing less than 12% economic rate of return are eliminated from the investment basket. The qualifying roads are then ranked according to their net present value-investment ratios and the investment package for each district is determined by the a pre-determined allocated length of roads for rehabilitation. The roads are included in descending order of their NPV/K until the threshold for that district is attained.

This methodology has demonstrated that while the VOC method as applied to highways (with large traffic volumes), or the combination of VOC and TTC may not generate sufficient roads producing a rate of return over 12% due to their reliance on traffic volume, the inclusion of a more important factor – the costs savings from producer surplus transportation - will allow a majority of the roads to be analysed and included.

It is important to note that this analysis has been possible because, in the case of Uganda, there is a good database, without which there could be some difficulties. The active participation of the beneficiaries both in the pre-screening and in the provision of the data requirement is an important factor for the successful application of the methodology. Nonetheless, this methodology has been found useful and quite simplified and can easily be adapted by Project Economists in the economic analysis and prioritization of rural feeder roads to be included for rehabilitation under capital rationing. This approach is quite practical and can be institutionalised. Where the database is poor, the understanding of the methodology can also encourage the development economists to begin to build up the necessary data requirement. It is important to note, however, that this methodology is not

[14] Where K is the initial capital investment.

required in justifying the project or programme as a whole, as that can be done by aggregating the total project/programme incremental benefits against the corresponding incremental costs. It is nonetheless, imperative, as earlier stated, when you have to make a choice and prioritize the array of feeder roads for rehabilitation.

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ANNEX 1:

GENERAL DATA REQUIRED FOR THE FEEDER ROAD MODEL COST-BENEFIT ANALYSIS

These data are required for each road to be rehabilitated.

1. Name of Road
2. Initial Estimate of Road Rehabilitation Cost per km
3. Length of Road (km)
4. Maintenance Cost/km/yr perkm
5. Area served by Road (Zone of Road influence – ha) under production
6. Number of Agricultural Households (No.)
7. Types of major Crops Grown – With Project/Without Project; % grown per crop
8. Average journey to Local Market (km)
9. Yield/ha/year (per crop) – With Project/Without Project
10. Total Produce Hauled - aggregate in tons (5 x 9) (Assume 100% less wastage, if cash crop and x% if food crop)/Without Project
11. Total Tonskm of Transport (10 x 8)/Without Project

Transport Costs (Cost of transporting I ton of produce to market)

12. Cost Bicycle (Without Project)
13. Bicycle (With Project – 50% Volume by System Assumed)
14. Average Cost Bicycle With Project
15. Savings per tonkm (12 -14)
16. Annual Savings (11x 15)

Other Costs

1. Periodic Maintenance Costs after every 5 years
2. Others – to decide as appropriate

Note that not all the data collected here may be used in the analysis but could be retained as control.

ANNEX 2:

DESIGN CHARACTERISTICS FOR REHABILITATION OF FEEDER ROADS[15]

The design of rural feeder roads should generally have the following characteristics:

1. Follow existing alignments to minimise costs and to avoid new negative environmental effects.

2. Where the terrain permits, and where justified by anticipated traffic volumes, the carriageway width should be minimal 4.0m with 1.0m shoulders on either side.

3. 1.0m wide "v" or trapezoidal drains, minimal 0.3m deep, leading to mitre drains (subject to additional requirements being dictated by the environmental impact assessment).

4. Drains to be provided with scour checks to reduce water velocities and to control erosion.

5. Gravelling will be done only on the carriageway to a compacted depth of 120mm thickness (the depth will depend on the class of road in question, with 100mm being a norm for Class II and Class III district roads). Compaction should be done mechanically up to at least 95% of the Maximum Dry density (MDD-AASHTO).

6. Depending on site circumstances, the surface will be scarified for good bonding before (re-)surfacing is carried out.

7. Camber would be maintained at 5% to 8% on all roads.

8. The right of way would be limited to 15m from centre of road.

9. Existing gradients would generally be maintained consistent with safe use and environmental considerations. Consideration could be given to limiting gradients to 12% provided this could be achieved within the per km cost ceiling.

10. Drainage structures such as pipe culverts, box culverts and small bridges would be installed in locations where there is need for cross drainage.

11. Embankment fills at swampy road sections are to be raised to a minimum height of 600mm above highest observed/recorded flood level.

12. Borrow pits will be restored (landscaped) after use with top soil spread and grass planted. Pits should have drainage or filled to drain off to avoid stagnant water.

[15] As established by the Uganda MOWHC.

Annex 3: Spreadsheet CBA Analysis

				UGANDA: AREA-BASED AGRICULTURAL MODERNISATION PROGRAMME				
				FEEDER ROAD ANALYSIS AND PRIORITIZATION				
A. ROAD BASIC DATA								
REGION:			SOUTHWESTERN UGANDA					
DISTRICT NAME:			MODEL DISTRICT					
ROAD NAME:			MODEL ROAD					
ROAD CODE:			MODEL CODE					
SUB-COUNTIES COVERED:			HIGH ALTITUDE MONTANE AREA					
POPULATION SERVED:			-					
ROAD LENGTH (KM):							10	
ANNUAL TRAFFIC GROWTH RATE:							0.05	
STANDARD CONVERSION FACTOR:							0.9	
AREA UNDER ROAD ZONE OF INFLUENCE (Ha)							2400	
TOTAL CAPITAL COST OF REHABILITATION BASE YEAR PLUS 10% PHYSICAL CONTINGENCY (USH'000):							FINANCIAL	ECONOMIC
							247,500	222,750
DAILY WAGE RATE/SHADOW WAGE RATE:							2,000	900
B. VEHICLE OPERATING COSTS (VOC) SAVINGS (ECONOMIC)								
							ANNUAL BASE	
			VOC/KM	VOC/KM	VOC	DAILY VOC	YEAR BENEFITS	
TYPE OF VEHICLE	ADT	ROAD LENGTH	BAD ROAD	GOOD ROAD	SAVINGS/KM	SAVINGS	(USH '000)	
							312	
CAR	4	10	283	133	150	6,000	1,872	
PICK-UP	8	10	398	182	216	17,280	5,391	
4X4	2	10	362	179	183	3,660	1,142	
MINI-BUS	2	10	388	186	202	4,040	1,260	
TRUCK	2	10	847	406	441	8,820	2,752	
TOTAL ANNUAL BASE YEAR COST SAVINGS (312 DAYS/YR)							**12,418**	
C. USER ROAD TRAVEL TIME COST (TTC) SAVINGS (ECONOMIC)								
								VALUE OF ANNUAL BASE YEAR
				SPEED	SPPED		TOTAL DAILY	BASE YEAR
			AVERAGE	BAD ROAD	GOOD ROAD	TTC SAVINGS	TTC SAVINGS	TTC SAVINGS
TYPE OF VEHICLE	ADT	ROAD LENGTH X2	VEH. OCCUPANCY	MIN/KM	MIN/KM	MIN/KM	(MIN)	(USH. '000)
CAR	4	20	4	3	1	2	640	337
PICK-UP	8	20	3	3	1	2	960	505
4X4	2	20	4	3	1	2	320	168
MINI-BUS	2	20	15	3	1	2	1200	632
TRUCK	2	20	4	3	1	2	320	168
	18	TOTAL ANNUAL BASE YEAR COST SAVINGS (312 DAYS/YR)						**1,811**

D. PRODUCER SUPPLUS TRANSPORT COST (PSTC) SAVINGS: NON MOTORIZED VEHICLE (BICYCLE) ECONOMIC									
	50% OF SUPPLUS PRODUCE CARRIED BY BICYCLE WITH PROJECT (100% WITHOUT PROJECT)						30% OF ARABLE LAND UNDER CULTIVATION		
	YIELD	TOTAL	HECTERAGE	TOTAL	LOSS IN	SYSTEM VOL	COST OF	COST OF	PSTC
MAJOR CROPS	TON/HA	HECTERAGE	UNDER EACH CROP	PRODUCE	CONSUMER	HAULED	TRANSPORT	TRANSPORT	SAVINGS/TON
ALL CROPS		2,400	70%	(TON)	SUPPLUS (%)	(TON)	BAD ROAD/TON	GOOD ROAD/TON	USH. '000
BEANS	1.5	30%	504	756	50%	378	18,000	9,000	9.0
BANANA	13	15%	252	3,276	30%	2293	18,000	9,000	9.0
MAIZE	3	10%	168	504	40%	302	18,000	9,000	9.0
IRISH POTATO	16	45%	756	12,096	50%	6048	18,000	9,000	9.0
			1,680	**16,632**		**9,022**		TOTAL ANNUAL PSTC SAVINGS	
E. ECONIMIC ANALYSIS OF DISTRICT PRIORITIZED ROADS									
			(USH. '000)						
YEAR	CAPITAL	ROUTINE MAINT.	PERIODIC	TOTAL	VOC	TTC	PSTC	TOTAL	NET
	COSTS	COSTS	MAINT. COSTS	COSTS	SAVINGS	SAVINGS	SAVINGS	BENEFITS	BENEFITS
		0.02	0.25						
1	222,750			222,750	0	0	0	0	-222,750
2		4,455		4,455	12,418	1,811	81,194	95,423	90,968
3		6,683		6,683	13,038	1902	81,194	96,135	89,452
4		8,910		8,910	13,690	1997	81,194	96,882	87,972
5		11,138		11,138	14,375	2097	81,194	97,666	86,528
6		-	55,688	55,688	15,094	2201	81,194	98,490	42,802
7		4,455		4,455	15,094	2201	81,194	98,490	94,035
8		6,683		6,683	15,094	2201	81,194	98,490	91,807
9		8,910		8,910	15,094	2201	81,194	98,490	89,580
10		11,138		11,138	15,094	2201	81,194	98,490	87,352
11		-	55,688	55,688	15,094	2201	81,194	98,490	42,802
12		4,455		4,455	15,094	2201	81,194	98,490	94,035
13		6,683		6,683	15,094	2201	81,194	98,490	91,807
14		8,910		8,910	15,094	2201	81,194	98,490	89,580
15		11,138		11,138	15,094	2201	81,194	98,490	87,352
16		-	55,688	55,688	15,094	2201	81,194	98,490	42,802
17		4,455		4,455	15,094	2201	81,194	98,490	94,035
18		6,683		6,683	15,094	2201	81,194	98,490	91,807
19		8,910		8,910	15,094	2201	81,194	98,490	89,580
20		11,138		11,138	15,094	2201	81,194	98,490	87,352
						ERR	**38%**		
						NPV	**347,882**		
						NPV/K	**1.56**		

Anex 4: Uganda AAMP: Model Road EIRR and Sensitivity Calculations

(USH'000)

Sensitivity of EIRR to changes in costs and benefits:

benefits:	base case	- 1 year	- 2 years	- 10%	- 20%
base case :	38.2%	28.0%	22.4%	33.7%	29.0%
costs + 10%	34.1%	25.4%	20.4%	29.9%	25.6%
costs + 20%	30.6%	23.0%	18.6%	26.7%	22.7%
costs + 40%	25.0%	19.2%	15.5%	21.5%	18.0%

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
total economic costs	222,750.0	4,455.0	6,683.0	8,910.0	11,138.0	55,688.0	4,455.0	6,683.0	8,910.0	11,138.0	55,688.0	4,455.0	6,683.0	8,910.0	11,138.0	55,688.0	4,455.0	6,683.0	8,910.0	11,138.0
total economic benefits	0.0	95,423.0	96,135.0	96,882.0	97,666.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0
costs + 10%	245,025.0	4,900.5	7,351.3	9,801.0	12,251.8	61,256.8	4,900.5	7,351.3	9,801.0	12,251.8	61,256.8	4,900.5	7,351.3	9,801.0	12,251.8	61,256.8	4,900.5	7,351.3	9,801.0	12,251.8
costs + 20%	267,300.0	5,346.0	8,019.6	10,692.0	13,365.6	66,825.6	5,346.0	8,019.6	10,692.0	13,365.6	66,825.6	5,346.0	8,019.6	10,692.0	13,365.6	66,825.6	5,346.0	8,019.6	10,692.0	13,365.6
costs + 40%	311,850.0	6,237.0	9,356.2	12,474.0	15,593.2	77,963.2	6,237.0	9,356.2	12,474.0	15,593.2	77,963.2	6,237.0	9,356.2	12,474.0	15,593.2	77,963.2	6,237.0	9,356.2	12,474.0	15,593.2
benefits delayed 1 year	0	0.0	95,423.0	96,135.0	96,882.0	97,666.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0
benefits delayed 2 years	0.0	0.0	0.0	95,423.0	96,135.0	96,882.0	97,666.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0	98,490.0
benefits -10%	0.0	85,880.7	86,521.5	87,193.8	87,899.4	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0	88,641.0
benefits -20%	0.0	76,338.4	76,908.0	77,505.6	78,132.8	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0	78,792.0
net streams:																				
base/base	-222,750.0	90,968.0	89,452.0	87,972.0	86,528.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0
base costs/delay 1 year	-222,750.0	-4,455.0	88,740.0	87,225.0	85,744.0	41,978.0	94,035.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0
base costs/delay 2 yrs.	-222,750.0	-4,455.0	-6,683.0	86,513.0	84,997.0	41,194.0	93,211.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0	42,802.0	94,035.0	91,807.0	89,580.0	87,352.0
base costs/benef. -10%	-222,750.0	81,425.7	79,838.5	78,283.8	76,761.4	32,953.0	84,186.0	81,958.0	79,731.0	77,503.0	32,953.0	84,186.0	81,958.0	79,731.0	77,503.0	32,953.0	84,186.0	81,958.0	79,731.0	77,503.0
base costs/benef. -20%	-222,750.0	71,883.4	70,225.0	68,595.6	66,994.8	23,104.0	74,337.0	72,109.0	69,882.0	67,654.0	23,104.0	74,337.0	72,109.0	69,882.0	67,654.0	23,104.0	74,337.0	72,109.0	69,882.0	67,654.0
costs+ 10%/base benef.	-245,025.0	90,522.5	88,783.7	87,081.0	85,414.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2
costs+ 10%/delay 1 year	-245,025.0	-4,900.5	88,071.7	86,334.0	84,630.2	36,409.2	93,589.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2
costs+ 10%/delay 2 yrs.	-245,025.0	-4,900.5	-7,351.3	85,622.0	83,883.2	35,625.2	92,765.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2	37,233.2	93,589.5	91,138.7	88,689.0	86,238.2
costs+10%/benef. -10%	-245,025.0	80,980.2	79,170.2	77,392.8	75,647.6	27,384.2	83,740.5	81,289.7	78,840.0	76,389.2	27,384.2	83,740.5	81,289.7	78,840.0	76,389.2	27,384.2	83,740.5	81,289.7	78,840.0	76,389.2
costs+10%/benef. -20%	-245,025.0	71,437.9	69,556.7	67,704.6	65,881.0	17,535.2	73,891.5	71,440.7	68,991.0	66,540.2	17,535.2	73,891.5	71,440.7	68,991.0	66,540.2	17,535.2	73,891.5	71,440.7	68,991.0	66,540.2
costs+20%/base benef.	-267,300.0	90,077.0	88,115.4	86,190.0	84,300.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4
costs+ 20%/delay 1 year	-267,300.0	-5,346.0	87,403.4	85,443.0	83,516.4	30,840.4	93,144.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4
costs+ 20%/delay 2 yrs.	-267,300.0	-5,346.0	-8,019.6	84,731.0	82,769.4	30,056.4	92,320.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4	31,664.4	93,144.0	90,470.4	87,798.0	85,124.4
costs+20%/benef. -10%	-267,300.0	80,534.7	78,501.9	76,501.8	74,533.8	21,815.4	83,295.0	80,621.4	77,949.0	75,275.4	21,815.4	83,295.0	80,621.4	77,949.0	75,275.4	21,815.4	83,295.0	80,621.4	77,949.0	75,275.4
costs+20%/benef. -20%	-267,300.0	70,992.4	68,888.4	66,813.6	64,767.2	11,966.4	73,446.0	70,772.4	68,100.0	65,426.4	11,966.4	73,446.0	70,772.4	68,100.0	65,426.4	11,966.4	73,446.0	70,772.4	68,100.0	65,426.4
costs+40%/base benef.	-311,850.0	89,186.0	86,778.8	84,408.0	82,072.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8
costs+ 40%/delay 1 year	-311,850.0	-6,237.0	86,066.8	83,661.0	81,288.8	19,702.8	92,253.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8
costs+ 40%/delay 2 yrs.	-311,850.0	-6,237.0	-9,356.2	82,949.0	80,541.8	18,918.8	91,429.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8	20,526.8	92,253.0	89,133.8	86,016.0	82,896.8
costs+40%/benef. -10%	-311,850.0	79,643.7	77,165.3	74,719.8	72,306.2	10,677.8	82,404.0	79,284.8	76,167.0	73,047.8	10,677.8	82,404.0	79,284.8	76,167.0	73,047.8	10,677.8	82,404.0	79,284.8	76,167.0	73,047.8
costs+40%/benef. -20%	-311,850.0	70,101.4	67,551.8	65,031.6	62,539.6	828.8	72,555.0	69,435.8	66,318.0	63,198.8	828.8	72,555.0	69,435.8	66,318.0	63,198.8	828.8	72,555.0	69,435.8	66,318.0	63,198.8

ANNEX 5:

Ranking of Priority Roads – by District

1. BUSHENYI

Rank	Link No.	Name of Road	Length (Km)	EIRR (%)	NPV (USH.'000)	NPV/K
1	438	Kanuka - Butare	5	54	286,016	2.57
2	439	Bucuro - Rwankondo	6	52	329,513	2.47
3	419	Kitagata - Kasara - Kyarwera	20	50	1,019,654	2.30
4	427	Kakanju - Katunga - Kashasha	7	50	359,338	2.30
5	437	Rutoto - Ndangaro	8	48	388,500	2.18
6	411	Mitooma - Kabira	10	47	475,660	2.14
7	429	Kamurinda - Ryanmasya	13	45	568,366	1.96
Total Kilometres			69			

2. KABALE

Rank	Link No.	Name of Road	Length (KM)	EIRR (%)	NPV (USH.'000)	NPV/K
1	9..?	Rugoma – Mucogo – Butambi	14	41	535,964	1.72
2	9..?	Muko – Kaara	7	33	189,352	1.21
3	937	Nfasha – Nyamiryango	15	24	221,947	0.66
4	912	Kabanyonyi – Kawereu – Maziba	16	15	59,152	0.17
5	927	Nyarutojo –Kitanga – Buhara	14	14	34,933	0.11
Total Length			66			

3. KABAROLE

Rank	Link No.	Name of Road	Length (KM)	EIRR (%)	NPV (USH.'000)	NPV/K
1	1042	Nyabukara – Harugongo	7.1	41	275,515	1.74
2	1015	Butebe – Mugusu	10.0	38	348,652	1.57
3	1046	Rwimi – Kasenda	12.5	37	411,701	1.48
4	1002	Nyarukoma – Kyakatwira	24.0	34	701,728	1.31
5	1013	Butiti – Nyantungo	26.0	34	752,167	1.30
Total Length			79.6			

4. KISORO

Rank	Link No.	Name of Road	Length (KM)	EIRR (%)	NPV (USH.'000)	NPV/K
1	1811	Kamonyi – Giseke – Nyakinama	13	36	410,322	1.42
2	1822	Mwaro – Busengo – Kinanira	18	29	400,447	1.00
3	1829	Nyarusiza – Rurembwe – Chanika	10	23	135,165	0.62
4	1815	Gisorora – Mbonjero – Matinza	9.2	21	99,558	0.49
5	1807	Mushungero – Rutaka – Mupaka	25	19	205,957	0.37
Total Length			75.2			

5. MBARARA

Rank	Link No.	Name: From – To	Length (km)	EIRR (%)	NPV (USH.'000)	NPV/K
1	2760	Nyakigera - Omukatoma	15	49	752,022	2.25
2	2749	Nyamukana - Byanamira	30	47	1,409,247	2.11
3	2722	Ruhamba - Bwengure	10	42	406,551	1.83
4	2709	Kaberebere - Kyamiyonga	22	39	657,968	1.60
Total Length			77			

6. NTUNGAMO

Rank	Link No.	Name: From – To	Length (km)	EIRR (%)	NPV (USH.'000)	NPV/K
1	3957	Rwentobo – Kaina – Rubaare	13.7	41	530,431	1.74
2	3901	Butare – Buraro	9.5	36	300,948	1.42
3	3954	Kacerere – Katungamo – Kyempene	14.0	32	355,165	1.14
4	3925	Kagarama – Rukarango – Rwamabondo	14.3	19	126,936	0.40
5	3965	Nombe – Rwemengo – Nyabihoko	16.0	18	107,089	0.30
Total Length			67.5			

7. SEMBABULE

Rank	Link No.	Name: From – To	Length (km)	EIRR (%)	NPV (USH.'000)	NPV/K
1	2440	Mitete – Kyebongotoko	21	54	1,231,519	2.63
3	2420	Bituntu – Kikoma	12	40	455,134	1.70
2	2442	Lwebitakuli – Kitoro	10	42	402,417	1.81
4	2427	Lwemiyago – Nabitanga	14	38	482,532	1.55
5	2443	Lwebitakuli – Kisindi - Katwe	14	35	428,026	1.37
Total Length			71			

8. RUKUNGIRI

Rank	Link No.	Name: From – To	Length (km)	EIRR (%)	NPV (USH.'000)	NPV/K
1	3614	Kebisoni – Mabanga – Kihanga	14.3	47	672,951	2.11
2	3633	Katete – Kyeiyanga	13	35	396,666	1.36
3	3622	Kihihi – Ishasha Junction	10	32	259,283	1.16
4	3610	Bigongozo – Kerere	16	30	381,278	1.07
5	3620	Rwerere – Bugangar	16	30	370,315	1.04
Total Length			69.3			

UN-PRIORITIZED & UNANALYSED ROADS

9. BUNDIBUGYO 63 km
10. KASESE 63 km

TOTAL ROAD LENGTH = 700.6 KM