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Accessibility Index to Public Facilities for Prioritisation of Community Access Road Development

Fhatuwani L. Nemvumoni

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Introduction

There is a need for a socio-economic ranking tool that:

- **Quantifies** social benefits
- Includes **measurable** variables for social facilities such as educational, healthcare and law enforcement
- Identify the **influence** potential developments may have on access to these facilities
- Benefits the community directly
- Compatible to various types of areas (rural, peri-urban & urban)

Objectives

Objective:

Develop and test model of ranking road development projects, with perspective of increasing accessibility to basic public facilities.

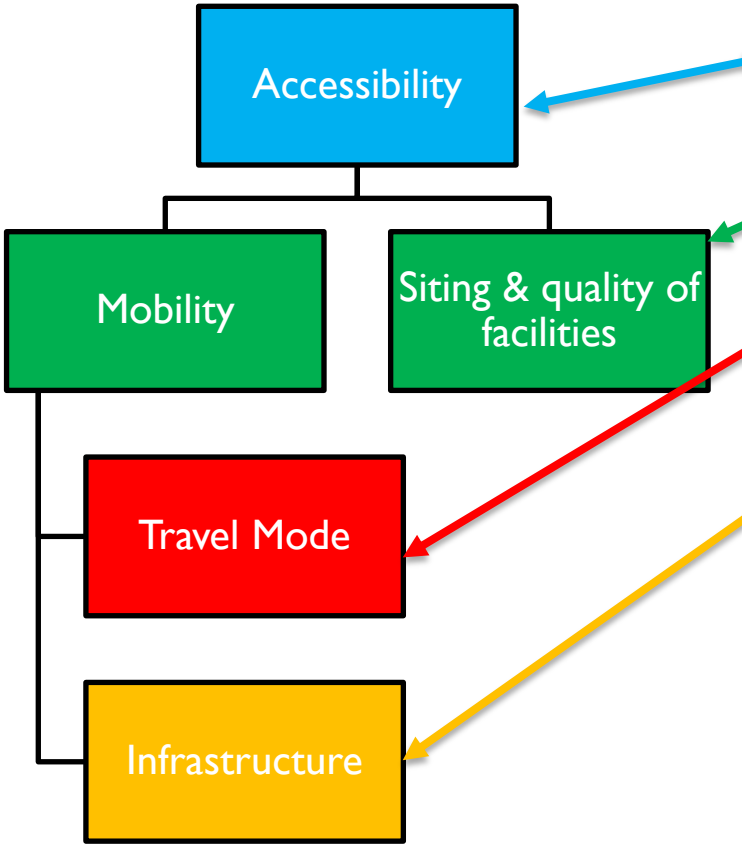
Ranking Method Must:

- Simpler data capturing method (no specialised skills or equipment)
- Method must be affordable

The model must be:

- Systematic
- Measureable
- Robust

The Model
Basic Working Model



$$AI_{ij}(k) = AI_{Q,k} \times AI_{TR,j} \times Q_{L_{i,j}}$$

Where:

$AI_{ij}(k)$ = Accessibility index of subject community to a facility k using road link i and transport mode j

$AI_{TR,j}$ = Accessibility index of community to travel mode j

$AI_{Q,k}$ = Accessibility index of community to quality service at facility k

$Q_{L_{i,j}}$ = Quality of link i using travel mode j

Figure 2.1. Components of accessibility (Hajj & Pendakur, 2000).

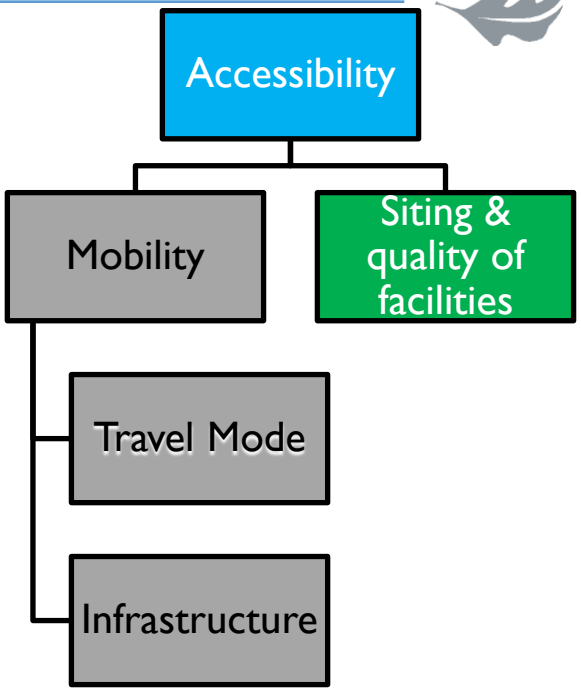
The Model
Facility quality

Facili

Public Schools

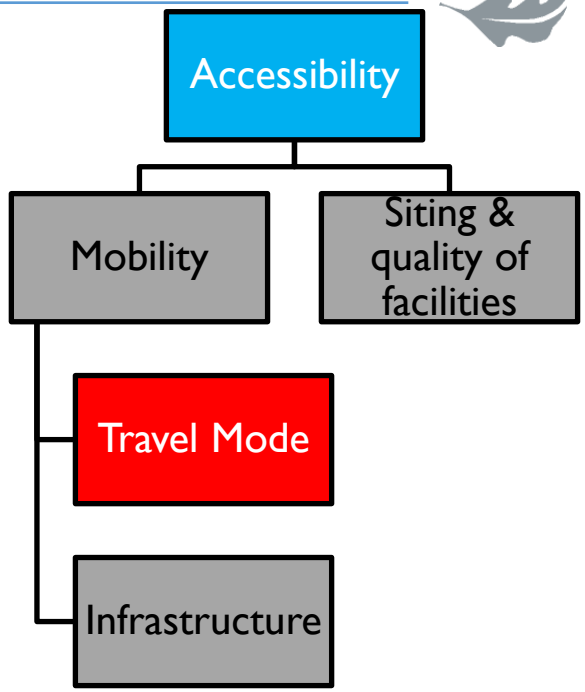
Clinics

Option 1	Doctor visitation	Waiting time	Not go
	Once a month	Less than 2 hours	
Mark selection			
Option 2	Doctor visitation	Waiting time	Not go
	Twice a week	More than 2 hours	
Mark selection			
Option 3	Doctor visitation	Waiting time	Not go
	Once a week	More than 2 hours	
Mark selection			



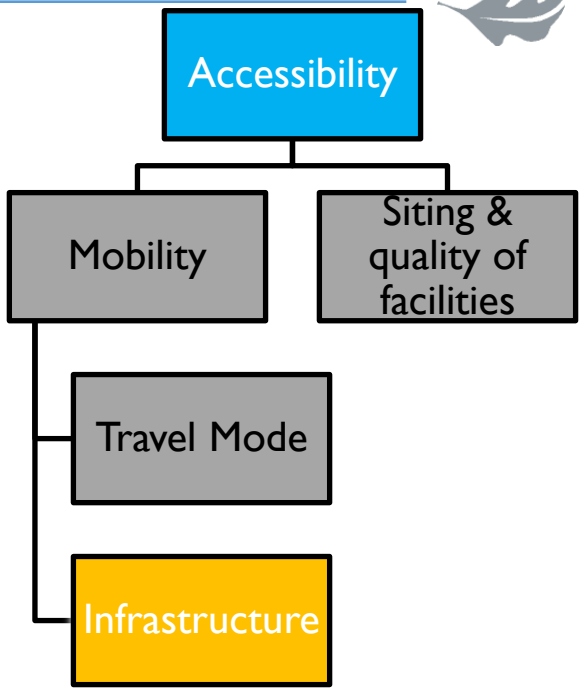
The Model
Travel mode

Attribute	Levels
Walking time	30 minutes
	1 hour
	2 hours
Public transport cost	R5
	R10
	R15



The Model
Infrastructure quality factor

Road class	Mobility Average Speed[1] (km/hr)	Recommended road widths[2] (m)			
		Existing traffic (VPD)			
		< 20	20 -50	50 - 200	> 200
R1	80 – 100	8.6			
R2	80 – 100	6		7.5	8.6
R3	60 – 80	6		7.5	8.6
R4	45 – 60	4	5	6	
R5	< 35	3	5	-	-
[1] van Zyl (2016)					
[2] Department of Transport and Public Works (2006)					



Path type	User	Traffic volume	Path width (m)
One-way footpath	Pedestrians	< 50/day	1.0
Two-way footpath	Pedestrians	> 500/day	1.2
One-way bicycle track	Bicycles	< 50/day	1.2
One-way track	Pedestrians Pack- animals	< 500/day	1.4
(I.T. Transport Ltd, 2002).			

The Model
Infrastructure quality factor

SPEED

- Functional assessment of road
- Correlation with road roughness (IRI)
- According to Sayers *et al.* (1986):

Class 4 - "*subjective ratings and uncalibrated measures*".

- Tool: handheld GPS

WIDTH

- Road safety
- Non-motorised transport modes in rural areas normally travel on the shoulder of the road
- Tool: measuring wheel

The Model
Weighted AI

$$AI_w(k) = \left(1 - AI_{ij}(k)\right) \times POPG_j(k) \times INVST_{POPG}$$

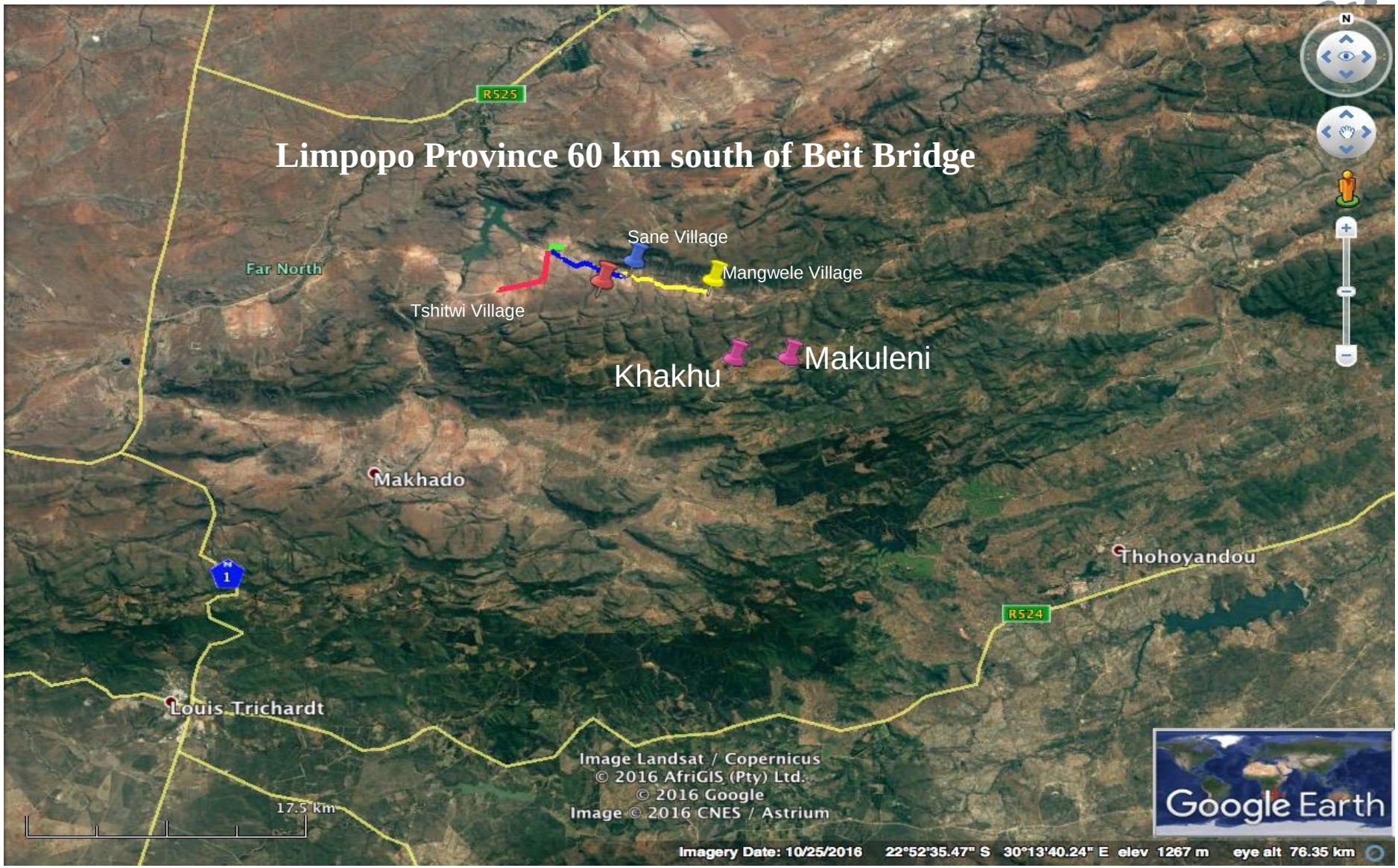
Where

$AI_w(k)$ = Weighted accessibility index in Rands
$POPG_j(k)$ = The number of persons who go to facility *k* using transport mode *j* from the subject village
$INVST_{POPG}$ = Average investment per capita made by the relevant facility, *k*, government department in the financial year

Weighted accessibility index represents that amount of investment made by government that is not being utilised efficiently

Calibration

Potential villages for model development and validation



Calibration

Model development-Education quality and transport preference

School Quality (y = *ATTEND*)		
Intercept		-0.62
Variables' Coefficients	Income group	-0.49
	Class size	-0.05
	Available text books	+6.80

Mode of transport to school (y = *USE PT*)		
Intercept		0.92
Variables' Coefficients	Students in household	-4.68
	Female students in high school	+5.19
	Female students in primary school	+4.55
	Male students in primary	+3.93
	Male students in high school	+3.60
	Income group	-0.56
	Walking time	+0.05
	Cost of public transport	-0.13

Quality characteristics

- High income decreases preference to attend the school
- Large class sizes decrease
- Availability increases preference

Transport characteristics

- Less preference to public transport with increasing number of students
- Households with more female students prefer public transport more
- Higher income decreases preference to public transport

Calibration

Model development- Healthcare quality and transport preference

Clinic Quality (y = *USE*)		
Intercept		+2.63
Variables	Frequency of doctor visits	-0.08
	Waiting time	-0.05

Mode of transport Clinic (y = USE PT)		
Intercept		-1.67
Variables	Walking time	+0.05
	PT cost	-0.13

Quality characteristics

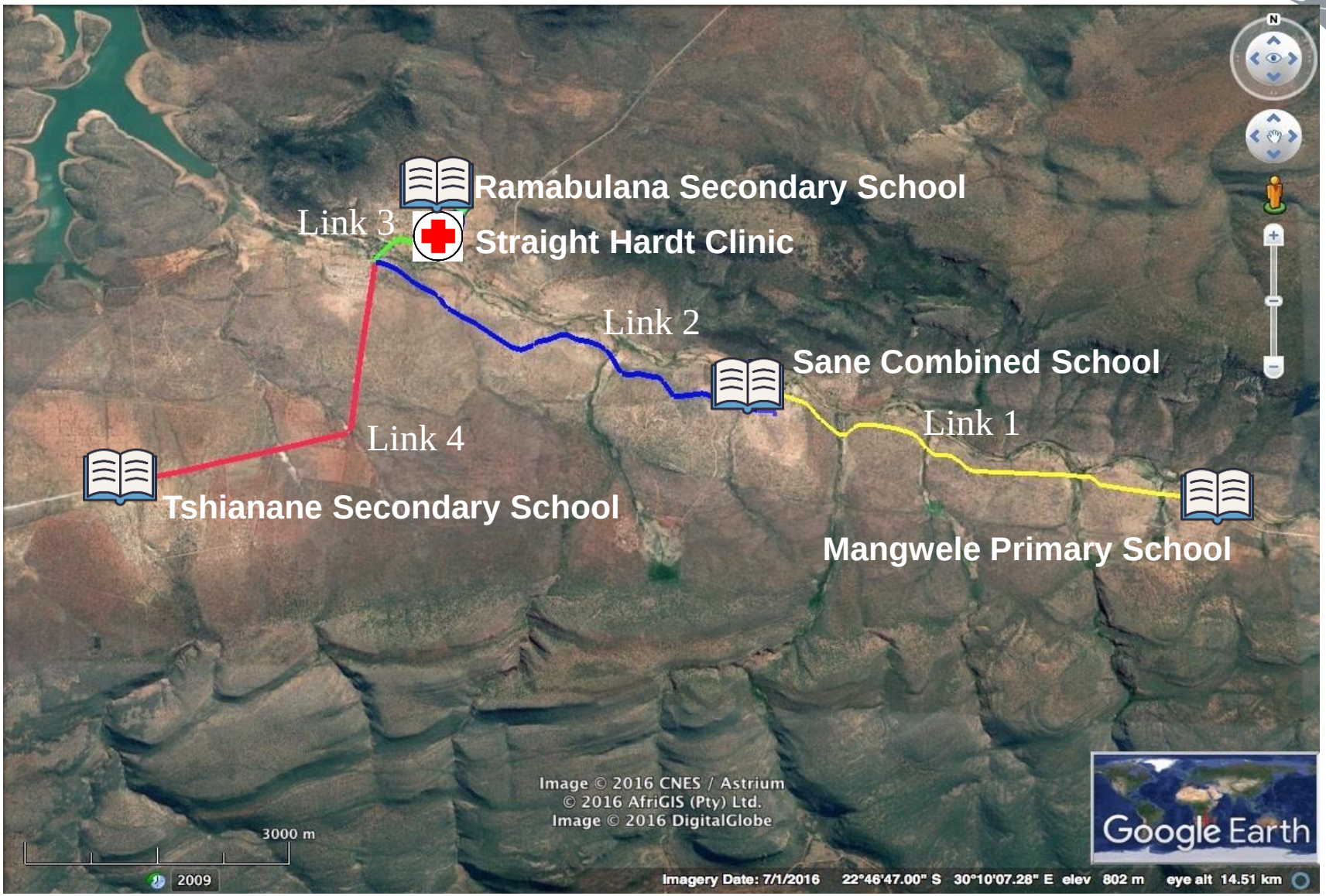
- More doctor visitations increases preference
- Long waiting times decrease preference

Transport characteristics

- Longer walking times increases preference to use PT
- High PT cost decrease preference to use PT

NEITHER PREFERENCE DEPENDS ON HOUSEHOLD CHARACTERISTICS

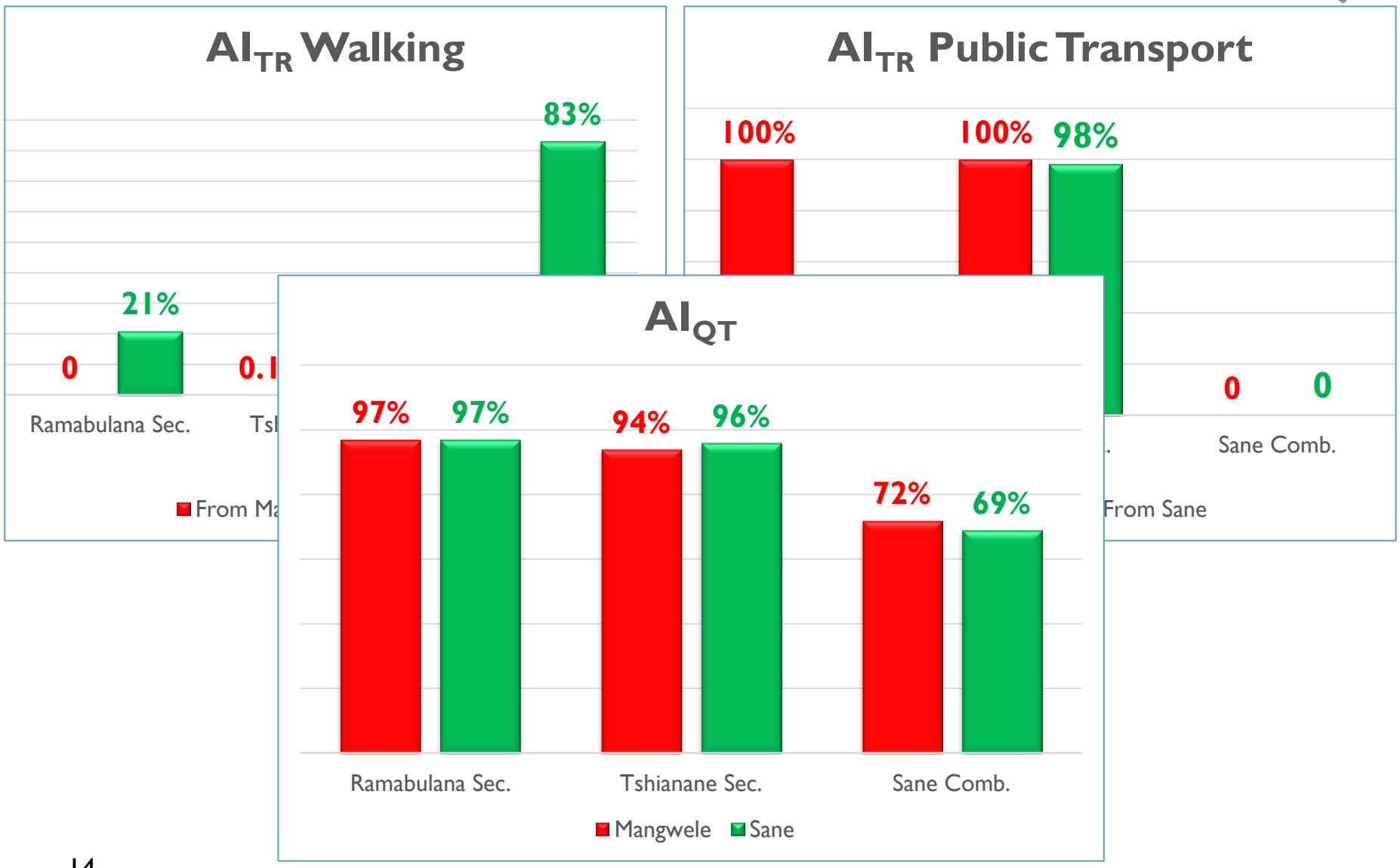
Validation
Villages, road links & facilities



Validation
Education - summary

Property	Mangwele Primary School	Ramabulana Secondary School	Tshianane Secondary School	Sane Combined School
Travel distance from Mangwele(km) (Percentage walking)	0.3 (100%)	12.86 (0%)	16.93 (20%)	6.32 (100%)
Travel distance from Sane(km) (Percentage walking)	No attendees	6.84 (100%)	10.91 (75%)	0.35 (100%)
Average class size (learners)	-	36.6	28.9	24
Average textbook availability	-	100%	85%	50%

Validation
Education - model outcomes



Validation
Healthcare - summary

Results

Model Validation – Mangwele & Sane health care survey summary

Property	Mangwele	Sane
Average household size	4.6	5.4
Clinic	Straight Hardt Clinic	Straight Hardt Clinic
Travel distance (km)	12.8	6.8
Estimated walking time (minutes)	154	82
Public transport cost	R10.58	R10.00
Average waiting time (minutes)	149	112
Straight Hardt doctor visitation frequency	3 times a week	3 times a week

Validation
Healthcare - model outcomes

Too far for walking (12.8 km)

Property	Community	
	Mangwele	Sane
AI_{TR} Public transport	99%	78%
AI_{TR} Walking	1%	22%
AI_{QT}	69%	79%

Walking distance 6.8 km

Mangwele reported longer waiting times

Validation
Road Links – Infrastructure quality

LINK 1

- Earth Road
- Average speed 30km/h
- Average width 5.5

Validation
Road Links – Infrastructure quality

LINK 2

- Mostly surfaced
- Average speed 30 km/h
- Average width 5.8 m

Validation
Road Links – Infrastructure quality

LINK 3

- Surfaced
- Average speed 27 km/h
- Average width 6 m

Validation
Road Links – Infrastructure quality

LINK 4

- Gravel
- Average speed 50 km/h
- Average width 7.5 m

Validation
Road Links – Infrastructure quality

- Handheld GPS records travelling speed at different ”legs”
- Speeds recorded in three phases
- Cumulative differences used to determine homogenous segments from the recorded legs
- Road width measured at random points of notably change

Phase	Number of legs	Average Leg length (m)	Average Leg time interval (seconds)	Maximum Leg time interval (seconds)	Minimum Leg time interval (seconds)
Phase 1	257	44.11	6	16	1
Phase 2	24	46.63	7	13	1
Phase 3	43	116.37	9	16	1

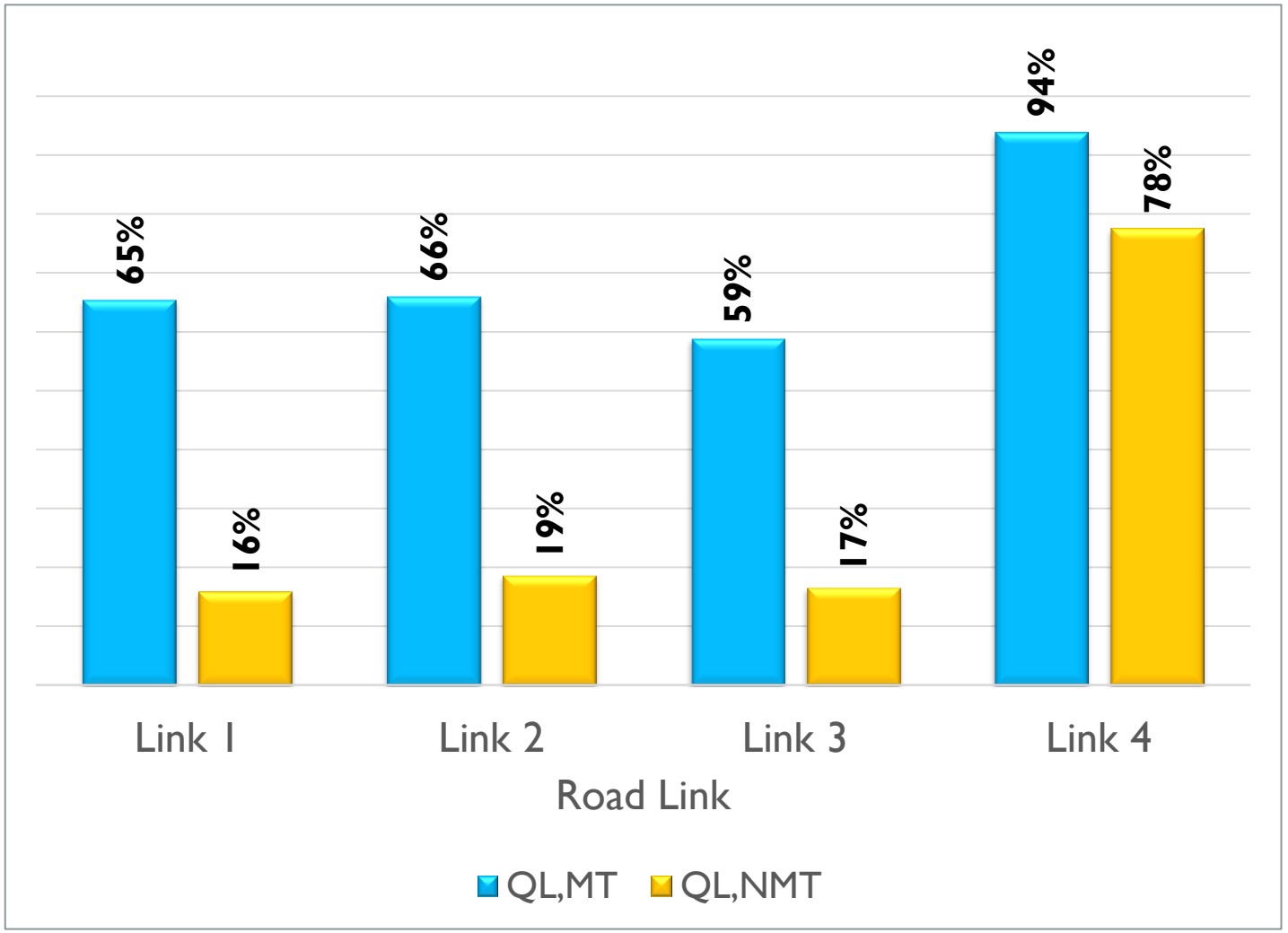
Validation
Road Links – Infrastructure quality

Validation

Road Links – Infrastructure quality

Validation

Road Links – Infrastructure quality factors



Validation
Weighted AI

Facility	2014 Budget	Investment per Capita ($INSVT_{POPG}$)
Basic education	R177 billion	R14 607.56
Public health care	R77 billion	R2 350.60

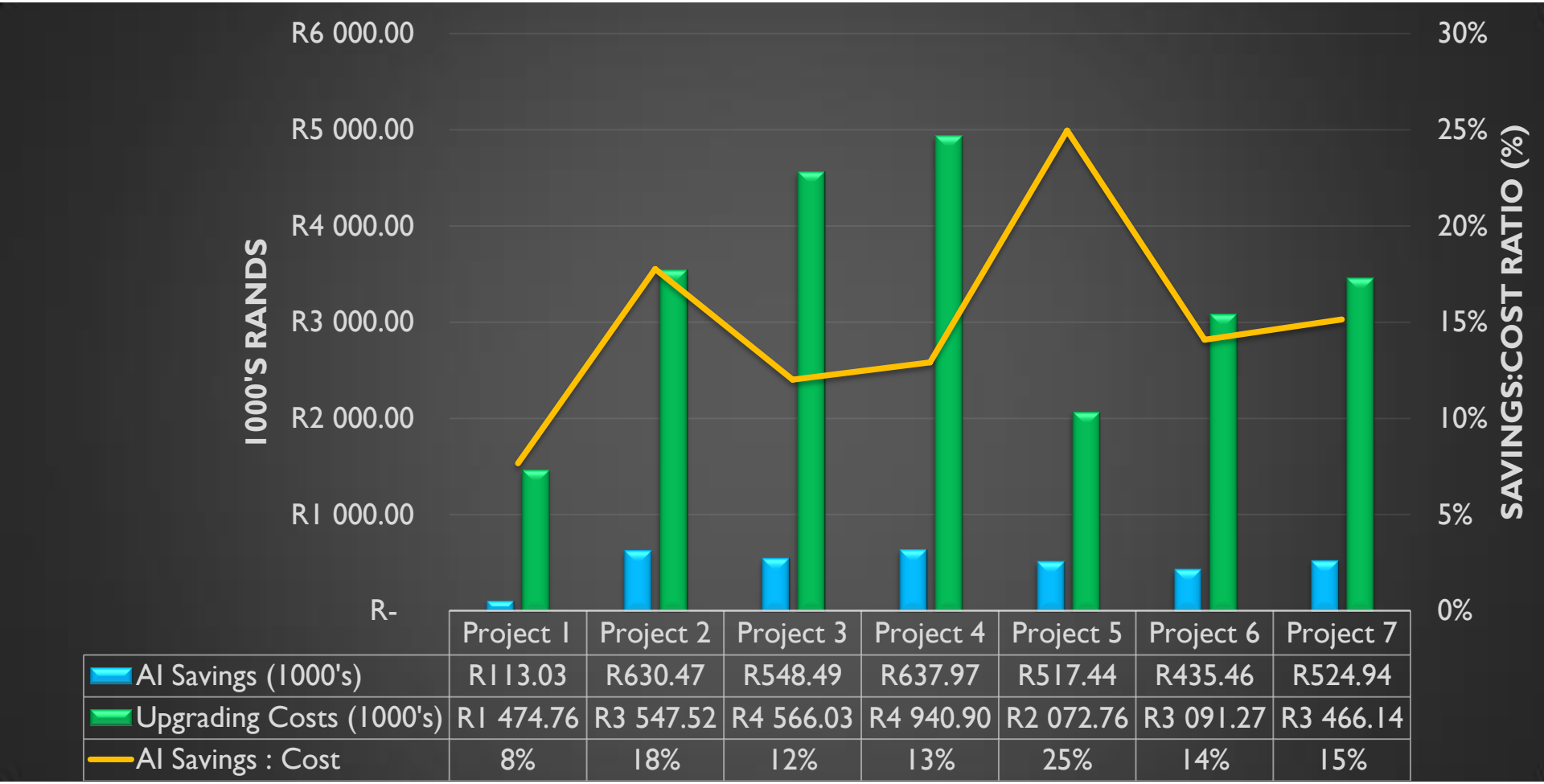
$$AI_w(k) = \left(1 - AI_{ij}(k)\right) \times POPG_j(k) \times INVST_{POPG}$$

Validation
Potential Projects

Project	Road Links	Project Length (km)	Community benefactors
Project 1	1	6.01	Mangwele
Project 2	1, 2, 3	12.46	Mangwele & Sane
Project 3	1, 2, 4	16.34	Mangwele & Sane
Project 4	1, 2, 3, 4	17.46	Mangwele & Sane
Project 5	2, 3	6.44	Mangwele & Mainly Sane
Project 6	2, 4	10.33	Mangwele & Mainly Sane
Project 7	2, 3, 4	11.45	Mangwele & Mainly Sane

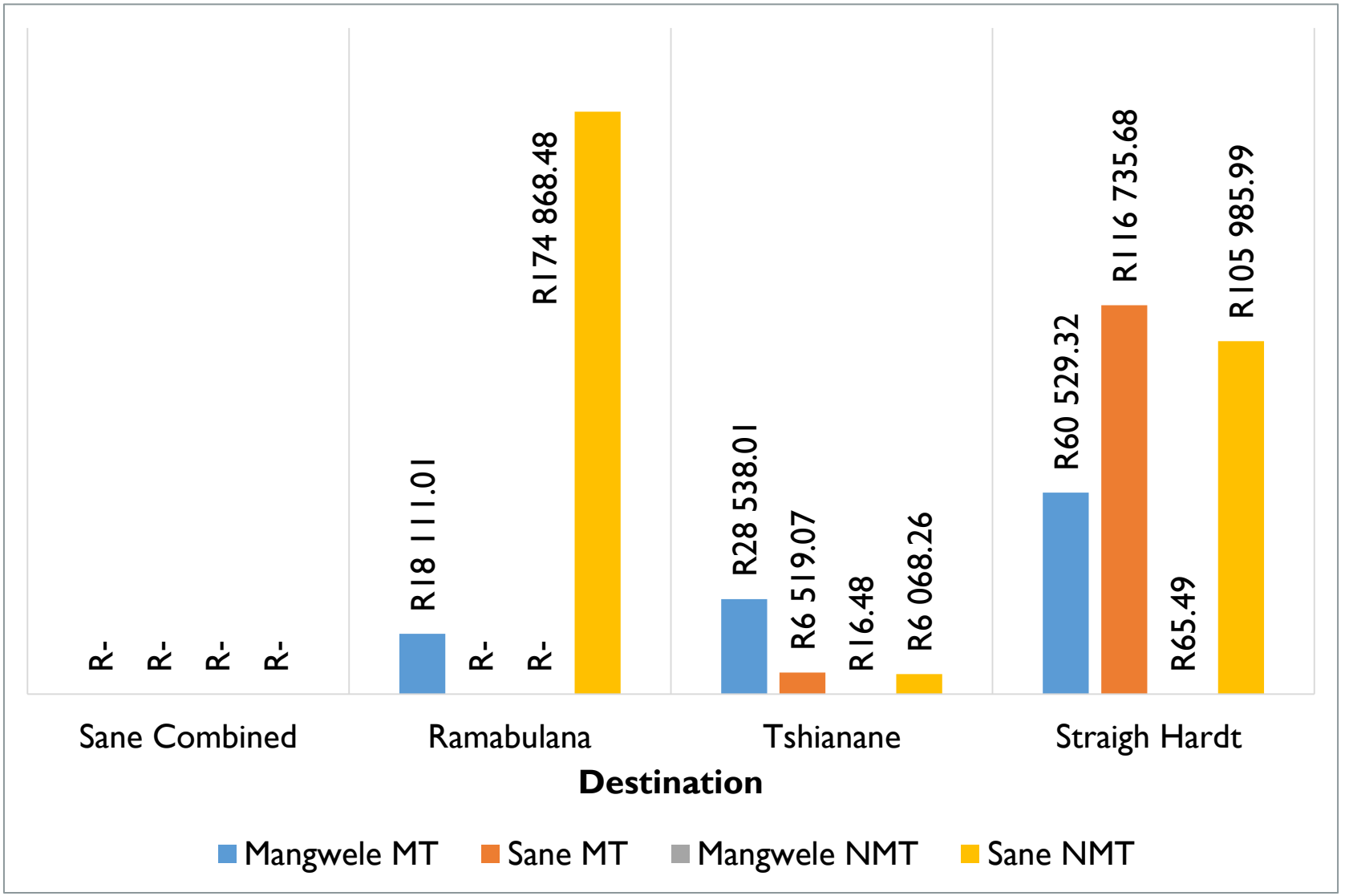
Works	Cost per m^2
Earth to gravel	R35.00
Surfacing to gravel	R50.00
Extend shoulder width (SW)	R35.00

Validation
Potential Projects Ranking

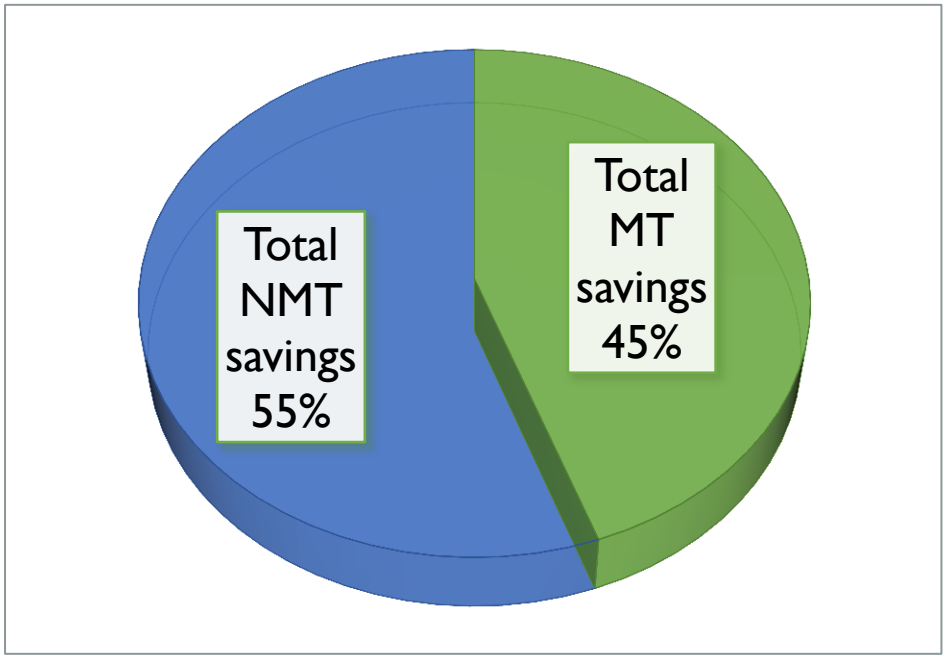


	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7
AI Savings (1000's)	R113.03	R630.47	R548.49	R637.97	R517.44	R435.46	R524.94
Upgrading Costs (1000's)	R1 474.76	R3 547.52	R4 566.03	R4 940.90	R2 072.76	R3 091.27	R3 466.14
AI Savings : Cost	8%	18%	12%	13%	25%	14%	15%

Validation
Project 5 Savings

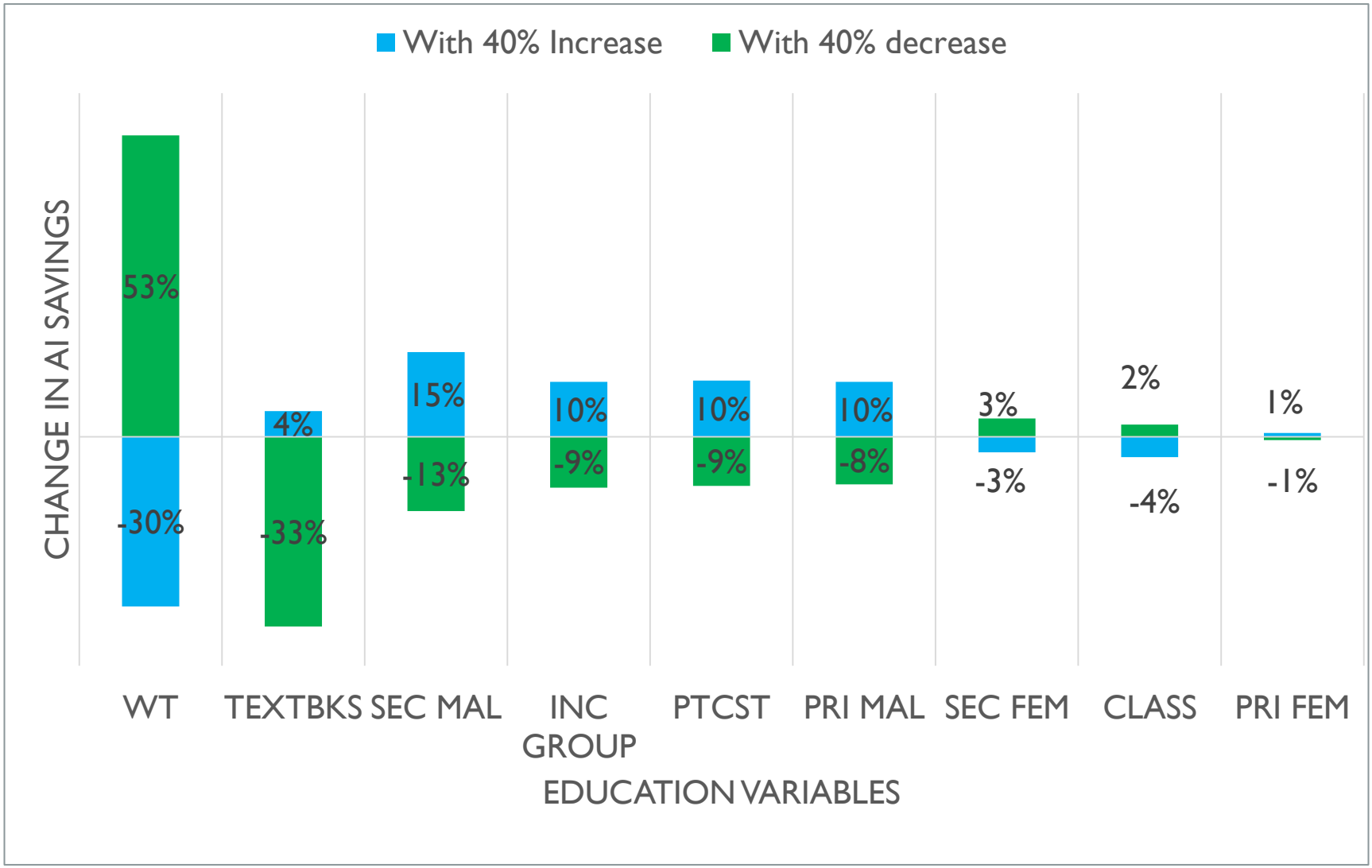


Contribution to savings according to mode of transport

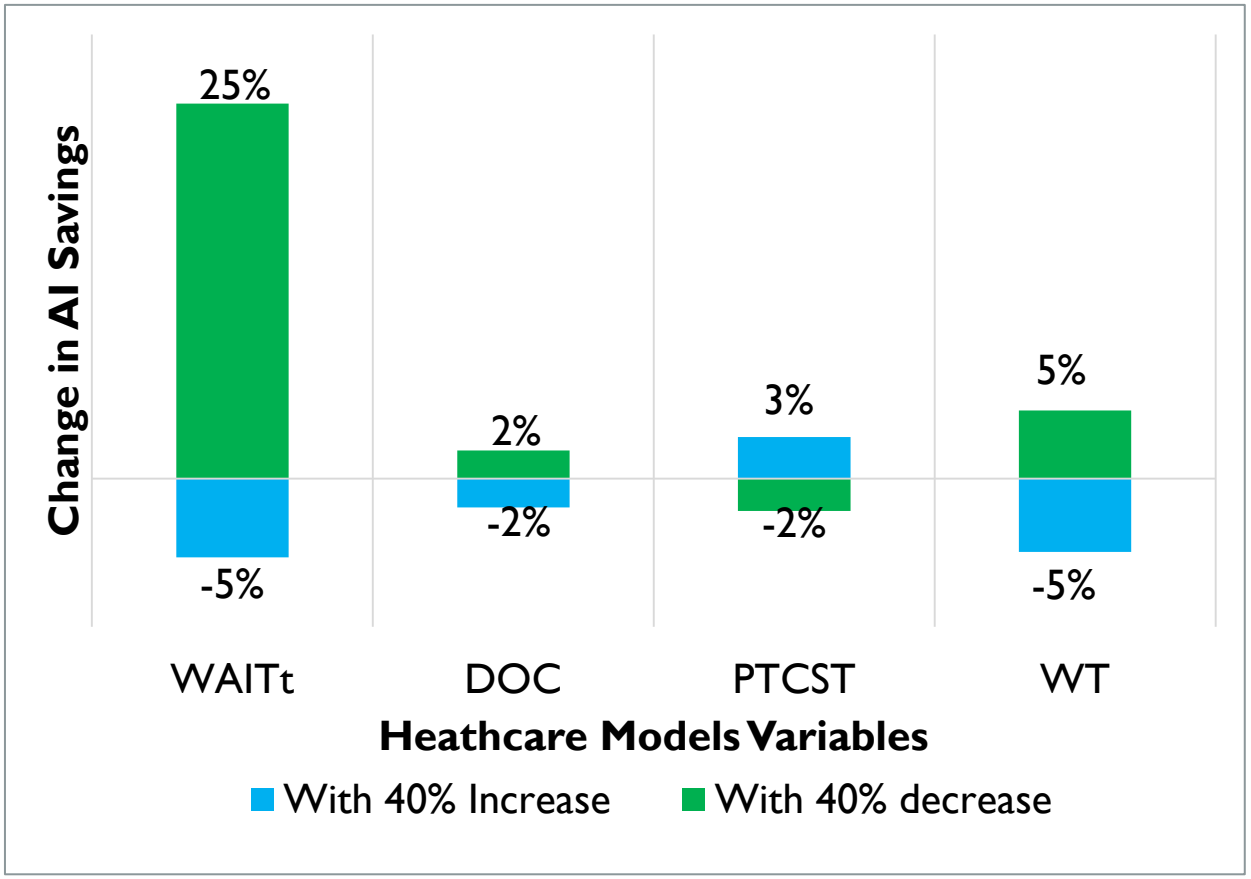


Sensitivity Analysis

Effects of Education Variables on Project 5 Savings



Sensitivity Analysis
Effect of Healthcare Variables on Project 5 Savings



Conclusions

- It is possible to measure social parameters and apply them in a model to yield unbiased outcomes
- Quality of infrastructure can be estimated robustly, using indirect parameters e.g. comfortable speed versus IRI
- Data gathering survey can be reduced by visiting facilities for information and using STATS SA
- Ranking from model provided realistic outcomes
- **MODEL PROVIDES SOCIO-ECONOMICALLY BASED PRIORITISATION METHODS FOR ACCESS ROADS IN RURAL/PERI-URBAN/URBAN COMMUNITIES**

Recommendations

- Model can be calibrated for selected areas with different community profiles
- More facilities can be added according to NDP, besides the current schools and clinics
- Model can be used for improved decision making beyond prioritisation of road infrastructure

END

THANK YOU

ANY QUESTIONS?

Results
Model Validation – Infrastructure quality factors

$$Q_{L,MT} = lesser\ of \quad \left. \sum_{s=0}^{n} \left(\left({}^{V_{s,avg}}/_{V_{s,cl}} \right) \times L_S \right) \right/ L_R \quad or \quad \left. \sum_{s=0}^{n} \left(\left({}^{W_{s,avg}}/_{W_{s,cl}} \right) \times L_S \right) \right/ L_R$$

Where

$Q_{L,MT}$ = Quality of link using motorised transport mode

$V_{s,avg}$ = Average measured speed over road link segment *s*

$V_{s,cl}$ = Average classification speed of road link segment *s*

L_S =Length of segment *s*

L_R = Length of road link *R*

$W_{s,avg}$ = Measured cross-sectional width of road link segment *s*

$W_{s,cl}$ =Average classification width of road link segment *s*

Model Validation – Infrastructure quality factors

$$Q_{L,NMT} = \left. \sum_{s=0}^{n} \left(\left({}^{SW_{s,avg}} / _{SW_{s,cl}} \right) \times L_S \right) \right/ L_R$$

where

$Q_{L,NMT}$ = Quality of link using non-motorised transport modes

$SW_{s,avg}$ = Average measured shoulder width of road link segment *s*

$SW_{s,cl}$ = Average classification shoulder width of road link segment *s* for relevant transport mode.

L_S =Length of segment *s*

L_R = Length of road link *R*