CASE STUDIES

Rural development and planning in LDCs: the "Gamba Deve – Licoma axis",district of Caia, Mozambique

Isacco Rama and Corrado Diamantini

PHOTO: Near Randinho – Caia, Mozambique. Isacco Rama.

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Rural development and planning in LDCs: the “Gamba Deve – Licoma axis”, district of Caia, Mozambique

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Rural Development and Planning in LDCs: The “Gamba Deve – Licoma axis”, District of Caia, Mozambique

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1. Introduction

It is believed that the development of rural areas of low income countries is an important factor in limiting migration to the cities, which do not appear capable of supporting this weight in terms of labour demand and supply of services to the immigrant population. In this kind of rural development, smaller towns play a key role and, thanks to the urban-rural relations that smaller towns activate, they act as exchange nodes in supralocal relationships.

These rural-urban relationships are facilitated by transport infrastructures that result in ever greater efficiency depending on their level of accessibility. One of the major problems of access to the interior rural areas of developing countries consists, in fact, in the seasonality of access to roads, often precluded during the rainy season.

Generally, benefits associated with efficient links between urban centres and rural areas are the marketing of agricultural surplus and access to goods and services considered to be urban. The creation of basic services distributed synergistically along rural axes is also crucial in order to ensure higher standards of welfare to the rural population. Rural infrastructural axes must be designed precisely to serve the local population and not solely in support of commercial exchanges.

A final aspect of the problem is related to the costs of road infrastructures. Local governments have often limited resources and the containment of costs during the design phase is a fundamental factor.

1.1. Disciplines covered

The proposed case study covers two disciplines, namely regional spacial planning and low-volume road infrastructure design.

Concerning the first discipline, key aspects of the case study are:

- identification of the most suitable areas for road infrastructure, taking into account both their growth potential and effectiveness for urban-rural relations;
- location of services to the population, taking into account the spatial distribution and accessibility of human settlements.
- With regard to the second discipline covered, the fundamental aspect is the road design aimed at maximizing the benefits with the minimum construction and maintenance costs.

1.2. LEARNING OUTCOMES

The learning objectives are:

- acknowledgement of the range of problems occuring in remote rural areas, with reference to subsistence strategies, meaning production and consumption by local population;
- acknowledgement of specific issues of the area, with reference both to the marketing of agricultural surplus and to the access to public and private services;
- ability to identify the appropriate contexts for investments in infrastructure and services;
- ability to set up a road design adapted to the actual conditions within a particular context, or at least the analysis of an infrastructure project in a low income rural area.

1.3. ACTIVITIES

In class, students are introduced to the project. A discussion is then launched aimed at clarifying doubts and, above all, determining any alternatives to the proposed technical solution.

Activities carried out by students outside of class are expected to be in groups formed on the basis of actual skills/interests possessed by each student.

2. DESCRIPTION OF THE CONTEXT

The following section is focused on the context in which the case study takes place. The problem of accessibility in remote areas will be detailed and the district of Caia will be described. Successively, the specific issue of the strategic importance of the Gamba-Deve / Licoma axis will be addressed, before providing a detailed description of the road services, other infrastructures and service networks.

2.1. THE PROBLEM OF ACCESSIBILITY OF REMOTE AREAS

The roadway communication network was built in Mozambique during the colonial period. There are settlements where the Portuguese roads did not arrive: the Portuguese favoured trading and administrative posts and did not penetrate to the more remote areas that were run by locals. The post-colonial government has invested as a priority in health and education in the main urban centres and the current government invests in major works on the main axis. It is therefore evident that a capillary road network has not been developed to date. Large areas still remain inadequately served by road networks for the transit of vehicles, motorbikes and bicycles. The situation is aggravated during the rainy reason, when the existing dirt roads become only partially passable due to the creation of mud and huge water puddles. This fact generates huge restrictions for the transit of people and goods. In countries where more than 70% of the population lives in rural areas, the lack of transport infrastructure means a consequent lack of health and education services, low variety of goods and general absence of modernity for the numerous remote areas.

2.2. The Caia District

Caia district is located in the central region of Mozambique, in a strategic position at the crossroads of the EN1, the main roadway of the country, and the axis Caia-Sena-Tete. The latter runs parallel to the railway line to Beira and Marromeu, the ER213 road and the Zambezi river.
With an area of 3.542km2 and a population of 115,612 inhabitants, Caia is one of the most densely populated rural districts of Mozambique (33ab / km2)1. The Caia district is bounded on the northwest by the District of Chemba, to the east by the Zambezi River, on the west by the District of Maringue and on the south by the districts of Cheringoma and Marromeu.

From the point of view of land cover, most of the district is savannah and wooded savannah (66.3%). There are some forest areas (10.4%), areas of cultivated land (8.2%) and wetlands and flooded areas (14.2%). Finally, infrastructure and settlements occupy a small part of the territory of the district (0.8%).

1 INE, Censo Geral da População, 2007

Figure 1 *location of Caia in Mozambique*

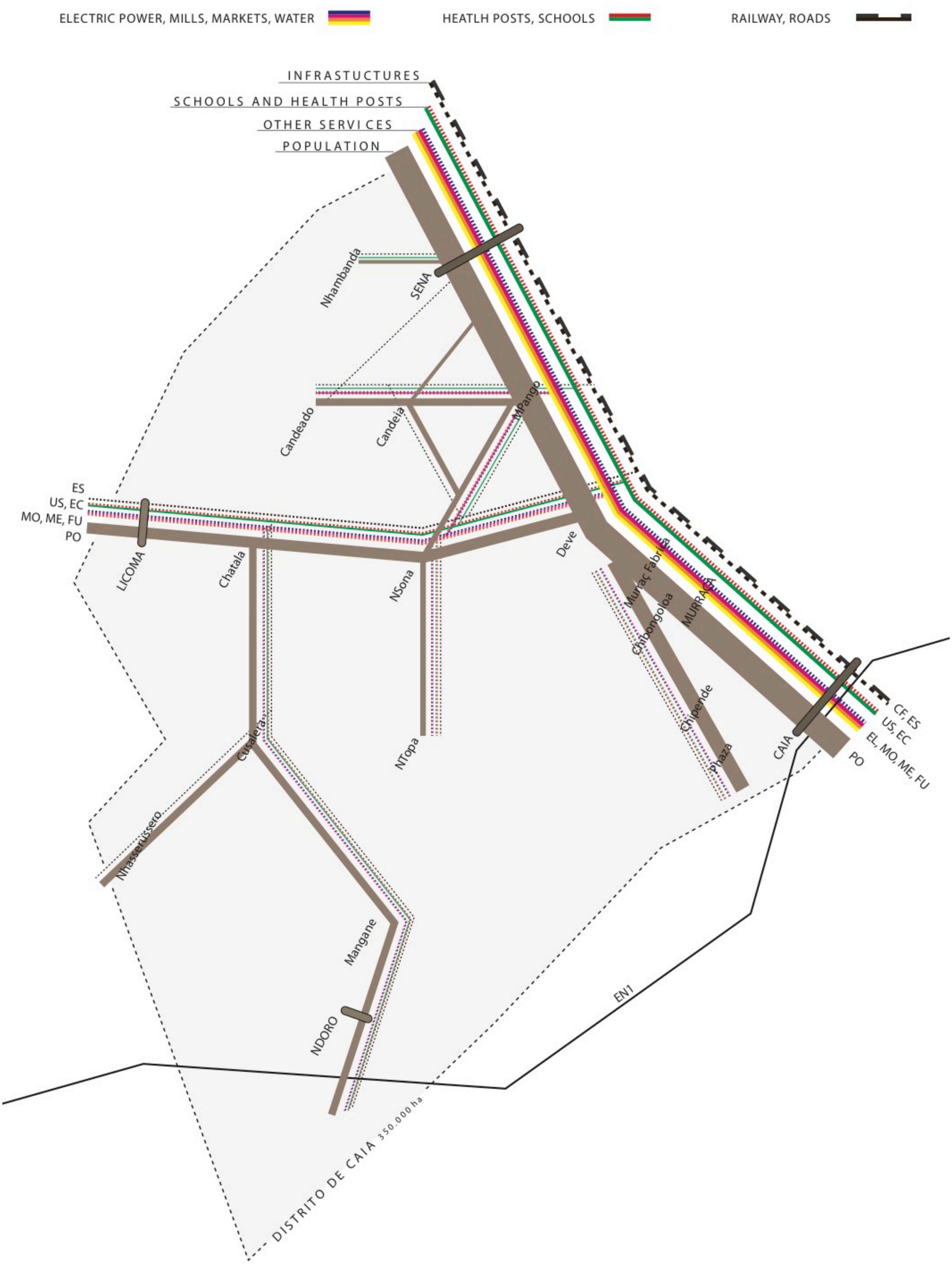

Figure 2 *Schematic representation of Caia District*

Typology	ha	%
Settlements and infrastructures	3 000	0,8
Agriculture	29 000	8,2
Forests	36 500	10,4
Wooded savannah	233 200	66,3
Floodable low-land and water	50 000	14,2
Total	**351 700**	**100**

Table 1 *land-cover types and areas of Caia District, PDUT 2012*

With respect to economic activities, in the district of Caia the most developed sector is undoubtedly the primary sector. It is estimated that nearly 80% of the population is directly dependent on subsistence farming while the remaining 20% have various sources of income that they integrate with agricultural practice2. The most productive areas of the district for crops (corn, rice, sorghum) are close to the main waterways (Zambesi, Zangue, Mepuze, Nhangue) along which there are also the most important human settlements (Caia, Sena, Murraça, Licoma, Ndoro among others)3.

The Vila de Caia (18,233 ab, 20074), formerly known as Vila Fontes, is the capital of the district. It is located at a distance of about 400km from the city of Beira, capital of Sofala Province. The Vila is situated in the eastern part of the district, at the crossing of the above-mentioned infrastructure axis and at a few kilometres from one of the only two bridges in the country that allow for the crossing of the Zambezi River. With this pre-eminent position, Caia has fully experienced all the processes of economic and social transformation that took place in Mozambique in recent years.

2.3. The strategic nature of the Gamba Deve – Licoma axis

The trajectory Gamba Deve - Licoma (GDL) is the most important infrastructure axis of the district after the one that connects the capital Caia with the town of Sena. The importance of this axis is given by two of its characteristics: on the one hand, this axis connects the east and west of the district; on the other hand, many settlements are concentrated along this axis, located inside a strip of fertile land that in addition to ensuring adequate living conditions for the population, is still partially unused. Along the GDL axis are also to be

2 Serviço Distrital de Planeamento e Infra-Estruturas, PDUT 2012
3 ibidem
4 INE, Censo Geral da População, 2007

found some important service infrastructures for the population such as education and health facilities, as well as private services that provide access to water and products on the local markets.

The East-West connection is guaranteed by the road axis called Estrada Distrital N° 1 (ED1). This road, in addition to crossing through the GDL axis, connects at Licoma, the Caia district with the district of Maringue, thus ensuring an inter-district link. The importance of the GDL axis for the district is therefore evident, not only when considering the local scale, but also on the regional scale.

Overall about 1/8 of the population of the district lives along the axis; that is about 14000 inhabitants. The population along the GDL axis is organized in settlements ranging from larger sized aggregates to scattered settlements. Along the ED1 from Gamba-Deve towards Licoma, are found the aggregates of Nhacuecha, Randinho, Nsona, Chatala and Licoma, and various scattered settlements which have developed following criteria of soil fertility, altitude and proximity to water sources. Detailed distribution of the population along the GDL axis is represented in appendix 1.

Settlement	population	%
Nhacuecha	1 000	7,8
Randinho	872	6,8
Nsona	1 088	8,5
Chatala	960	7,5
Licoma	352	2,8
Total principal settlements	**4 272**	**30,8**
Magagade	968	7,6
Conge	480	3,8
Luate	264	2,1
Cofi	608	4,8
Nhachilaua	272	2,1
Total secondary settlements	**2 610**	**18,7**
Total scattered settlements	**7 014**	**50,5**
Total GDL axis	**13 896**	**100,0**

Table 2 *population of human settlements along the GDL axis*[5]

5 *“Local Development and Spacial Planning in Developing Context: an Executive Plan of The Plano de Uso da Terra in a Rural District of Mozambique”*, Isacco Rama, 2014

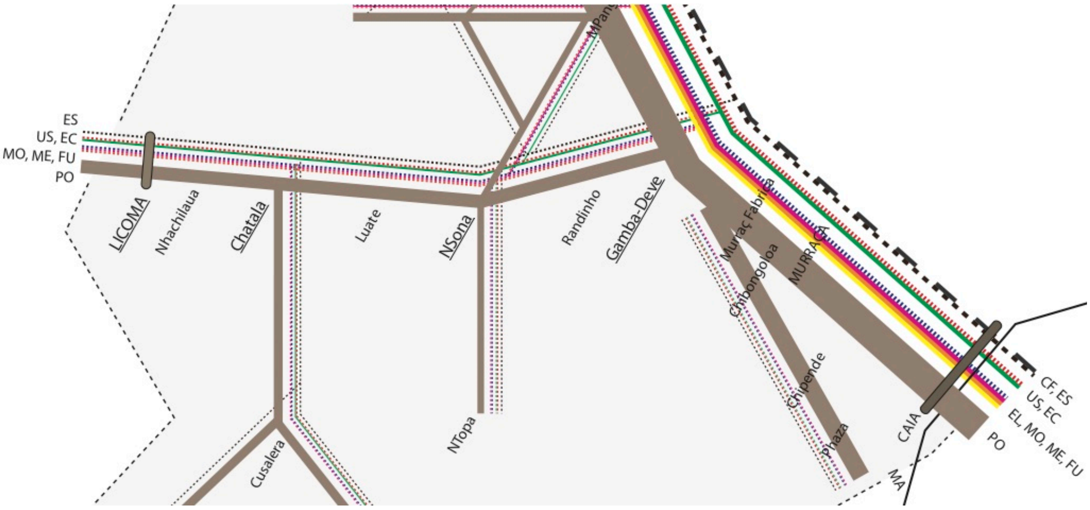

Figure 3 *Schematic representation of GDL axis*

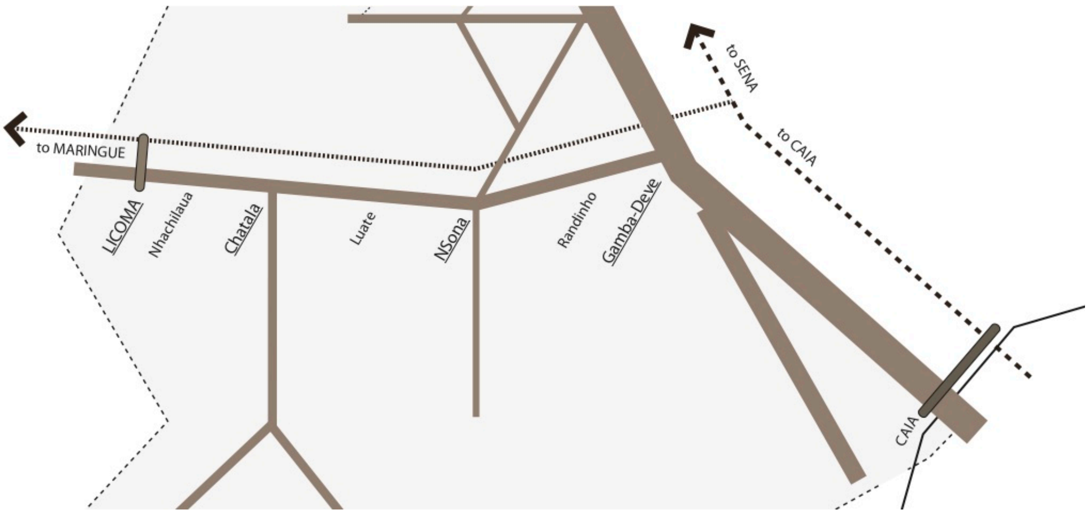

Figure 4 *Schematic representation of GDL external road connections*

2.4. THE INFRASTRUCTURAL NETWORK

As mentioned above, the axis Gamba-Deve / Licoma runs perpendicular to the main Caia-Sena axis and runs for about 45.00 km in the East-West direction. The element that forms the backbone infrastructure of the GDL is the Estrada Distrital No. 1 (ED1). The ED1 is a gravel road of Portuguese origin. It therefore runs on land that was mapped and developed during the colonial occupation, before 1974. The current conditions of practicability of the ED1 are not good, since the road is often interrupted by defects such as holes, erosion, cross-ripple and others. In addition to the structural layer, the very horizontal alignment presents in some sections shortcomings of the road’s width (often less than 2.5m), and substantial presence of vegetation. In addition, the road has a seasonal practicability limited to the dry season. Up to date traffic data is scarce but from observations made on site, a transit of maximum 5 cars per day can be estimated, limited to vehicles with a dry mass of less than about 5.5 tons.

The presence of defects along the ED1 road is a major limitation to the passage of people and goods along the GDL axis. The greatest number of defects occurs on the road surface due to two main factors: the longitudinal inclination of the track and the proximity to the river Mepuze. Both these elements, combined with torrential rainfall between November and March, contribute to engender the defects on the road, which, together with the low maintenance of the road, severely restrict transit along the DGL. Transit which is currently only possible for four-wheel drive vehicles or vehicles which are very well raised from the ground.

From the intersection with the ER213 "Caia-Sena", the infrastructure track of the ED1 runs for about 9.6 km in an altimetrically depressed section where the presence of still water on the road surface is an almost complete obstacle to transit during almost half of the year and a critical constraint also in the remaining months.

From km 9.6 to km 13.8 the ED1 rises slightly away from the level of the Mepuze river. Along this section, the main difficulty is the longitudinal erosion of the structural layer, associated with problems of slipperiness and the presence of holes.

Over the following 11km (13.8 km - 24.6 km) the path of the ED1 crosses at 8 points, some of the minor streams that feed the river Mepuze. These crossings are characterized by the presence of seasonal water in the rainy season that can reach a few feet high, invading the road and making it nearly impossible to pass for all motor vehicles from November to late March or so.

Finally, along the last section of its path (km 24,6 - 41,4 km), the ED1 road rises its altitude up to a maximum of 185m above sea level before falling back towards Licoma which is located at an altitude of about 140m above sea level. In this last section the ED1 crosses the river Mepuze in a spot where currently there is no bridge that would allow the smooth passage of vehicles.

In addition to the upgrading of the road layout, as part of the PDUT of Caia it is expected that the axis from Gamba-Deve in the direction of Licoma will be electrified.

Figure 5 *view of the Mepuze river and ED1 road*

2.5. Services to the population

In rural areas of Mozambique, the network of public and private initiatives are cohabiting and easily distinguishable. The public authority is represented by the administrative structure of the state and provides two basic services to the population: education and healthcare. The private sector is present with various initiatives, especially related to family-size or cooperative structures, such as management of local markets, management of mills and the network of water wells, supply of transport to the population, production and trade of agricultural goods and, more rarely, working as employees.

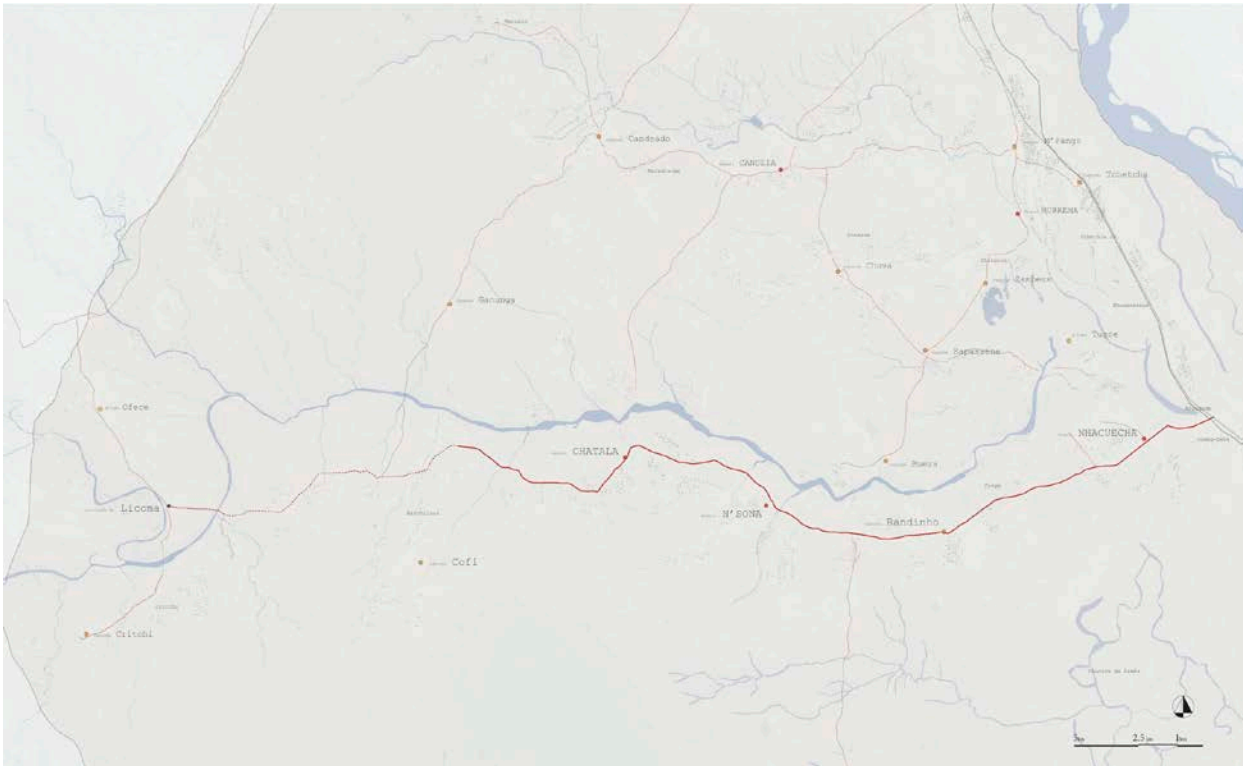

Figure 6 *simplified map of the ED1 Gamba/Deve - Licoma and Mepuze river*

Again with reference to rural areas in Mozambique, basic health facilities, namely Centro de Saude and Posto de Saude, as well as basic educational facilities, Escola Primaria de 1° grau (EP1) and Escola Primaria Completa (EPC), are constructed according to an architectural standard. This provides for simple structures in reinforced concrete, featuring two or three rooms. Often, schools and health facilities do not have electricity, or resort to the use of solar panels. They often do not have running water and if not, they may resort to simple ad-hoc hydraulic systems. Schools work on several shifts during the day. In the vast majority of cases professionals of the two sectors (teachers, nurses, attendants) come from outside GDL and are housed in public residential facilities.

In terms of the GDL axis, the presence of the public sector is translated into administrative structures, such as the Posto da Localidade de Licoma (PAL) and the network of schools and health facilities. At the PAL sits a public official (called Chefe da Localidade) and a small secretariat (composed of two people). This administrative structure exerts some simple mandates of an executive nature, including the promotion of health and education within its jurisdiction. The schools and health facilities network along the GDL follows, with some key exceptions, the presence of the population. Structures are in fact placed to coincide with the main centres (aggregates). In particular, schools can be found near Gamba-Deve, Nhacuecha, Randinho, Nsona, Chatala, Cofi and Licoma. Health posts can be found in

Gamba-Deva, Randinho, Chatala and Licoma. Aggregates listed above, all of medium size, have a theoretically sufficient coverage of services.

The difficulty of access to services by the rural population is caused on the one hand by the numerically significant presence of scattered settlements placed at a distance from the aggregates, and on the other hand by the low quality of both education and health care services. In fact, regarding schools, critical issues are related to: extremely high pupils/teacher ratios, few school grades offered (grades 1 to 5), difficult access for distant households, lack of teaching materials. As for the health care facilities, critical issues are linked to: absence of qualified staff, lack of medicines and medical supplies, lack of health care equipment, isolation of the health posts with respect to the hospital of Caia, resulting in difficulty in the mobility of health staff and patients.

Health post	population
Centro de Saude de Gamba-Deve	3 198
Posto de Saude de Randinho	2 015
Centro de Saude de Chatala	3 166
Centro de Saude de Licoma	2 143
Total	**10 522**

Table 3 *population per health post along the GDL axis*

School	grade	pupils	teachers	ratio
EP1 Nhacuecha	1°-5°	246	5	50
EP1 Randinho	1°-5°	240	3	80
EP1 Nsona	1°-5°	605	8	76
EP1 Chatala	1°-5°	553	6	93
EP1 Nhachilaua	1°-5°	455	4	114
EP1 Licoma	1°-5°	214	5	43
Total	**-**	**2 864**	**42**	**69**

Table 4 *pupils and teachers per school along the GDL axis*

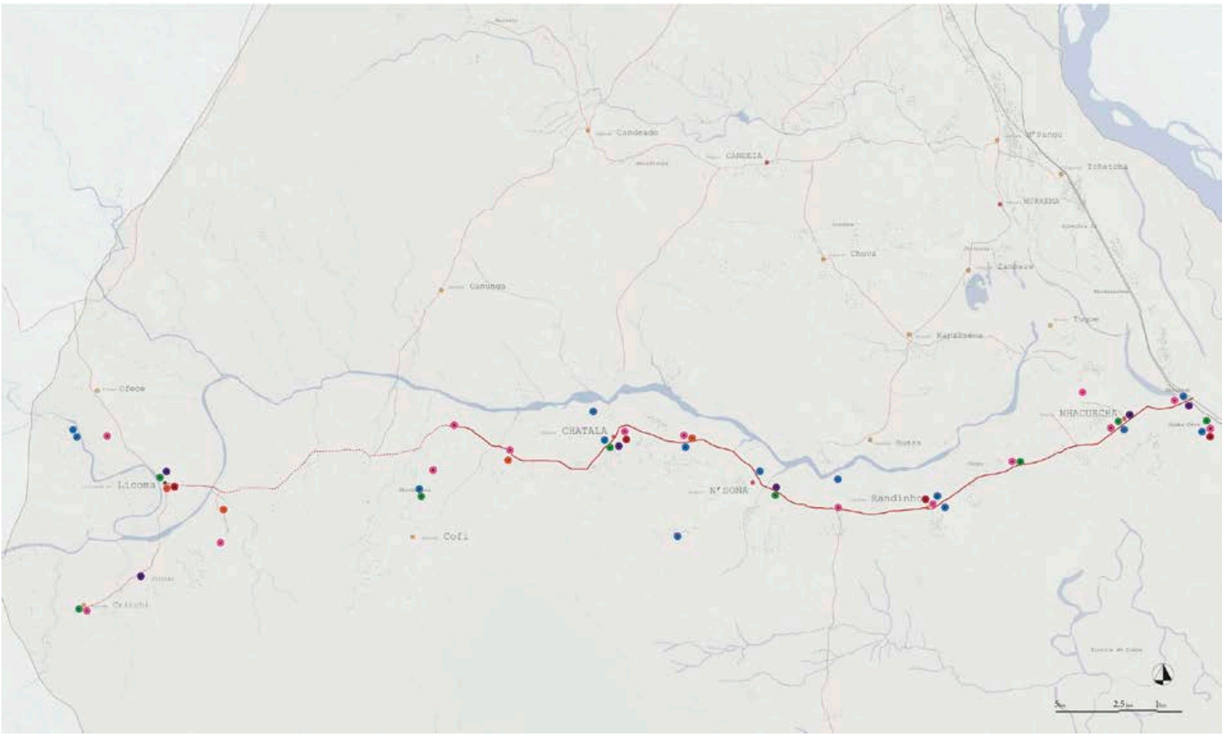

Figure 7 *distribution of services along the GDL axis (schools, health posts, wells, markets, mills)*

In general, it can therefore be said that, although in recent years considerable efforts have been made by local and national governments to improve networks and structures, a shortage of materials/staff and poor quality of service remain at a critical level.

With regard to the services offered to the population and managed by the private sector, i.e. mills, water wells and local markets, the network is more dense and it is less easy to make generalizations. The water wells are generally constructed with funds managed partly by the technical district office (SDPI) and often obtained from donations. On average, wells do not exceed 35/40m depth and are composed of a battery of tubes connected with the water pump. Afridev-type manual water pumps are often used while more rarely small electric pumps are installed. As for the other services, the water well network follows largely the presence of the population, although there are a larger number of scattered settlements that are not covered by the service.

<u>Activity</u>: graphically analyse the distribution of services (schools, health posts, water wells, markets, mills) with respect to the presence of population centres (aggregates and scattered settlements); see appendix 8 and appendix 10.

	Nhachilaua	Randinho	GDL
Partial no water coverage	79,2 %	39,5 %	35,5 %
Total no water coverage	79,3 %	39,5 %	23,5 %
Potential water coverage	20,8 %	60,5 %	76,6 %

Table 5 *population covered by protected water supplies along the GDL axis*[6]

Local markets are constituted by a set of informal structures standing side by side and are characterized by the presence of a scarce number of different products. Most goods are bought by traders in the markets of Caia and Sena and resold at the local market. These include basic foodstuffs such as salt, oil, soap, and coal and other products such as alcohol, clothes and shoes, small household utensils, cigarettes, disposable batteries, cleaning products, carbonated drinks and some spare parts for bicycles and motorcycles. Electric energy not being present, along the GDL means that there are no refrigerators, because of which foodstuffs for sale do not include dairy products, fish, meat or similar. The market locations correspond to the population aggregates.

Detailed distribution of services along the GDL axis is represented in appendix 2.

> Suggested research: What role should local markets have in rural-urban relations in Sub-Saharan Africa? What relationship have they got with public services and the presence of population centres in rural areas?

6 Serviço Distrital de Planeamento e Infra-Estruturas, PDUT 2012

Figure 8 *services along the GDL axis.*

From top-left: health post in Chatala, market in Chatala, Afridef-type water pump, school in Nhacuecha, school in Nsona, diesel-engine mill

3. Class activity

It is suggested that the introduction to the project is made in 4 phases: (1) inspection of context and determinants, (2) examination of the roadway and roadway defects, (3) description of adopted technical solutions, (4) description of synergies adopted with the roadway. In order to simplify the transmission of concepts during the lecture, in the following section each of these stages will be illustrated.

Classroom activities can be developed according to the methods preferred by the professor, although leaving ample space for interaction between students is considered of particular importance. This is to be seen in the perspective of alternative proposals in terms of technical-specific design for ED1 and the service network made by student groups during the homework activity.

3.1. Context and determinants

It is very important to consider that the Case Study has been carried out in a rural area of one of the countries with the lowest GDP per capita in the world. The GDL axis is characterized by technological backwardness in agricultural practice, media isolation, endemic poverty of the population. The rational allocation of resources is therefore of fundamental importance, the detailed examination of the context and clarification of the determining factors are the basis for a successful project.

First of all it is important to consider that three out of four of the Regulados that stand on the GDL axis have a per capita monetized annual production higher than the district average. In relation to the Caia district, the overall productivity (the sum of the agricultural product and that of animal hubandry) in Nhacuecha, Nsona, Chatala and Candeia is up to 6% higher than the average.

Regulado	**yearly per capita production (MZN)**
Nhacuecha	5 643
Nsona	4 949
Chatala	5 904
Candeia	8 337
GDL average	**6 208**
Caia district average	**5 853**

Table 6 *Yearly per capita production per Regulado along the GDL axis*[7]

In addition, observing related data, we can see how families of the GDL base their productivity mainly on farming, highlighting the suitability of the area to agricultural practice. This is made possible thanks to red clay and lime soils, which, although partially waterproof, are very conducive to the practice of agriculture.

Secondly, an important consideration concerning the demographic data, with particular reference to the education system, is to be borne in mind. If we observe the age pyramid of Caia district, we will notice the large number of citizens in the age group 15-24 years8. The number of young citizens estimated to belong to this age group is 17063. This fact, considered along with the great distance from Caia's middle and high schools to GDL and the average number of students in such structures, justifies the elevation to grade 12 of one educational structure inside the GDL.

7 Serviço Distrital de Planeamento e Infra-Estruturas, PDUT 2012
8 *“Local Development and Spacial Planning in Developing Context: an Executive Plan of The Plano de Uso da Terra in a Rural District of Mozambique”*, Isacco Rama, 2014

age range	born	population	%
0 – 4	2003 / 2007	24685	21.4%
5 – 9	1998 / 2002	20707	17.9%
10 – 14	1993 / 1997	15056	13.0%
15 – 24	1983 / 1992	17063	14.80%
25 – 34	1973 / 1982	14881	12.9%
35 – 44	1963 / 1972	9661	8.4%
45 – 54	1953 / 1962	6224	5.4%
55 - 64	1943 / 1952	3726	3.2%
64 <	before 1943	3609	3.1%
Total		115612	100.0%

Table 7 *Age pyramid in the Caia District*[9]

Finally, another important element of the context is the easy access to valuable forest resources. Chatala is located the northern entrance to the most valuable forest of the district, called Ziwe-Ziwe. This forest, as well as providing wood for domestic use to the local population, has great value in terms of biodiversity, also thanks to the complementary relationship with the wetland ecosystem known as Dimbe.

Determinants for class work are thus twofold. On the one hand there are factors with greater influence on the technical aspects of the proposed solution for the design of ED1, on the other hand there are some social factors that allow us to formulate proposals for the design of the services network along GDL. In the first group it is worth mentioning the element of proximity of the GDL infrastructural system to the river Mepuze, rainfall information of the area should be supplied, as well as information on orography and secondary water courses. The low level of technological context in which the Case Study operates is also an important element to consider. Generally speaking, these are all elements that have an influence on the ED1 roadway design. Regarding the services network design, elements of paramount importance are the large number of scattered settlements (50.5% of the population), the high percentage of young population (67% < 24 years), the agricultural-based economy and the significant GDL axis isolation.

9 INE, Censo Geral da População, 2007

aggregate	distance to Caia (km)	distance to Caia (h)
Nhacuecha	39 km	1h
Randinho	48 km	1h 30m
Nsona	56 km	1h 50m
Chatala	63 km	2h 10m
Licoma	84 km	3h 20m

Table 8 *Distance trough GDL by vehicle (4x4 car or motorcycle) from principal aggregates to Caia*[10]

3.2. Examination of roadway and roadway defects

The viability of Estrada Distrital No. 1 is totally compromised during many months of the year and transit is limited to four-wheel drive vehicles. The main difficulties encountered along the way are due to poor or inadequate maintenance of the road exacerbated by natural degenerative processes. The main defects encountered are due to the presence of abundant water during the rainy season (900mm/year concentrated from November to April). If during the period between the end of November and April the water will not allow transit mainly due to the slippery surface, during dry season, road conditions are effected by erosion, showing evident fractures in the structural mantle and localized surface erosion.

Moving from east to west, the ED1 encounters at first a wide flat area that is only a few meters above the Zambezi River (35-40 m.a.s.l. compared to the 30-25 m.a.s.l. of the river). During the wet season, transit on the ED1 is already compromised on this first section, being the same level as the surrounding countryside and often flooded by heavy rains. After about 10km the natural terrain rises abandoning the area of influence of the Zambezi River. At this point, the road gathers approx. 25 m in just over a kilometre (average gradient of 2.3%). Over the following 35km up to Licoma, ED1 has an altimetric inconstant trend with the tendency to rise to a maximum of 185 m.a.s.l. near the crossing of the Mepuze (155 m.a.s.l.). The main defects that occur along the way are, in order of importance: surface erosion, surface slipperiness, presence of holes, inconstancy of resistant layer, presence of ruts from the passage of heavy vehicles and inadequacy of structural layer. In addition to these road defects, river crossing during the rainy season is precluded.

10 *“Local Development and Spacial Planning in Developing Context: an Executive Plan of The Plano de Uso da Terra in a Rural District of Mozambique”*, Isacco Rama, 2014

As seen, defects can be of different natures and suggest different design approaches. For ED1, transit is affected basically by two main factors: presence of water on the road surface and crossing of secondary water courses. Aside from these, crossings of Mulala and Mepuze rivers are at the present moment nominally in the preliminary design and construction phases.

Going back to road defects, the presence of water causes principally erosion and slipperiness of the surface. This second defect is the more frequent as the wearing course is composed of fine-grained soils (silts and clays). The interaction of these with water during the rainy season gives rise to a highly plastic layer that can measure up to 20-25cm, precluding the passage of all sorts of vehicles. This phenomenon has been observed both in the low area adjacent to the Zambezi, and in lowland areas in the proximity of N'Sona and Chatala where it is associated with the aggravating circumstance of a longitudinal gradient /slope of the road higher than approx. 5/8%.

With regard to secondary water courses, these cross orthogonally the ED1 and during the rainy season collect water from the corresponding basins (10km2 average size). A typical crossing during the dry season is represented in figures 9 and 10.

> Suggested material: “The Structural Design, Construction and Maintenance of Unpaved Roads”, Department of Transport, Pretoria, Republic of South Africa, 1990, is the South Africa legislation reference for unpaved road design. See appendix 11.

Figure 9 *Secondary water course crossing during dry season*

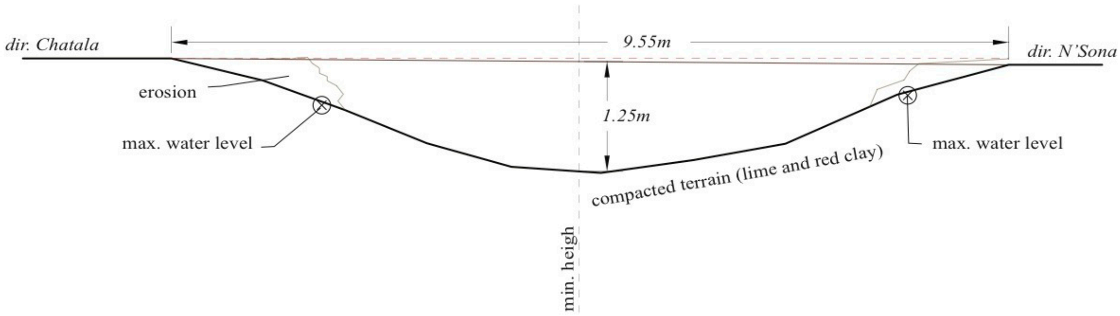

Figure 10 *metric survey of a secondary water course crossing with ED1*

Figure 11 *Most common defects associated with dirt roads in Southern Africa.*

From top-left: dust, pothole, tracks, mud (slippery surface), longitudinal/transverse erosion, superficial undulation

Slipperiness and slipperiness associated with longitudinal slope involve approx. 25 km of the ED1, namely more than half of the total road (58.2%). These two major defects, represent a limit for transit both seasonally and yearly. Moreover, the absence of structured crossings of the secondary water courses is a total obstacle to transit in the wet season, and represents a major obstacle during the dry season. In fact, crossing of these courses represents a serious problem for ED1 throughout the year.

specification		notes
soil type	silt, red clay	with heavily saturating effects
rain (mm/y)	984 mm/y	concentrated between November and April
considered length of Mepuzi river	36 760 m	see appendix 3
average considered steepness of Mepuzi river	0,39 m/km	on the considered river length
size of considered Mepuzi water basin	312.5 km^2	see appendix 3
n° of secondary water courses crossed by ED1	8	see appendix 5
average size of water basins of secondary courses	10.0 km^2	see appendix 3
average steepness of secondary water courses	0,47 m/km	-
expected max. speed on ED1	50 km/h	-
expected max. number of vehicles/day for ED1	12 vehicles	-
expected max. weight of vehicles for ED1	7.5 tons	small truck for commercial purpose

Table 9 *Synthetic table of element for ED1 road deign*11

3.3. Technical solutions adopted

The design of the road section will address the issues raised in the previous paragraph. Design choices have been made considering above all the low-volume, low-transit, low-technology, low-income context. Specifically, with reference to the relief of defects along the ED1 (see appendix 5), four main unmetalled road sections have been formulated, namely:

11 *“Local Development and Spacial Planning in Developing Context: an Executive Plan of The Plano de Uso da Terra in a Rural District of Mozambique”*, Isacco Rama, 2014

- model section
- embankment section (km 0.00 → km 9.60)
- longitudinal slope section (gradient >5/8%)
- secondary waterways crossing section (punctual)

These 4 design solutions will be briefly described below. Based on the cognitive framework offered, students are encouraged during the homework activity to propose alternative solutions that can subsequently be discussed in plenary.

3.4. MODEL SECTION

The model section for ED1 is constituted by a 150mm thickness compacted soil on which lays the structural gravel-made basic course and, above, the wearing course. The resistant substrate, consisting of fine-grained soil found on site and compacted, provides the road with the necessary inclination for the proper disposal of rainwater during the wet season. The presence of lateral ditches allows the flow of such water to the natural course. Given a required low-volume transit, the width of the road will be 3,75m while the width of the road-shoulders 0.5m each.

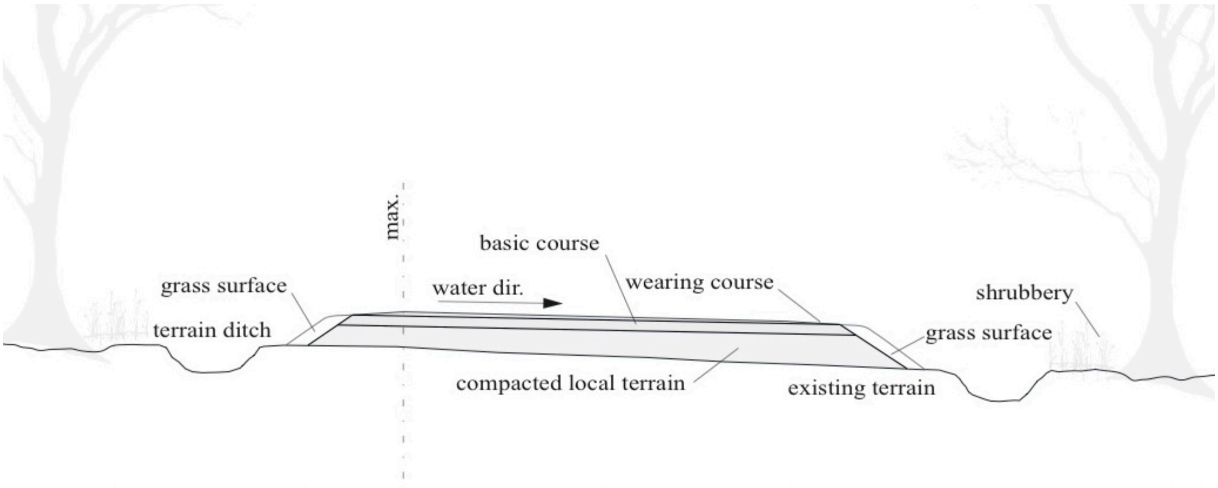

Figure 12 *schematic model road section for ED1*

3.5. EMBANKMENT SECTION

As seen, from km 0.00 to km 9.60 ED1 runs at ground water level in an area where heavy summer rains are not absorbed by the soil. Effects of the presence of water on the road have already been described and the most suitable solution to these is to raise the road from the ground level. A trapezoidal cross section of the embankment is constituted basically by local soil. Base course and wearing course are finished with multi-granulometric gravel12. At intervals of 500m are placed transversal conducts to allow the passage of water.

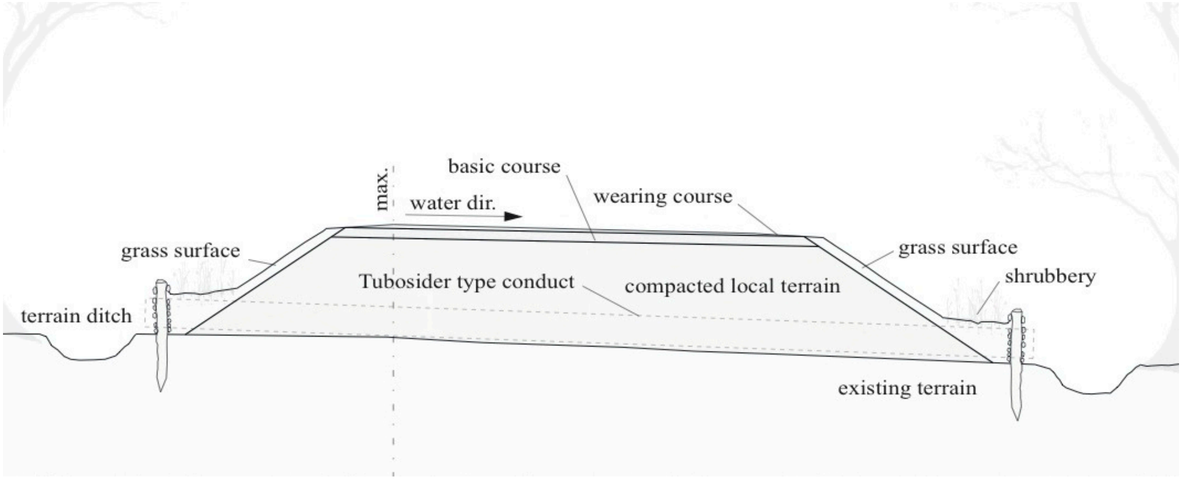

Figure 13 *schematic embankment road section for ED1*

3.6. Longitudinal slope section

The slipperiness defect is encountered where ED1 crosses flat terrains with a tendency of water accumulation. In addition to direct meteoric water, seen in the proximity of the current route with the river, possible overflowing of the Mepuze where it coincides with secondary courses can affect the natural water-flow negatively. The fundamental design indication for these road stretches is to decrease the longitudinal inclination of the track and where necessary to insert transverse drains in order to facilitate the flow of water from the wearing course. In addition, it is suggested that in flat terrains and where necessary, the thickness of compacted local-soil sublayer is brought to 15-20 cm.

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12 *The Structural Design, Construction and Mantainance of Unpaved Roads*, Department of Transport, Pretoria, Republic of South Africa, 1990

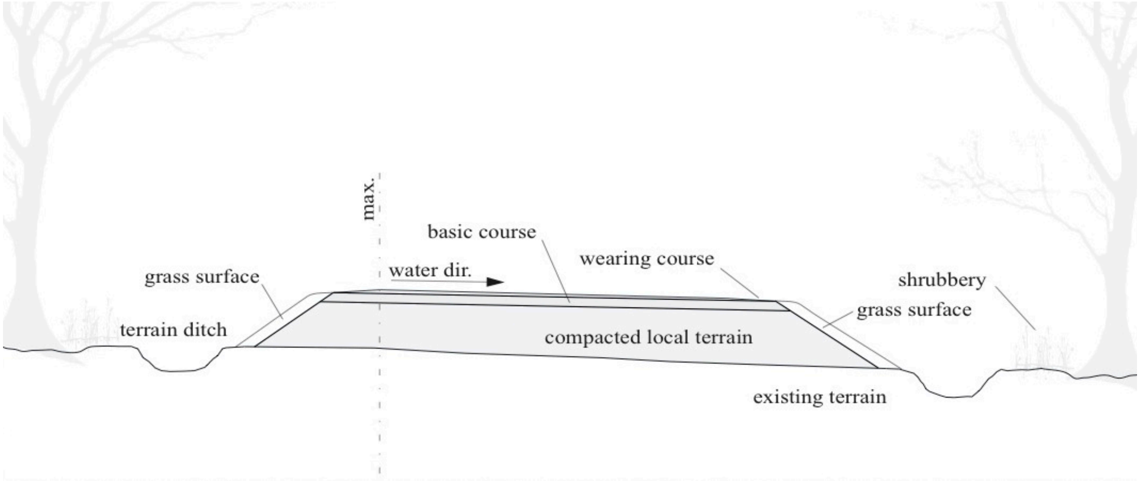

Figure 14 *schematic road section for longitudinal slope for ED1*

3.7. Secondary waterways crossing section

The bed of these courses has never been protected and their cross section has varied much over the years. It can change structure mainly because of water erosion. Given the small size of the intervention and the need of a simple implementation and low-cost solution, it was decided to have recourse to the use of corrugated steel pipelines over which to pass the road. These ducts ensure the passage of water and at the same time allow the transit of vehicles of mass also higher than the required (exceeding 7ton for a lowered section of 1,0m of light). This type of conduct is produced all over the world under different commercial names and is also widely used in Southern Africa. Particular attention should be paid to the protection of the riverbed for a length of 5m upstream and 3m downstream from the crossing.

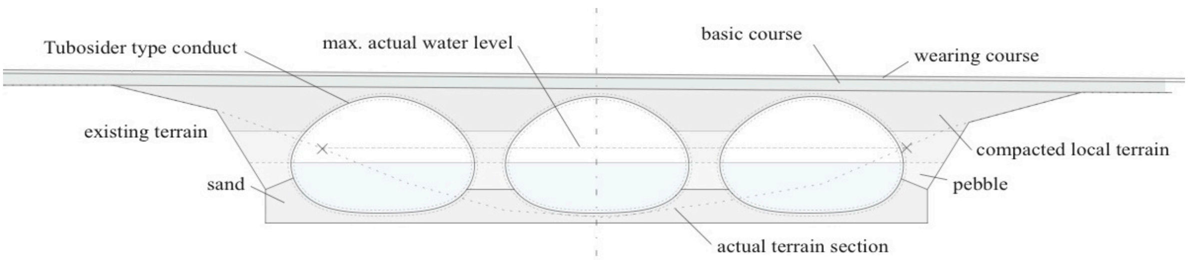

Figure 15 *schematic transversal section of secondary water courses crossing ED1*

Suggested class discussion: with reference to the knowledge framework offered and the disciplinary background achieved, what alternative road section design would the students propose? See homework activity.

As for the planimetric layout of ED1, it is suggested to follow to a large extent the track of Portuguese origin along which the road runs today. An exception to this indication is for the crossing of the scattered human settlements between the aggregates of Nsona and Chatala. Along this length, the proposed route does not run on the previous track but deviates from the settlements and from river Mepuze, altimetrically considered to be too close to the road.

3.8. Synergies achieved with the roadway

Through the construction of the new ED1, it is expected to achieve among other positive effects, the following results:

- Increased trade in agricultural products
- presence of new products on local markets
- presence of new investors in agriculture/forestry/tourism
- reduction of transport costs/time
- reduction of the price of goods
- better connectivity with major centres for medical emergencies and for specialised medical examination
- local presence of skilled medical personnel
- greater possibilities for accessing high-grade education for locals

Finally, given the high number of students, patients and scattered settlements, and the characteristics of each aggregate, the expansion of local service centres is of fundamental importance. In particular, it is important to follow local territorial vocations: Nsona with an educational calling and Chatala with a health calling.

> Suggested class discussion: with reference to the knowledge framework offered and the disciplinary background achieved, what undesirable lateral effects could the implementation of ED1 introduce to GDL? See homework activity.

4. Homework activity

Students are divided on the basis of their expertise and interests. Each group has a proposed problem to solve with reference to:

- technical alternatives for the ED1 design and or planimetric ED1 layout (for students confident with road infrastructure design);
- size and location of services to the population (services network design);
- identification of the expected benefits of the prospected solutions with respect to rural-urban linkages and welfare conditions.

In the following chapter requirements for each group of students we will specified. Note that this exercise does not provide an assessment/mark to the student but encourages students to support the choice of their proposal based on the cognitive framework offered.

4.1. ED1: PLANIMETRIC LAYOUT AND TECHNICAL SOLUTIONS

Specifically, students are required to verify the quality of the solution offered in the Case Study and to formulate alternative solutions to the ED1 planimetric track layout. Essential elements for the chosen formulation are: (1) distance to the river Mepuze, (2) relative location of aggregates and scattered settlements. The suggested layout is shown in Appendix 7 and Appendix 9.

The design sections for the ED1 have been described in the previous chapter. The technical solution is based on the context description made at the beginning of this Case Study. Students are invited to design alternatives to the proposed road sections, both in the use of materials and machine technology. Essential elements to be considered are: (1) use of local materials (soil, gravel, wood), (2) low-budget of the solution offered, (3) ease of implementation.

4.2. SERVICES TO THE POPULATION

The size of the network of services depends largely on the number of potential users that each service may have. On this principle, and on the necessary quality of service offered, is based the proposal to make Nsona an educational node and Chatala a healthcare node. For both nodes an increase is expected in numeric capacity and an improvement in quality of service. As shown, areas are found where the shortage of protected water sources is a critical problem for the population, as well as the lack of basic products due to the absence of local markets. The proposed reorganization of the services network for GDL is shown in Appendix 3 and Appendix 8. It is based on the cognitive framework provided in chapter 1 and emphasizes the priority of each single intervention.

Given this description of the context, students are asked to propose any alternative configuration of the network of public and private services that can meet the needs of the population for now and in the near future. Essential elements for this are: (1) identification of the most critical areas on the basis of the distribution of the population (Appendix 1) and the current network of services (Appendix 2), (2) careful analysis of travel times to access the services. In this sense, the joint reading of the functional restoration of ED1 and the proposed revision of the services network is necessary to obtain an holistic overview of the GDL system.

4.3. EXPECTED BENEFITS IDENTIFICATION AND CLASSIFICATION

As previously mentioned in the Case Study the synergies expected thanks to the joint process of functional restoration of ED1 and revision of the network of services to the population have been highlighted. The joint design of infrastructure and services network offers to the local population an enormous amount of benefits. As an example, thanks to the new road, there is a reduction in time for transporting goods along the GDL as well as an increase in the access to specialist health services for the population. In this last proposed exercise, the student is required to identify, justifying each one, the expected benefits of the joint design. It is also asked that they relate consequentially to each other such benefits and study any adverse effects related to the incompleteness of the proposed solutions.

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APPENDIXES

appendix 1: human settlements for GDL (cartography 1:50.000)

appendix 2: distribution of services for GDL (cartography 1:50.000)

appendix 3: proposed distribution of services for GDL (cartography 1:50.000)

appendix 4: water basin of the Mepuze River and secondary water courses (cartography 1:50.000)

appendix 5: photographic map of actual defects along ED1

appendix 6: in-site survey of present defects along ED1 (cartography 1:50.000)

appendix 7: proposed planimetry design for ED1 (cartography 1:50.000)

appendix 8: proposal for services and infrastructure for GDL (cartography 1:50.000)

appendix 9: schematic analysis of services and aggregates of GDL

appendix 10: functional scheme of services and aggregates of GDL

appendix 11: “The Structural Design, Construction and Maintenance of Unpaved Roads”, Department of Transport, Pretoria, Republic of South Africa, 1990.

Appendixes 1 to 10 are taken from I. Rama, 2014, Local Development and Spacial Planning in Developing Context: an Executive Plan of The Plano de Uso da Terra in a Rural District of Mozambique.

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