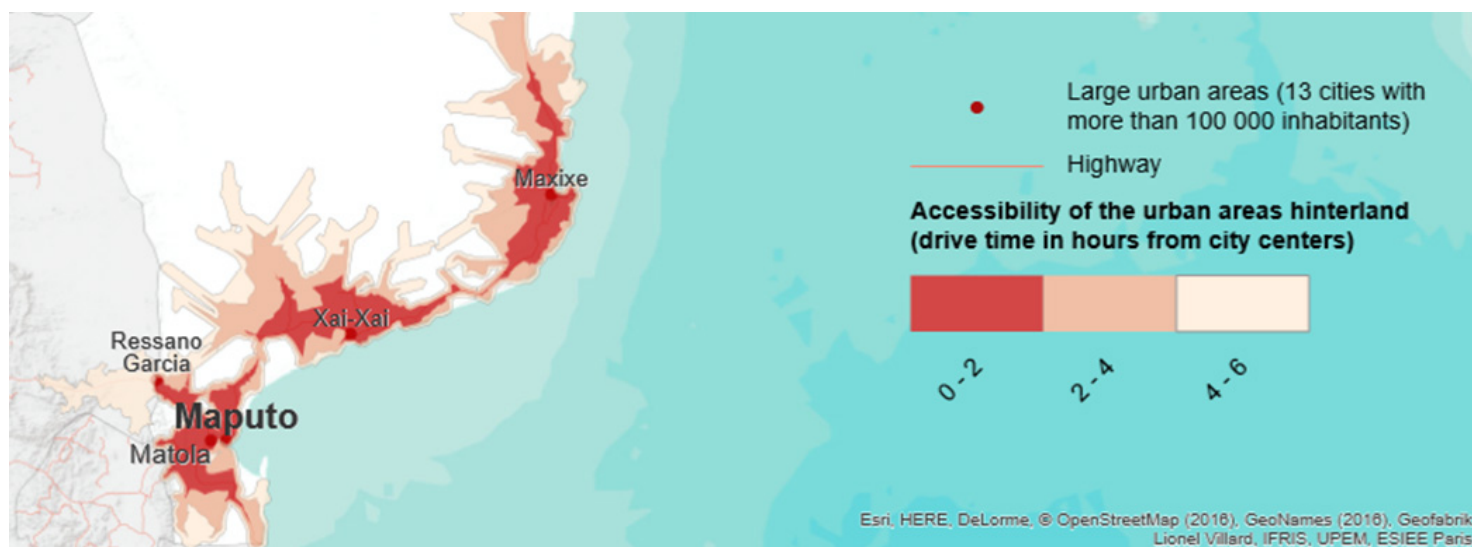


The objective of this article is to build a cartographic representation of drive time for freight transport companies from the 13th most important cities in Mozambique.

This model is based on an open source dataset of transport networks (OpenStreetMap, 2016) in Mozambique and the bordering countries. It is simulating, at a fine-grained level, the behaviours of truck drivers by taking in account both, barriers (one-way roads, pedestrian or cycling paths, tracks for agricultural purpose...), and common situations for drivers (border crossing time, turns and U-turns, junctions, local road crossing a regional road...). The model define six classes of roads (from local roads to highways) for more than one million kilometres of roads, with specific average traffic speed empirically deduced from a sample of transit times of a Mozambican freight transport company. This complex network of more than 1 million of road sections is analysed with ArcGIS, in order to build drive time areas (2, 4 and 6 hours), from the city centres of the major urban areas (more than 100 000 inhabitants, GeoNames, 2016). The map illustrates the interconnections of these urban areas and the problems of accessibility of their hinterlands in term of land transportation.

! This article is only a short abstract of the original one, [in french](#) !



## 1 / Building the roads network

[Open Street Map](http://www.openstreetmap.org) ( [www.openstreetmap.org](http://www.openstreetmap.org) ):

- Botswana (BW) : 78 502 roads sections
- Congo Democratic Republic (CD) : 197 038 roads sections
- Lesotho (LS) : 79 763 roads sections
- Malawi (MW) : 85 159 roads sections
- Mozambique : 157 368 roads sections
- South-africa (ZA) : 502 417 roads sections
- Swaziland (SZ) : 22 274 roads sections
- Tanzania (TZ) : 166 555 roads sections
- Zambia (ZM) : 53 923 roads sections
- Zimbabwe (ZW) : 82 394 roads sections

[Geofabrik](http://download.geofabrik.de/africa.html) ( <http://download.geofabrik.de/africa.html> )

## 2 / Building the model

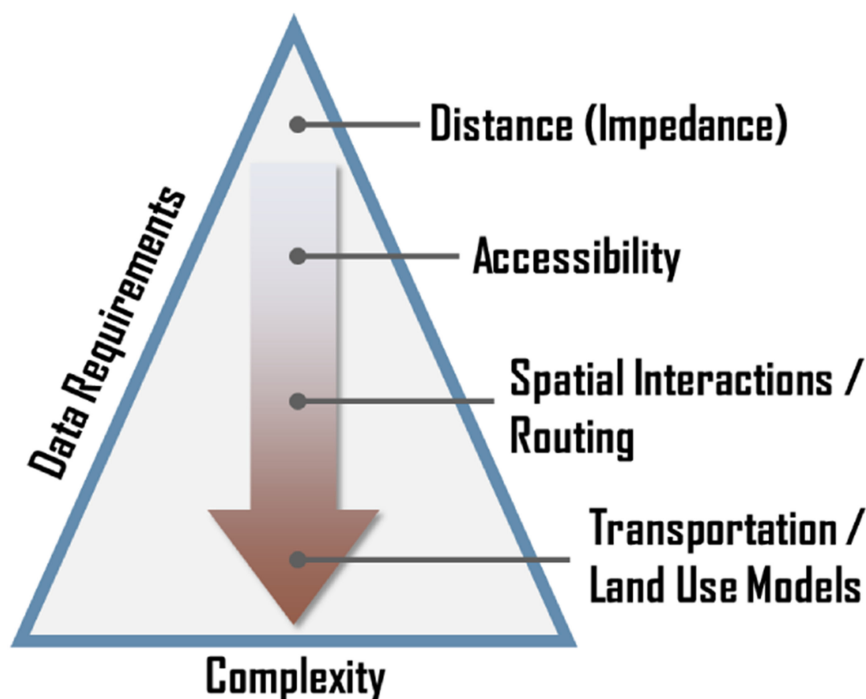


Fig 1 : Modèles dans la géographie des transports

Geography of transport systems, Jean-Paul Rodrigue et al., 3rd édition, 2013 :

Each [level is built] upon the other, implying for instance that the estimation of accessibility cannot be assessed without information about distance and that spatial interactions are derived from accessibility assessments:

- **Distance.** The most fundamental element of geography in general and transport geography in particular. Distance can be represented in [different manners](#) , from a simple Euclidean distance calculation to a complex estimation of a logistical distance that considers all the tasks necessary for the realization of a movement.
- **Accessibility.** Defined as the measure of the capacity of a location to be reached by, or to reach different locations. Therefore, the capacity and the arrangement of transport infrastructure are key elements in the determination of [accessibility](#) . It is thus based upon the concept of location and distance.
- **Spatial Interaction.** A [realized movement](#) of people, freight or information between an origin and a destination. It is a transport demand / supply relationship expressed over a geographical space. [Routing](#) is a specific category of spatial interaction that considers a given set of origins and destination for which specific (often optimal) routes are found.
- **Transportation / Land Use Models.** A [complex framework](#) trying to assess the numerous relations and feedback effects between transportation and the spatial structure.

## 2.1 / Classes of roads networks

roadstype	fclass	Distance cumulée en km	% km	Nombre de routes
highway	trunk	32 305,86	2,45	6 477
highway	primary	17 124,76	1,30	2 517
highway	secondary	7 217,16	0,55	934
highway	motorway	3 887,58	0,30	3 000
highway	motorway_link	1 203,88	0,09	3 336
highway	tertiary	769,96	0,06	150
highway	unclassified	199,70	0,02	40
highway	track	39,72	0,00	14
highway	trunk_link	20,56	0,00	30
highway	residential	16,23	0,00	19
highway	service	4,91	0,00	6
highway	track_grade1	1,43	0,00	1
highway	primary_link	0,46	0,00	3
highway	living_street	0,32	0,00	1
highway	secondary_link	0,02	0,00	1
secondary	secondary	95 073,57	7,22	20 798
secondary	primary	52 886,68	4,02	12 991
secondary	trunk	3 714,15	0,28	1 055
secondary	trunk_link	307,48	0,02	894
secondary	primary_link	283,64	0,02	1 830
secondary	secondary_link	135,37	0,01	1 200
local	unclassified	342 480,48	26,01	265 663
local	residential	197 498,16	15,00	552 025
local	tertiary	181 968,45	13,82	37 945
local	track	144 228,49	10,95	174 820
local	unknown	90 536,28	6,88	35 793
local	track_grade3	33 035,40	2,51	11 180
local	service	19 485,83	1,48	73 435
local	track_grade2	6 001,39	0,46	2 848
local	track_grade1	2 119,68	0,16	1 260
local	tertiary_link	1 064,00	0,08	1 068
local	living_street	731,32	0,06	2 967
non_for_car	path	62 937,51	4,78	170 539
non_for_car	track_grade4	7 424,98	0,56	3 047
non_for_car	footway	5 986,88	0,45	28 987
non_for_car	track_grade5	5 071,52	0,39	4 932
non_for_car	cycleway	726,13	0,06	721
non_for_car	pedestrian	257,07	0,02	1 224
non_for_car	bridleway	102,53	0,01	202
non_for_car	steps	32,94	0,00	1 439
		1 316 882,51		1 425 392

Tab 1 : roads type

## 2.2 / Defining roads speed

roadstype	moyspeed	Total de la distance en km	% km	Nombre de routes
highway	80	7 491,09	0,61	2 018
highway	70	49 934,79	4,05	12 092
highway	60	4 368,47	0,35	1 266
highway	50	19,64	0,00	29
highway	40	542,70	0,04	772
highway	30	263,66	0,02	303
highway	20	164,82	0,01	45
highway	10	7,38	0,00	4
secondary	50	105,34	0,01	25
secondary	45	32,57	0,00	35
secondary	40	57 946,89	4,69	16 299
secondary	30	92 981,95	7,53	22 224
secondary	20	1 333,24	0,11	177
secondary	10	0,91	0,00	8
local	50	2,21	0,00	1
local	45	14,60	0,00	30
local	40	2 782,20	0,23	313
local	30	7 279,20	0,59	19 358
local	26	2,77	0,00	28
local	25	0,85	0,00	1
local	20	184 287,42	14,93	41 179
local	15	1,11	0,00	19
local	10	792 607,31	64,21	1 087 056
local	5	32 171,82	2,61	11 019
		1 234 342,94		

Tab 2 : type of roads and speed

## 2.3 / Turns, junctions and one way



Direction	Description	Secondes
Orientée	De la voie Local à Local Ne traverser aucune voie	2
Orientée	De la voie Local à Local Traverser la voie Local	8
Orientée	De la voie Local à Local Traverser la voie Secondaire ou principal	20
Orientée	De la voie Local à Secondaire	12
Orientée	De la voie Secondaire à Local	12
Orientée	De la voie Secondaire à Secondaire Ne traverser aucune voie	2
Orientée	De la voie Secondaire à Secondaire Traverser la voie Local	6
Orientée	De la voie Secondaire à Secondaire Traverser la voie Secondaire ou principal	60
Inversé	De la voie Local à Local	12
Inversé	De la voie Local à Secondaire	60
Inversé	De la voie Secondaire à Local	20
Inversé	De la voie Secondaire à Secondaire	20
Tournant à droite	De la voie Local à Local	8
Tournant à droite	De la voie Local à Secondaire	12
Tournant à droite	De la voie Secondaire à Local	8
Tournant à droite	De la voie Secondaire à Secondaire	12
Tournant à gauche	De la voie Local à Local	8
Tournant à gauche	De la voie Local à Secondaire	40
Tournant à gauche	De la voie Secondaire à Local	20
Tournant à gauche	De la voie Secondaire à Secondaire	32

Fig 2.1 : turns and penalties (AroGis)



Fig 2.2 : turns and angles

roadstype	oneway	Nombre de routes
highway	B	8124
highway	F	8403
highway	T	2
secondary	B	25104
secondary	F	13605
secondary	T	59
local	B	1138941
local	F	19632
local	T	431

Fig 3.1 : one way

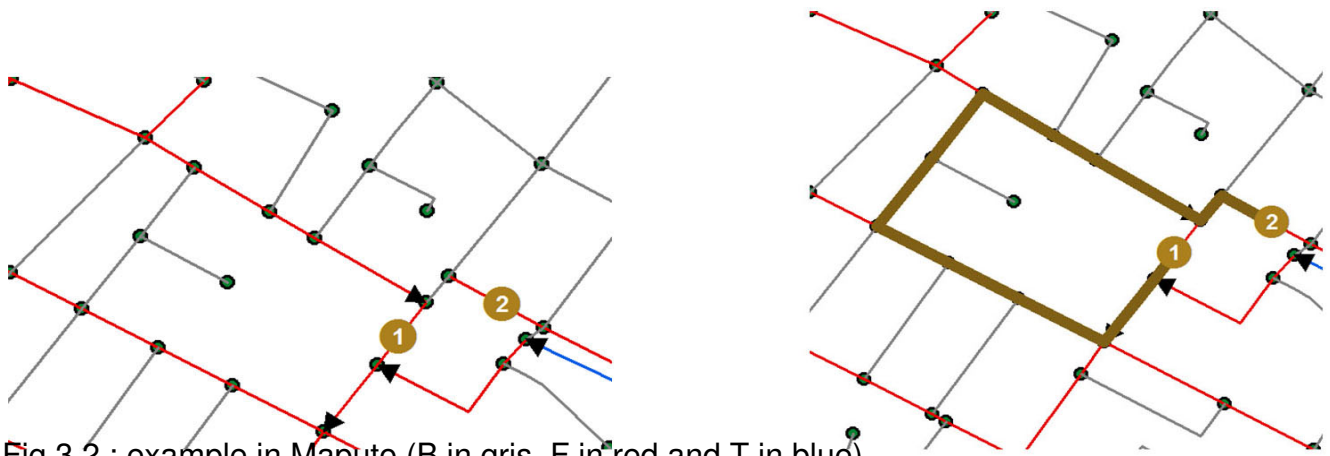


Fig 3.2 : example in Maputo (B in gris, F in red and T in blue)

### 3 / Core cities

22 061 451 inhabitants, [GeoNames, 2016](#)

country	asciiname	population	geonameid	rank
MZ	Maputo	1 191 613	1040652	1
MZ	Matola	675 422	1039854	2
MZ	Beira	530 604	1052373	3
MZ	Nampula	388 526	1033356	4
MZ	Chimoio	256 936	1049261	5
MZ	Nacala	224 795	1035025	6
MZ	Quelimane	188 964	1028434	7
MZ	Tete	129 316	1026014	8
MZ	Xai-Xai	127 366	1024552	9
MZ	Maxixe	119 868	1039536	10
MZ	Ressano Garcia	110 000	1028079	11
MZ	Lichinga	109 839	1043893	12
MZ	Pemba	108 737	1028918	13
MZ	Dondo	78 648	1024696	14
MZ	Antonio Enes	74 624	1052944	15
MZ	Inhambane	73 884	1045114	16
MZ	Cuamba	73 268	1047660	17
MZ	Montepuez	72 279	1037125	18
MZ	Chokwe	63 695	1048364	19
MZ	Chibuto	59 165	1049861	20
MZ	Ilha de Mocambique	54 315	1037390	21
MZ	Mutuali	30 523	1088155	22
MZ	Mocimboa	27 909	1037370	23
MZ	Manjacaze	25 541	1040938	24
MZ	Macia	23 156	1024701	25

Tab 3 : 13th core cities (GeoNames, 2016)



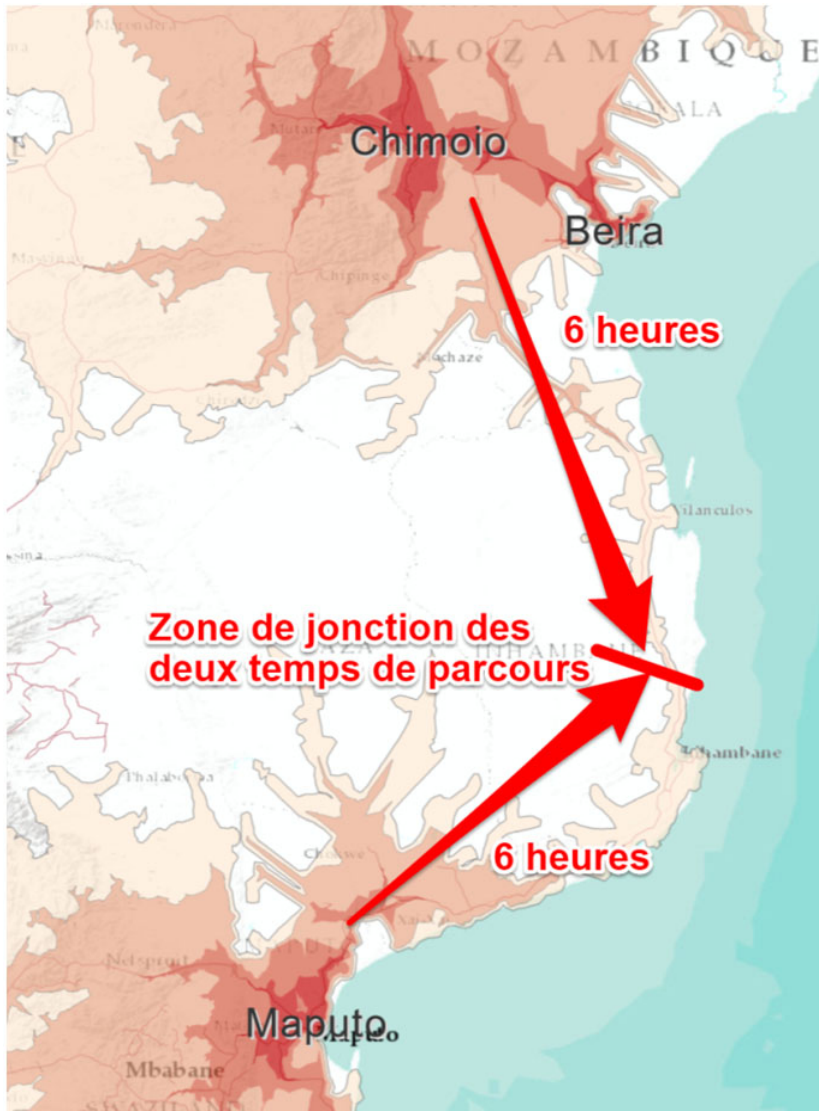


Fig 4 : Example between Maputo and Beira-Chimoio (illustration)

## 4 / Validation and main results

see [final map \(annex 4\)](#) or [the pdf file](#) .

## 5 / Discussion

**Annex 1 / Geofabrik OSM Standard, OpenStreetMap Data in Layered GIS Format (Version 0.6.7)**

All kinds of roads from motorways to gravel tracks as well as cycleways, footpaths, etc.

Additional attributes:

Attribute	PostGIS Type	Description	OSM Tags
ref	VARCHAR(20)	Reference number of this road ('A 5', 'L 605', ...)	ref=*
oneway	BOOLEAN	Is this a oneway road?	oneway=*
maxspeed	SMALLINT	Max allowed speed in km/h	maxspeed=*
layer	SMALLINT	Relative layering of roads (-5, ..., 0, ..., 5)	layer=*
bridge	BOOLEAN	Is this road on a bridge?	bridge=*
tunnel	BOOLEAN	Is this road in a tunnel?	tunnel=*

Roads of type 5111 (motorway) and 5112 (trunk) are always oneway.

The following feature classes exist in this layer:

code	layer	fclass	Description	OSM Tags
511x	roads		<b>Major roads</b>	
5111	roads	motorway	Motorway/freeway	highway=motorway
5112	roads	trunk	Important roads, typically divided	highway=trunk
5113	roads	primary	Primary roads, typically national.	highway=primary
5114	roads	secondary	Secondary roads, typically regional.	highway=secondary
5115	roads	tertiary	Tertiary roads, typically local.	highway=tertiary
512x	roads		<b>Minor Roads</b>	
5121	roads	unclassified	Smaller local roads	highway=unclassified
5122	roads	residential	Roads in residential areas	highway=residential
5123	roads	living_street	Streets where pedestrians have priority over cars	highway=living_street
5124	roads	pedestrian	Pedestrian only streets	highway=pedestrian
513x	roads		<b>Highway links (sliproads/ramps)</b>	
5131	roads	motorway_link	Roads that connect from one road to another of the same or lower category.	highway=motorway_link
5132	roads	trunk_link		highway=trunk_link
5133	roads	primary_link		highway=primary_link
5134	roads	secondary_link		highway=secondary_link
514x	roads		<b>Very small roads</b>	
5141	roads	service	Service roads for access to buildings, parking lots, etc.	highway=service
5142	roads	track	For agricultural use, in forests, etc. Often gravel roads.	highway=track without tracktype specification
5143	roads	track_grade1	Tracks can be assigned a "tracktype" from 1 (asphalt or heavily compacted) to 5 (hardly visible). A detailed description is here: <a href="http://wiki.openstreetmap.org/wiki/Tracktype">http://wiki.openstreetmap.org/wiki/Tracktype</a>	... with tracktype=grade1
5144	roads	track_grade2		... with tracktype=grade2
5145	roads	track_grade3		... with tracktype=grade3
5146	roads	track_grade4		... with tracktype=grade4
5147	roads	track_grade5		... with tracktype=grade5
515x	roads		<b>Paths unsuitable for cars</b>	
5151	roads	bridleway	Paths for horse riding	highway=bridleway or highway=path with horse=designated
5152	roads	cycleway	Paths for cycling	highway=cycleway or highway=path with cycle=designated
5153	roads	footway	Footpaths	highway=footway or highway=path with foot=designated
5154	roads	path	Unspecified paths	highway=path without cycle/foot/horse=designated
5155	roads	steps	Flights of steps on footpaths	highway=steps
			<b>Unknown</b>	
5199	roads	unknown	Unknown type of road or path	highway=road

*Note: For large excerpts where the roads data becomes too large to fit all roads in one shape file, we will split the roads layer in six: "major" (codes 5110-5119), "minor" (codes 5120-5129), "link" (codes 5130-5139), "small" (codes 5140-5149), "paths" (codes 5150-5159) and "other" (all others).*

## Annex 2 / Map of roads for « highway » and « secondary » classes





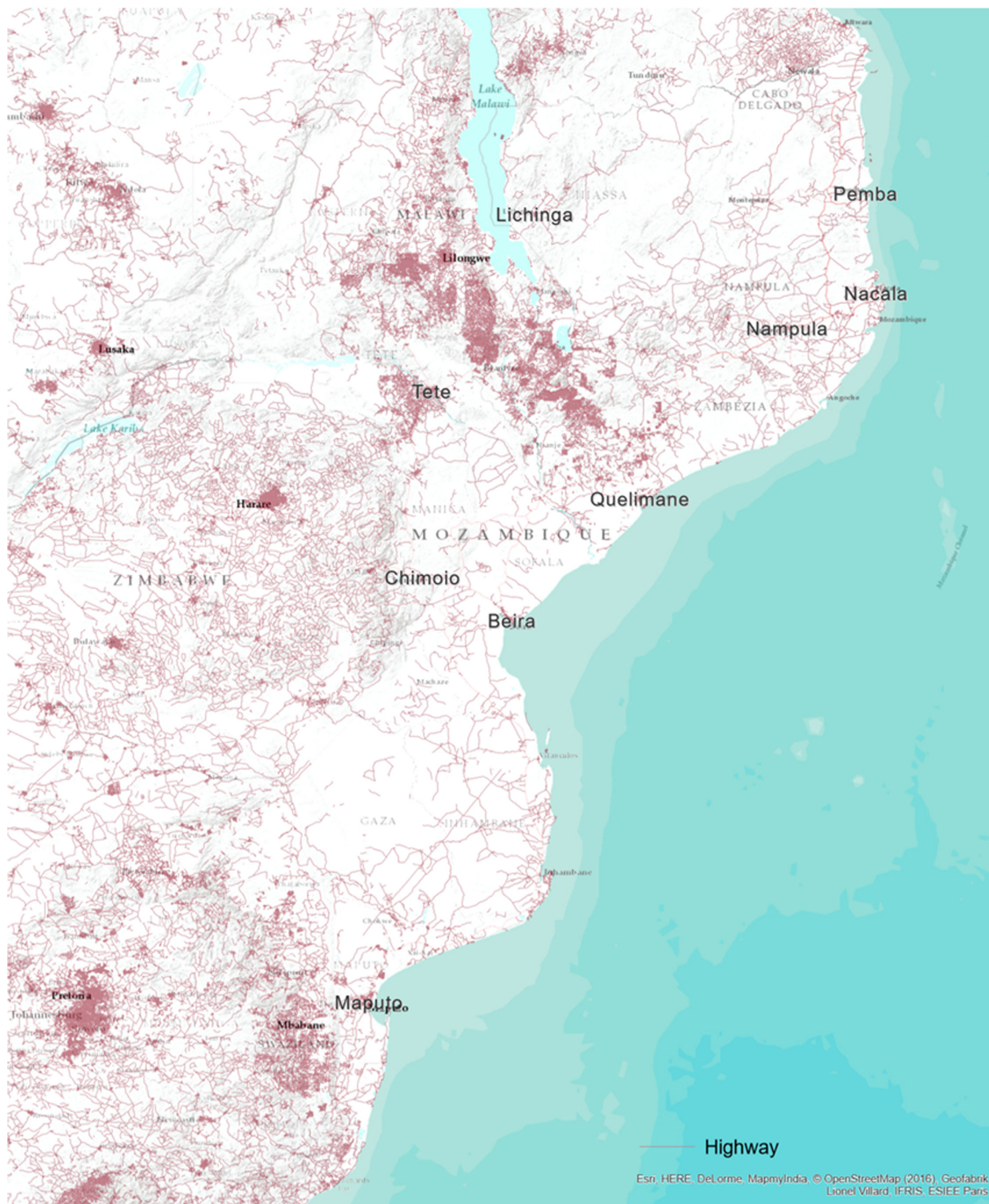
**Annex 4 / Map of roads for « local » classe**





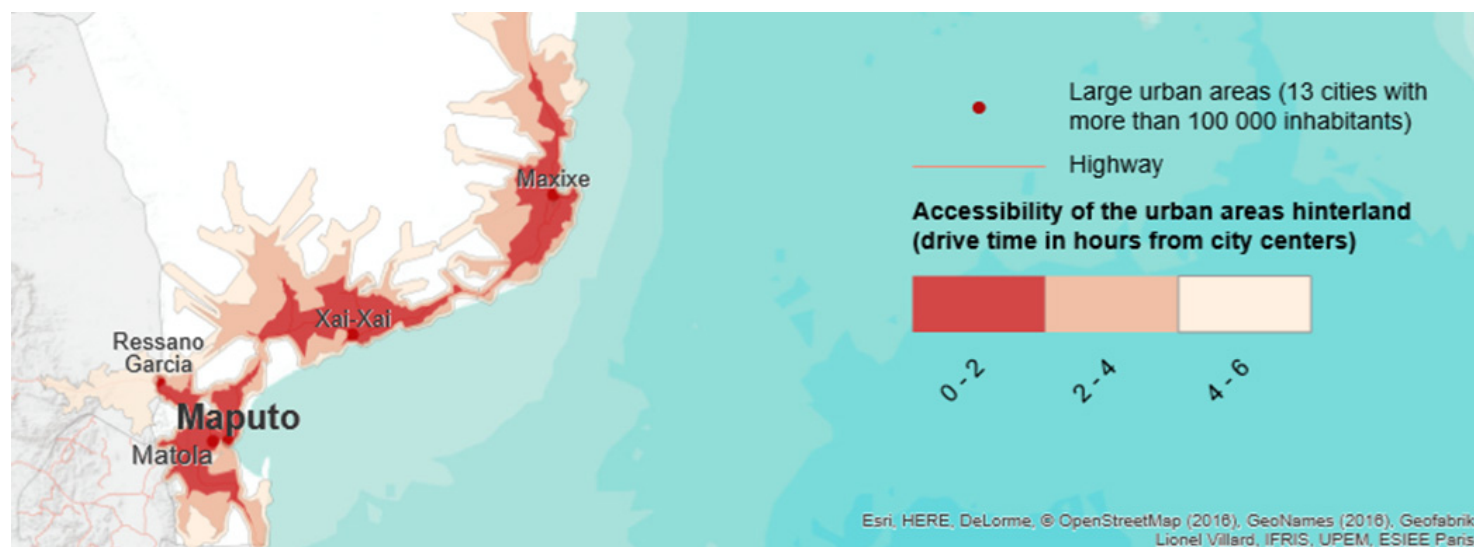
# Building drive time areas: cities and hinterlands accessibility in Mozambique

Last Updated Sunday, 02 April 2017 12:37





## Annex 4 / Download the final map (v15)



## Annex 5 / Resources and scripts used with ArcGis 10.2 (Network Analysis)

```
1 2 3 4 5 6 7 8 9 'pre logic VBScript roadstypetype (text): building roads types
```

```
1 2 3 4 5 6 7 8 9 'pre logic VBScript roadstclass (entier court): building roads classes
```

```
1 2 3 4 5 6 7 8 'pre logic VBScript roadsspeed (entier court): defining roads speed
```

```
1 2 3 4 5 6 7 8 9 # Dintance for each road section (double) (dist_km) =
```