ROad Network Evaluation Tools (RONET)

Application of RONET in Uganda

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Presentation Structure

- Introduction;
- Model description;
- Specific RONET inputs;
- RONET Outputs;
- Benefits of RONET;
- Drawbacks;
- Conclusion.

Introduction

- RONET Ver.1 (2007) is an improvement PAM (2003);
- Development under SSATP;
- Designed to carry out strategic or macro assessments of road systems;
- Deterioration models based on HDM-4 relationships;
- World Bank RUCKS used to determine RUC;

Introduction…

- Results from the macro assessment are only indicative;
- Future enhancements to current model will include:
  - Road user charges evaluation;
  - Life-cycle economic evaluation;
  - Budget optimization and constrained analysis;
  - Network improvements evaluation.

Model Description

- A programmed Microsoft office excel 2003 workbook designed to carry out macro or strategic network analysis in order to:
  - Derive current road network statistics;
  - Derive current road network performance monitoring indicators;
  - Evaluate road network performance under different rehabilitation and maintenance standards.

Model Description…

- Inputs to the model include
  - Country name and year;
  - Land area, total population, rural population, GDP, total vehicle fleet, discount rate, traffic growth rate;
  - Capital road works unit costs.

Network Statistics

- Road lengths and utilization;
- Asset value;
- Roughness;
- Network distribution.

Monitoring Indicators

- Network density;
- Network condition;
- Network standards;
- Network utlisation;
- Network asset

Model Description…

- RUCKS model:
  - Used to derive RUC equation calibration coefficients;

"Unit Road User Costs ($/vehicle-km) = a0 + a1*IRI + a2*IRI^2 + a3*IRI^3"

  - Country specific vehicle fleet data is required e.g. vehicle prices, fuel and lubricant price, annual km driven, working hours, etc.

Specific RONET Inputs (Country Data)

Name and Year

Country Name	Uganda
Current Year	2007

Basic Characteristics

Land area (sq km)	197,097
Total population (million persons)	28.000
Rural population (million persons)	22.40
GDP ($ Billion)	8.502
Total vehicle fleet (vehicles)	278,595
Discount Rate (%)	12
Traffic Growth Rate (%)	3

Specific RONET Inputs (Road Network Management)

Management Type	Network Type	Terrain Type	Environment Type
Ministry of Works	National Roads	Hilly	Sub – humid, Sub – tropical Hot
Local Governments	District Roads		
LC3	Community Access Roads		
Urban Authorities	Urban Roads		
None	Unclassified		

Specific RONET Inputs (Unit Costs) - 1

Capital Unit Costs

Surface Type	Current Condition	Road Work	Two-Lane Unit Costs of Road Works ($/km)					Thickness (mm)	Reconstructio Structural No
			National Roads	District Roads	Community Access Roads	Unclassified	Urban Roads		
Concrete	Good Condition	Preventive Treatment	21,875	14,875	8,750	5,250	21,875		
	Fair Condition	Resurfacing (Overlay)	78,750	43,750	47,250	47,250	78,750	50	
	Poor Condition	Strengthening (Overlay)	227,500	131,250	136,500	136,500	227,500	100	
	Very Poor Condition	Reconstruction	612,500	437,500	241,500	241,500	612,500		3
	No Road	New Construction	1,050,000	700,000	367,500	367,500	1,050,000		
Asphalt Mix	Good Condition	Preventive Treatment	12,500	8,500	5,000	3,000	12,500		
	Fair Condition	Resurfacing (Overlay)	45,000	25,000	27,000	27,000	45,000	50	
	Poor Condition	Strengthening (Overlay)	130,000	75,000	78,000	78,000	130,000	100	
	Very Poor Condition	Reconstruction	350,000	250,000	138,000	138,000	350,000		3
	No Road	New Construction	600,000	400,000	210,000	210,000	600,000		
Surface Treatmeant	Good Condition	Preventive Treatment	10,000	7,500	5,000	1,000	10,000		
	Fair Condition	Resurfacing (Reseal)	25,000	25,000	15,000	15,000	25,000	12	
	Poor Condition	Strengthening (Overlay)	75,000	75,000	35,000	35,000	75,000	50	
	Very Poor Condition	Reconstruction	250,000	250,000	75,000	75,000	250,000		3
	No Road	New Construction	400,000	400,000	125,000	125,000	400,000		
Gravel	Good Condition	Spot Regravelling	5,000	5,000	2,500	625	5,000		
	Fair Condition	Regravelling	10,000	10,000	5,000	1,250	10,000	200	
	Poor Condition	Partial Reconstruction	25,000	25,000	13,000	2,500	25,000		
	Very Poor Condition	Full Reconstruction	40,000	40,000	20,000	5,000	40,000		
	No Road	New Construction	60,000	60,000	30,000	8,750	60,000		
Earth	Good Condition	Spot Repairs	1,000	500	125	125	1,000		
	Fair Condition	Heavy Grading	2,500	1,000	250	250	2,500		
	Poor Condition	Partial Reconstruction	5,000	2,500	625	625	5,000		
	Very Poor Condition	Full Reconstruction	6,500	4,500	1,125	1,125	6,500		
	No Road	New Construction	10,000	6,000	1,500	1,500	10,000		

Specific RONET Inputs (Unit Costs) - 2

Maintenance Unit Costs

Surface Type	Road Condition	Road Work	Two-Lane Unit Costs of Road Works ($/km-year)				
			National Roads	District Roads	Community Access Roads	Unclassified	Urban Roads
Concrete	Very Good	Recurrent Maintenance	1,000	750	500	500	1,000
	Good	Recurrent Maintenance	1,250	938	625	625	1,250
	Fair	Recurrent Maintenance	1,500	1,125	750	750	1,500
	Poor	Recurrent Maintenance	1,750	1,313	875	875	1,750
	Very Poor	Recurrent Maintenance	2,000	1,500	1,000	1,000	2,000
Asphalt Mix	Very Good	Recurrent Maintenance	1,875	750	500	500	1,875
	Good	Recurrent Maintenance	1,875	938	625	625	1,875
	Fair	Recurrent Maintenance	2,500	1,125	750	750	2,500
	Poor	Recurrent Maintenance	6,250	1,313	875	875	6,250
	Very Poor	Recurrent Maintenance	12,500	1,500	1,000	1,000	12,500
Surface Treatmeant	Very Good	Recurrent Maintenance	1,500	1,125	500	100	1,500
	Good	Recurrent Maintenance	1,500	1,125	625	100	1,500
	Fair	Recurrent Maintenance	2,000	1,500	750	100	2,000
	Poor	Recurrent Maintenance	5,000	3,750	875	100	5,000
	Very Poor	Recurrent Maintenance	10,000	7,500	1,000	200	10,000
Gravel	Very Good	Recurrent Maintenance	1,500	1,125	563	100	1,500
	Good	Recurrent Maintenance	1,500	1,125	563	100	1,500
	Fair	Recurrent Maintenance	3,500	2,625	1,313	100	3,500
	Poor	Recurrent Maintenance	4,500	3,375	1,688	100	4,500
	Very Poor	Recurrent Maintenance	7,500	5,625	2,813	100	7,500
Earth	Very Good	Recurrent Maintenance	150	113	50	50	150
	Good	Recurrent Maintenance	175	131	50	50	175
	Fair	Recurrent Maintenance	200	150	50	50	200
	Poor	Recurrent Maintenance	250	188	100	100	250
	Very Poor	Recurrent Maintenance	300	225	100	100	300

Specific RONET Inputs (Traffic Characteristics and levels)

			Traffic Level	T1	T2	T3	T4	T5	T6	T7	T8	T9
			Average Annual Daily Traffic (AADT)	5	20	65	200	650	2,000	6,500	20,000	65,000
Vehicle Type	Equivalent Standard Axles (ESA/vehicle)	Payload (Tons/vehicle)	Passengers (persons/vehicle)	Typical Traffic Composition (%)								
				(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Motorcycle	0.00	0.20	0.2	22.9%	22.9%	22.9%	22.9%	22.9%	22.9%	22.9%	22.9%	22.9%
Car Small	0.00	1.45	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Car Medium	0.00	1.45	2	19.4%	19.4%	19.4%	19.4%	19.4%	19.4%	19.4%	19.4%	19.4%
Delivery Vehicle	0.00	2.50	7.3	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Four-Wheel Drive	0.00	2.50	3.8	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%	6.7%
Truck Light	0.50	4.00	6.6	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Truck Medium	3.00	10.60	5.4	9.7%	9.7%	9.7%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Truck Heavy	7.00	22.60	0	0.0%	0.0%	0.0%	2.1%	2.1%	2.1%	2.1%	2.1%	2.1%
Truck Articulated	8.50	40.30	0.4	0.0%	0.0%	0.0%	4.6%	4.6%	4.6%	4.6%	4.6%	4.6%
Bus Light	0.00	2.60	13.8	22.1%	22.1%	22.1%	22.1%	22.1%	22.1%	22.1%	22.1%	22.1%
Bus Medium	0.70	4.80	30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bus Heavy	2.50	12.20	49	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%
			Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
			ESA Loading (M ESA/year)	0.001	0.002	0.008	0.049	0.160	0.491	1.597	4.913	15.967
			Payload/Vehicle (tons/vehicle)	2.74	2.74	2.74	4.36	4.36	4.36	4.36	4.36	4.36
			Passengers/Vehicle (persons/vehicle)	6.14	6.14	6.14	5.80	5.80	5.80	5.80	5.80	5.80

Specific RONET Inputs (RUC Calibration)

- The RUCKS model was used to derive the following RUC equation calibration coefficients as input to the RONET model:

Vehicle Fleet Unit Road User Costs Relationship to Roughness

	Traffic Level	T1	T2	T3	T4	T5	T6	T7	T8	T9
	Average Annual Daily Traffic (AADT)	5	20	65	200	650	2,000	6,500	20,000	65,000
Unit Road User Costs ($/veh-km) = a0 + a1*IRI + a2*IRI^2 + a3*IRI^3	a0 coefficient	0.29686	0.29686	0.29686	0.29686	0.29686	0.29686	0.29790	0.30856	0.58094
	a1 coefficient	-0.00876	-0.00876	-0.00876	-0.00876	-0.00876	-0.00876	-0.00892	-0.01066	0.00380
	a2 coefficient	0.00232	0.00232	0.00232	0.00232	0.00232	0.00232	0.00236	0.00268	0.00046
	a3 coefficient	-0.00005	-0.00005	-0.00005	-0.00005	-0.00005	-0.00005	-0.00005	-0.00006	-0.00001

Specific RONET Inputs (Road Inventory)

- Road Network Distribution;

Attribute \ Road Category	National Roads (Primary)	District Roads (Secondary)	Community Access Roads (Tertiary)	Urban Roads
Size (km)	10,820	26,751	35,000	3,579
Percentage	**14%**	**35%**	**46%**	**5%**

- Road Network Condition Distribution;

Condition \ Road Category	National Roads (Primary)	District Roads (Secondary)	Community Access Roads (Tertiary)	Urban Roads	Overall Percentage
Very Good	657			301	1%
Good	1,533			701	3%
Fair	6,688	2,809	10,000	901	27%
Poor	777	9,577	10,000	670	28%
Very Poor	1,165	14,365	15,000	1,006	41%

Specific RONET Inputs (Road Inventory)…

- Road Network Distribution by Surface Type;

Road Category / Surface Type	National Roads (Primary)	District Roads (Secondary)	Community Access Roads (Tertiary)	Urban Roads	Overall Percentage
Asphalt	89				0.12%
Surface Treatment	2,588			314	3.81%
Gravel	8,143	8,025		1,242	22.86%
Earth		18,726	35,000	2,023	73.21%

- Road Network Distribution by Traffic Levels

Road Category / Traffic Level	National Roads (Primary)	District Roads (Secondary)	Community Access Roads (Tertiary)	Urban Roads	Overall Percentage
Traffic I	584	13,108	35,000	31	64%
Traffic II	4,312	7,223		1,012	16%
Traffic III	2,917	5,484		1,977	14%
Traffic IV	2,788	936		559	6%
Traffic V	219				0.03%

Specific RONET Inputs (Standards)

- Surface Treated Roads (Capital Works);

Scenario		Roughness Range and Required Road Work				
		IRI<=4.0 Reseal	4.0<IRI<=6.0 Reseal	6.0<IRI<=8.0 Strengthening	8.0<IRI<=10.0 Reconstruction	10<IRI Reconstruction
Code	Standard Name	Time Interval (years)		Roughness Threshold (IRI)		
A	Very High Standard	7	7	6.00	8.00	10.00
B	High Standard	9	9	6.50	8.50	10.50
C	Medium Standard	11	11	7.00	9.00	11.00
D	Low Standard	13	13	7.50	9.50	11.50
E	Very Low Standard	15	15	8.00	10.00	12.00
F	Do Minimum	99	99	8.00	10.00	14.00
G	Do Nothing	99	99	8.00	10.00	25.00

Specific RONET Inputs (Standards)

- Gravel Roads (Capital Works);

Scenario		Postponement (years)	Average Yearly Roughness Level (IRI - m/km)
Code	Name		
A	Very High Standard	0	5
B	High Standard	1	7
C	Medium Standard	2	11
D	Low Standard	3	16
E	Very Low Standard	4	20
F	Do Minimum	5	22
G	Do Nothing	999	25

- Earth Roads (Capital Works): Similar but lower specification

Specific RONET Inputs (Standards)

- Recurrent Maintenance Works
  - Annual c-way and off c-way works;
  - Should reflect local practices;
  - Inputs in main model are for ‘very high standard’;
  - Lower standard interventions taken care of using ‘recurrent cost multipliers’.

Scenario		Surface Type				
Code	Name	Concrete	Asphalt	S.T.	Gravel	Earth
A	Very High Standard	1.00	1.00	1.00	1.00	1.00
B	High Standard	0.90	0.90	0.90	0.90	0.90
C	Medium Standard	0.75	0.75	0.75	0.75	0.75
D	Low Standard	0.50	0.50	0.50	0.50	0.50
E	Very Low Standard	0.25	0.25	0.25	0.25	0.25
F	Do Minimum	0.10	0.10	0.10	0.10	0.10
G	Do Nothing	0.00	0.00	0.00	0.00	0.00

Specific RONET Inputs (Custom Standard)

- Allows application of different standards to different road network categories;
- Can take into account the organization's policies, road's functional importance, funding availability for particular network, etc;
- The following 'custom standard' was applied:

Code	Network Type	Select a Standard per Network Type	
		Standard Name	Standard No.
R	National Roads	Medium Standard	3
S	District Roads	Low Standard	4
T	Community Access R	Do Minimum	6
U	Unclassified	Do Nothing	7
V	Urban Roads	Medium Standard	3

RONET Outputs (Network Monitoring)

Network Density

Monitoring Indicator	Unit	Overall
Road network per thousand land area	km/1000 sq km	386.36
Road network per thousand total population	km/1000 persons	2.720
Road network per thousand rural population	km/1000 persons	3.400
Road network per thousand vehicles	km/1000 vehicles	273.34
Road network per $ million GDP	km/million $	8.96

Network Condition

Monitoring Indicator	Unit	Overall
Percentage of road network in good and fair condition	%	31.0
Percentage of paved roads in good and fair condition	%	88.2
Paved roads average roughness weighted by km	IRI, m/km	5.23
Percentage of unpaved roads that are all-weather roads	%	25.4

Less than 1/3 of network in maintainable state.

RONET Outputs (Network Monitoring)

Network Standards

Monitoring Indicator	Unit	Overall
Percentage of unpaved roads with 300 AADT or more	%	4.5
Percentage of paved roads with 300 AADT or less	%	13.5
Percentage of paved roads with 10,000 AADT or more	%	7.3

- 4.5% of gravel road network uneconomic to maintain

Network Utilization

Monitoring Indicator	Unit	Overall
Annual motorized vehicle utilization	million vehicle-km	5,305
Annual freight carried over road network	million ton-km	22,409
Annual passengers carried over road network	million pass-km	30,919
Average network annual average daily traffic	vehicles/day	191

- 82% of total national travel takes place on national road network while 9.9% takes place on urban roads.

RONET Outputs (Network Monitoring)

Network Assets

Monitoring Indicator	Unit	Overall
Current Road asset value	million $	1,856.4
Current Road asset value as a share of maximum/replacement road asset value	%	76.0
Current Road asset value as a share of GPD	%	21.8

- Distribution of Asset Value by Road Category

National Roads	District Roads	Community Access Roads	Urban Roads
73%	15%	1%	10%

- Distribution of Asset Value by Surface Type

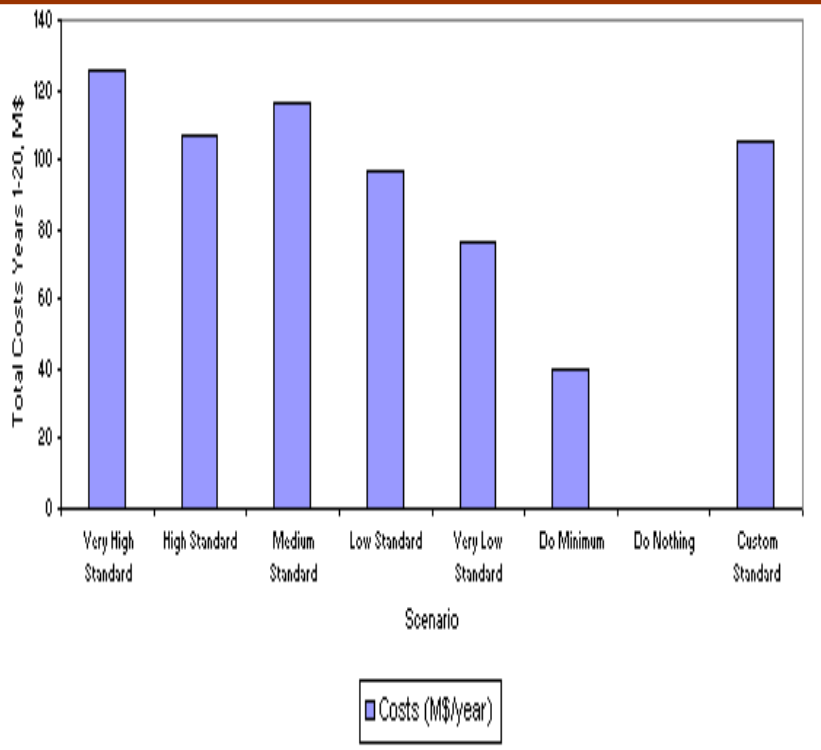
Asphalt	SurfaceTreatment	Gravel	Earth
2.6%	56.6%	36.3%	4.6%

Above info can be useful in prioritizing allocation of Road Fund revenue

RONET (Performance Assessment)

♦Road Agency Requirements

Network	Standard	Road Agency Costs (M$)	Road Agency Costs (M$/year)	Senario (%)
Total	Very High Standard	2,506	125	100%
Network	High Standard	2,133	107	85%
	Medium Standard	2,323	116	93%
	Low Standard	1,932	97	77%
	Very Low Standard	1,529	76	61%
	Do Minimum	791	40	32%
	Do Nothing	0	0	0%
	Custom Standard	2,110	105	84%

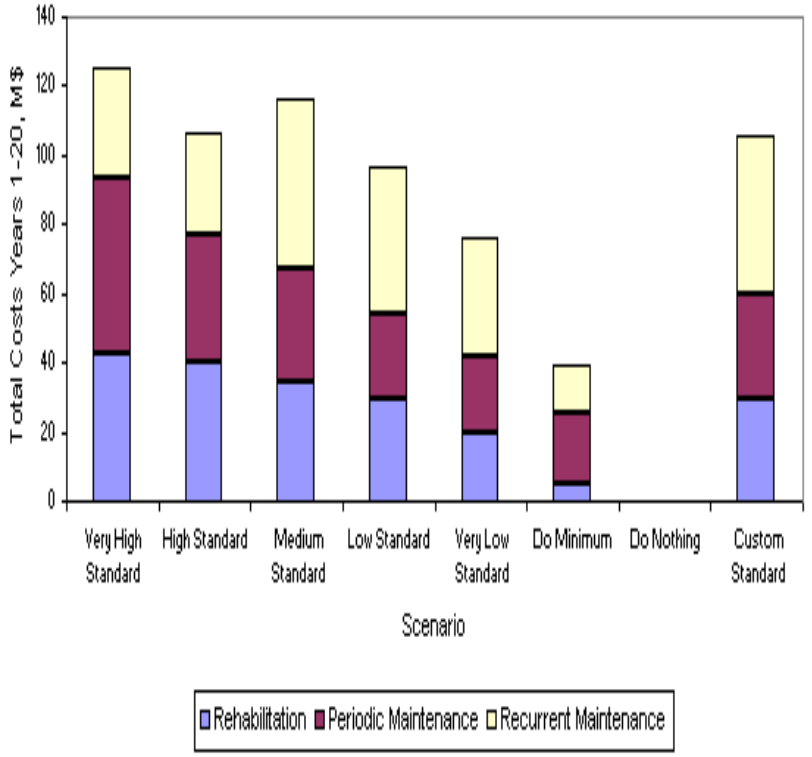


- Custom standard lies between the ‘‘Medium’’ and ‘‘Low’’ Standard wrt to the requirements for the ‘‘very high’’ standard.

RONET (Performance Assessment)

- Road Agency Requirements…

Network	Standard	Total Costs Years M$/Year				
		Rehabilitation	Periodic Maintenance	Recurrent Maintenance	**Maintenance**	**Total Road Agency Costs**
Total Network	Very High Standard	42	51	32	83	125
	High Standard	40	36	30	67	107
	Medium Standard	35	32	49	82	116
	Low Standard	29	25	42	67	97
	Very Low Standard	20	22	34	57	76
	Do Minimum	5	20	14	34	40
	Do Nothing	0	0	0	0	0
	Custom Standard	29	31	46	76	105



- The above chart shows the breakdown of the maintenance budget between periodic and recurrent expenditures.

RONET (Performance Assessment)

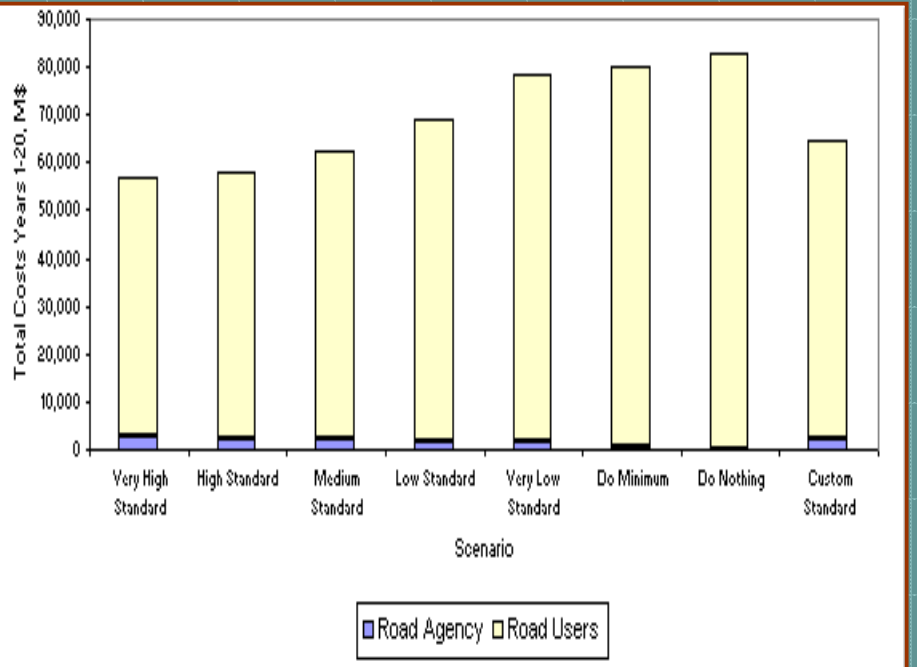
- **Road Agency Requirements….**
  - Given that current total expend on maintenance = US$ 55 mn, the previous figures show that we can only afford to implement the "Do-Minimum" – "Very Low Standard";
  - At the same time, the annual rehabilitation backlog is equivalent to US$ 20 mn;
  - As long as no additional resources are made available to respond to the maintenance and rehabilitation needs, the situation concerning poor road conditions will become more acute.

RONET (Performance Assessment)

- Consequences of various standards

Society Costs

Network	Standard	Total Costs Years 1-20, M$		
		Road Agency	Road Users	Society
Total Network	Very High Standard	2,506	54,165	56,671
	High Standard	2,133	55,860	57,993
	Medium Standard	2,323	60,284	62,607
	Low Standard	1,932	67,199	69,131
	Very Low Standard	1,529	76,697	78,226
	Do Minimum	791	79,392	80,183
	Do Nothing	0	82,907	82,907
	Custom Standard	2,110	62,450	64,560



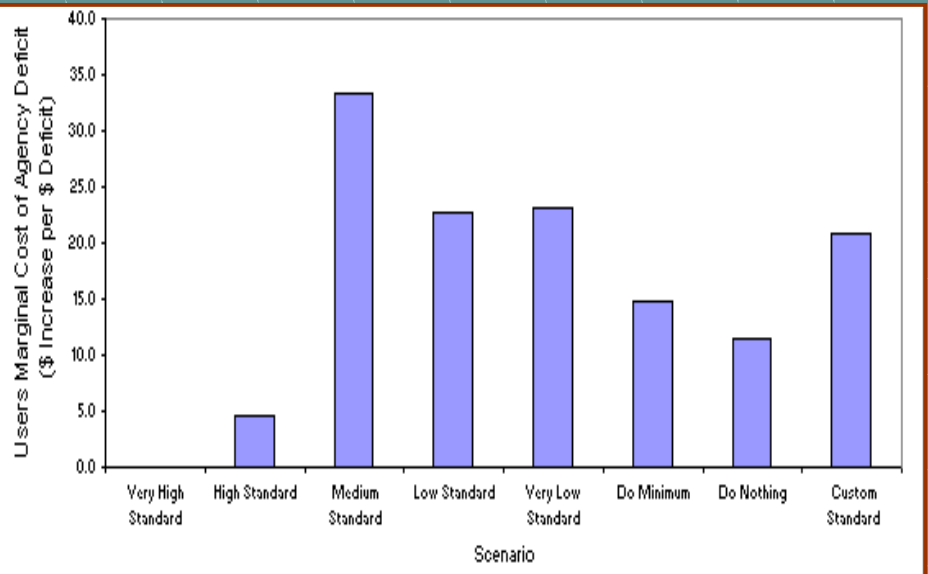
- Society Costs increase by US$ 23.8 Bn when standard is reduced from “Very High” to “Do-Minimum”.

RONET (Performance Assessment)

- Consequences of various standards…

Road User Marginal Costs

Costs Comparison with Very High Standard				
		Total Costs Years 1-20, M$		User Costs
Network	Standard Scenario	Agency Deficit	Users Costs Increase	Increase per Agency Deficit
Total Network	Very High Standard	0	0	0.00
	High Standard	373	1,695	4.54
	Medium Standard	183	6,119	33.40
	Low Standard	574	13,034	22.69
	Very Low Standard	977	22,532	23.07
	Do Minimum	1,715	25,227	14.71
	Do Nothing	2,506	28,743	11.47
	Custom Standard	396	8,285	20.90



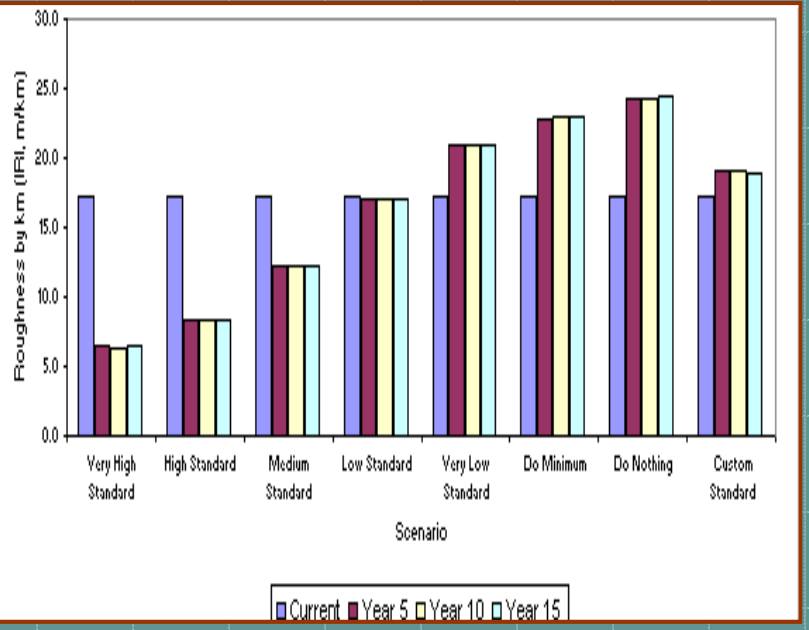
- Road Users are spending an additional US$ 14.71 – 23.07 for every US$ 1 not expended wrt to the "Very High" standard.

RONET (Performance Assessment)

- **Consequences of various standards…**

Roughness weighted by Km

Network	Standard	Roughness by Km (IRI, mm/km) Current	Year 5	Year 10	Year 15
Total Network	Very High Standard	17.2	6.4	6.4	6.4
	High Standard	17.2	8.4	8.3	8.3
	Medium Standard	17.2	12.3	12.2	12.2
	Low Standard	17.2	17.1	17.0	17.0
	Very Low Standard	17.2	20.9	21.0	21.0
	Do Minimum	17.2	22.8	22.9	22.9
	Do Nothing	17.2	24.3	24.3	24.4
	Custom Standard	17.2	19.1	19.0	19.0



- It is evident that implementing anything below the "Low" standard will result in further deterioration of the road network;
- The "custom" standard results in further deterioration of the road network but at a slower pace than the "Very Low" Standard.

Benefits of RONET

- Tool is a MS Excel spreadsheet which makes it easily usable by many people and analysis time is short;
- Provides more information to decision makers than was possible previously;
- Inputs are easily acquirable from budget reports, feasibility studies, World Bank tools, etc;
- Outputs will lend credence to budget requests by roads organizations.

Drawbacks of RONET

- The summary aggregate data required is very susceptible to errors;
- Up to date traffic and condition data for secondary and tertiary networks not usually available;
- Model does not yet carry out standards optimization;
- Impact elasticity of inputs on outputs not yet known yet crucial;
- Impacts of overloading on network needs cannot be easily modeled yet.

Conclusion

- Absence of simple analytical models has often failed road organizations in articulation the case for their needs before donors and politicians;
- RONET is an attempt at creating a simple model to address this problem;
- Model does not yet carry out standards optimization;
- Model is still under development and results so far obtained are for “beta testing” the model;
- Model development is funded by SSATP of the World Bank;
- Model development is benefiting from pilot testing in 4 African Countries i.e. Ghana, Mozambique, Tanzania and Uganda.