

International Conference – Green Urbanism, GU 2016

Health System Planning. A methodology to locate Social and Health Structures in Developing Countries

Domenico Chizzoniti^{*a},

^a Politecnico di Milano, Piazza Leonardo da Vinci 32, Milan 20133, Italy

Abstract

The subject of this research is the identification of an experimental method to locate social-sanitary structures in some countries with situations of great emergency. At the beginning, this research analyses the collection of some data related to main characteristics of emergency areas, such as population density, health care facilities, environmental situations, proximity of the rivers, availability of infrastructure, settlements, floods and characters of the site.

Through this experimental method, each data allows to realize a map, which shows the places where are located the areas with major problems related to that specific factor. The results of each map can be compared and summarized into a complete table that allows to realize a final map with the worst situations of each areas (“stress” areas), that require priority interventions.

Finally, by recognizing a long-term strategy, this research identifies a precise case study to verify this experimental method.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the organizing committee of GU 2016

Keywords: Methodology; social and health structures; system planning; developing countries.

1. Introduction

The health system planning based only on the construction of the building (typological space, dimensions, construction techniques, materials, etc.) would give too poor results, since the health facility will fail to function properly if we do not take into account other surrounding factors. It is therefore necessary an integrated planning process that takes into consideration the diseases to be treated, the area of influence of the health facility, the resources available on site, the quantity and quality of the medical staff. These main factors will have to be arranged

* Corresponding author. Tel.: +0-0000-00000.

E-mail address: domenico.chizzoniti@polimi.it

through a methodology that links each of them [7]. A plan for health facilities is an integral part of a global health strategy; it should also be developed in relation to multi-disciplinary approach of national planning. The principal functions of planning are the allocation, organization and evaluation of resources (human, technological, physical), which are defined equally for all areas. The development of inappropriate buildings is often due to the lack of well-documented guidelines; this absence hampers the work of architects and planners [4]. The lack of the current system can be summarized in these steps:

- the planning is based on arbitrary priorities with little foresight in programming and to the health facility management methods;
- health facilities are built without proper planning as a response to an immediate need.

The construction planning process is therefore uncoordinated and requires an integrated design [8]. However, the production of the most relevant publications has led to a beneficial effect in the way of thinking, therefore now there is a more solid basis for establishing advanced guidelines, which help to plan logically, easily identifying problems and solving them rationally.

2. Research objectives

The objective of work is to define a methodological criterion for locating the Health Post network in rural areas of the Third World (Fig. 1).

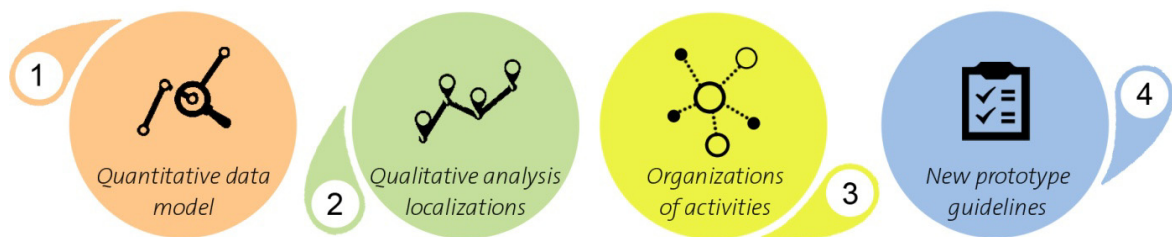


Fig. 1. Methodologies for health system planning

- A settlement strategy through quantitative data to locate Primary Health Care facilities on the rural areas of developing countries.
In this field it is important to identify the area to work on; collect data about the disease characteristics, the population density, the health care facilities, understand the environmental situation, etc. in order to extract quantitative data.
- A locating process through qualitative choices.
The numerical data obtained should be considered for locate the health structures from a critical approach that evaluate the quantitative data through the qualitative choices: proximity of the rivers, settlements, floods, characters of the site, availability of infrastructure, etc.
- Methods to identify the activities, functions and cultural local habits.
Before describe the prototype construction, it is important to define the catchment area of the health facility for identify the different activities to be performed inside, according to the population that revolve around to the health post. We should also understand local cultural habits to figure out how to organize the internal and external spaces of the centre.

- A criterion to define the guidelines for the health architectural prototype.
The final phase is focused on settlements and cultural aspects related to the architectural issue. The attention of typological choices and the figurative architectural space, takes into consideration the cultural and technological traditions on site, involving the local community. The new construction system should comply the characteristics of flexibility, modularity, aggregability and reversibility.

The goal of this research is therefore to create a construction process able to complete the peripheral segments of care even now lacking of health systems employed in many developing countries: from the rural areas of sub-Saharan Africa to the rural areas of Latin America and suitable for exporting to other countries with high social marginalization. This paper focuses on defining a methodology for the first two points, or rather an integrated planning process to locate the PHC facilities through quantitative data and qualitative analysis of the site.

3. Method

Whereas hospitals are located in towns and mainly serve urban settlements, Health Posts have to be placed in peripheral areas and serve peasants. Before analyzing the functional aspects of the health facility, it is important to choose the area where it will be placed. The health planning methodology used in this research takes into consideration the localization method of the architectural thesis of Enrico Orofino published in 1983 [7]. The exact position of the structure must not only be chosen on the basis of physical factors (such as road access) because it is not able to verify the areas requiring a priority intervention. The knowledge of the area consists of the systematic collection of data and information relating to the resident population, the occupation of the soils and their use, the characteristics of the building and services to the population (primary and secondary infrastructure); in the elaboration of thematic maps that summarize the contents [6].

First, to do this in a short time was necessary to collect data: population density; water supply; health facilities coverage; access to health care facilities and primary schools.

The health facilities planning can be performed well, only when the necessary data are available to create the ‘local model’ with realistic criteria. For each of factors is given a score; the minimum score is attributed to the factor that has the maximum value. For example, the wells are divided into functioning (score 1), to restore (score 3), to build (score 5). To the factors such as the population density, it is necessary to divide it into 5 classes of the population: very low (score 5), low (score 4), scarce (score 3), high (score 2), very high (score 1).

But in order to exactly define the weight to be given to each of these factors, we can do it on site (if possible), interviewing local people, trying to understand their needs and their requirements. Inter-views can also be made preparing questionnaires to accelerate data collection and asking to local people to give a value (from 1 to 5) for each factor. The weight is the average judgment for each factor.

The methodology involves dividing the map of the identified area with a grid (of appropriate size relative to the scale of the map). For each indicator must be made a map, which shows where are located the areas with major problems related to that specific factor (highlighting the “squares” of the grid with colors or different graphics). Afterwards, comparing the maps of each factor should make a qualitative analysis. The results of each map must be compared and synthesized into a summary table (see table A).

Table A. Total score for each square in the map

FACTORS	A _x	B _y	C _j	E _z	F...
	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS
Population density
Water supply
Health facilities coverage
Access to health facilities
...
SCORE

Each rank score has to be divided into classes (a: 0-10; b: 11-20; c: 21-30; d: 31-40) and for each class should be identified some squares where through the participatory survey, we can define the weights. So, the next step is to identify the relative weight of each indicator through a ranking depending on the case study analyzed (see table B).

Table B. Identification of the “stress” area.

FACTORS	RANKING WEIGHT	A _x	B _y	C _j	E _z	F...
		RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS
Population density
Water supply
Health facilities coverage
Access to health facilities
...
STRESS SCORE

By multiplying the ranking weight of each factor with the Score of each square we obtain the areas with the worst situation (“stress” areas). The final step is to represent a last map through the stress score obtained for each square. The stress score should be divided into groups that show graphically the different levels of stress areas obtained in which we must act. In conclusion, this methodology aims to locate the basic health units in the areas with worst situations, close to main rural infrastructure networks, not far from villages, to reduce the impact of the distance between the residence and the peripheral health facility.

If the distance between villages and Health Posts increases, the health care utilization decreases consequently, also because in developing countries the means of transportation most commonly used is ‘walking’ and roads are not paved; this makes it more difficult to reach basic health facilities by increasing the mortality rate of the local population. A health facility acts as a pole not only for attracting people but also for irradiating services on the territory.

Therefore, it has to promote settlements, including all the activities needed by the population, such as health facilities, schools, markets and water wells, in order to ensure health and hygiene in villages (Fig. 2). This fact does not only implies that the location of the construction unit should be barycentric with respect to the catchment area, but it also implies that only few services will be located in the center.

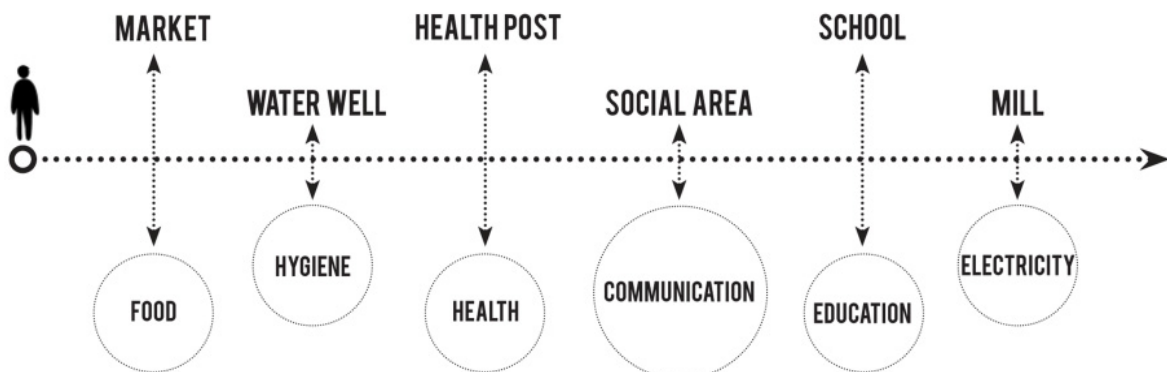


Fig. 2. Network of services implementation

4. Case study

Among the ways of understanding the Primary Health Care, the choice has been to focus the attention on the structures of health facility in the contexts of Sub-Saharan Africa that could be exported in other developing country. In particular, the city of Caia in Mozambique was chosen as a case study to test the health system planning explained in the previous paragraph. The area to be considered as a case study concerns the territories on the road axis along the trajectory called GaDe-Li (GambaDeve–Licoma, named ED1, Estrada Distrital n°1). The ED1 runs east-west parallel to the river Mepuze. Along the way it crosses important centers such as Nhacuecha, N'Sona and Chatala (Fig. 3).

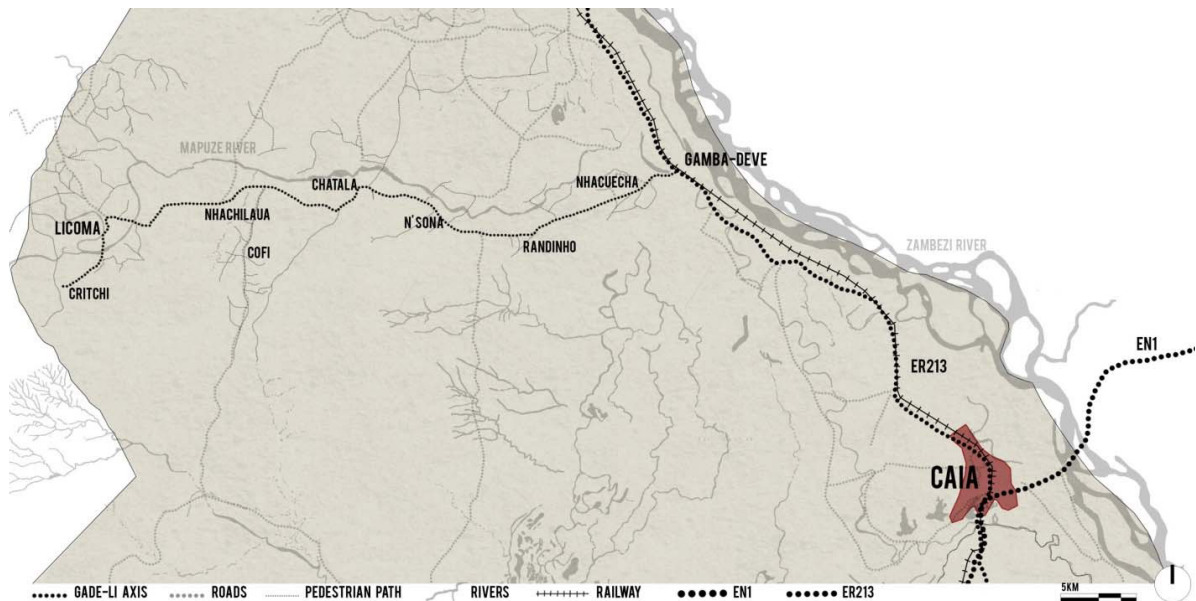


Fig. 3. Urban setting of Caia, Mozambique

The first approach is to COLLECT DATA along the axis Gamba Deve – Licoma. These DATA were taken from the research thesis of the engineer Isacco Rama (DICAM-University of Trento) [9]. A research team of the DICAM department (Civil, Environmental and Mechanical Engineering) of the University of Trento, coordinated by Professor Corrado Diamantini, have drawn up guidelines for land use planning in Mozambique: such as the Plano de Ordenamento Territorial da Vila de Sena, the Plano de uso da terra of the Caia district, as well as the Plano de Ordenamento Territorial da Vila de Caia. In his work, Isacco Rama analyzed in detail a project proposal implementation of the Plano, giving the district a tool to improve the system of services along the axis. The first DATA collect are the main diseases in the selected area and more in general in Sub-Saharan African. The main problem in African countries is to fill the gap between curing illness and preserving health. In addition, according to healthcare providers, aid organizations and entrepreneurs, one of the biggest factors hampering Africa's ability to face its multiple health challenges is a structural one. The problem is that all the healthcare systems remain focused on acute, short-term treatment, on fighting the traditional battles against infectious and tropical diseases, diarrhea, as well as maternal and child mortality. The approach towards primary healthcare is changing due to the growing amount of chronic conditions and the increased populations coping with diseases for longer periods. Hence, new emphasis is put on preserving good health instead of investing in big and expensive new structures. In most developing countries, the health care system has the task to increase the community aware-ness of the causes underlying diseases. According to the Health Situation Analysis in the African Region, (Atlas of Health Statistics 2011 by World Health Organization), the disability-adjusted life-year (DALY) provides a consistent and comparative description of the burden of diseases and injuries needed to assess the comparative importance of

diseases and injuries in causing premature death, loss of health and disability in different populations [1]. The DALY extends the concept of potential years of life lost due to premature death to include equivalent years of ‘healthy’ life lost by virtue of being in states of poor health or disability. These may include domestic causes such as contaminated water, lack of services or sewerage, waste disposal, lack of attention to personal hygiene and preservation, processing and preparation of food.

The methodology was applied by dividing a map of the axis Ga De-Li with a grid of 5km x 5km, inasmuch it would be better locate the primary health care unit no further than 5km from neighboring villages. Each Health Post should thus be distributed rationally within a catchment radius which in any case does not exceed 10-15km [3]. According to the data collected in the thesis, I identified ten indicators and for each of them has been done a map. Below are listed methodological analysis applied only to certain indicators, to better explain the process.

4.1. Population density

The map of density population was divided with a grid 5km x 5km to identify five different classes of population density; to judge the number of population were counted the Mudzi (a set of huts that belong to a family) inside of each square (Fig. 4).

- 1 = very high (81-100 mudzi).
- 2 = high (61-80 mudzi)
- 3 = scarce (41-60 mudzi)
- 4 = low (21- 40 mudzi)
- 5 = very low (0-20 mudzi)

The result shows where there are located the most populated areas and which are not (Fig. 4).

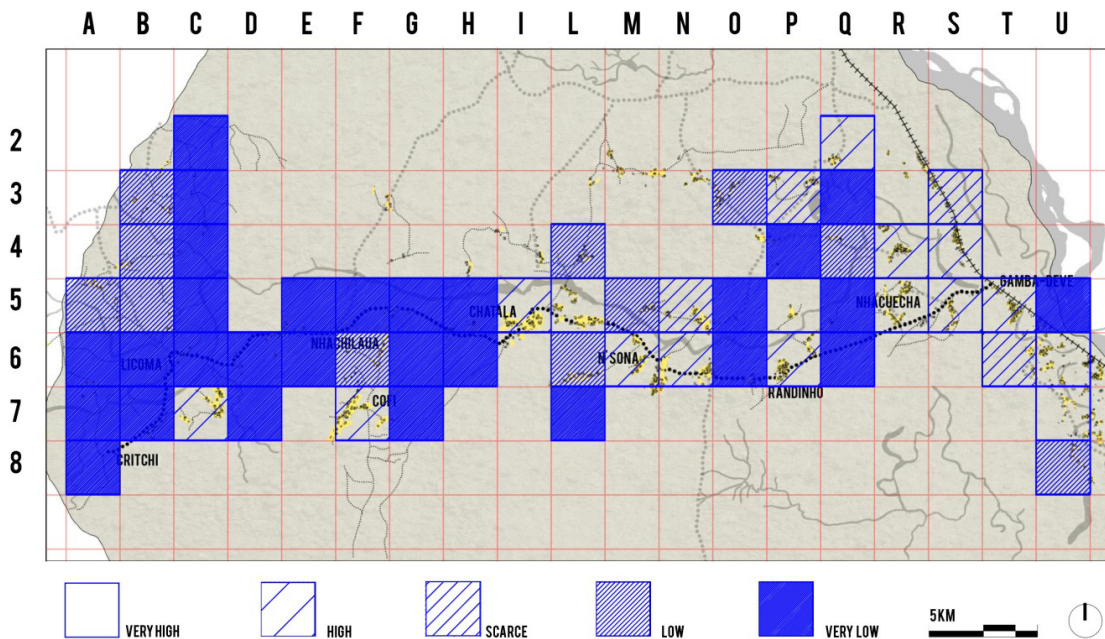


Fig. 4. Distribution of population along the axis

With an area of 3,542km² and a population of 115,612 inhabitants (2007) Caia is one of the most densely populated rural districts of Mozambique (33 people/km²). The population of the district is mainly young, under the

age of 24 years old. The total population of the three centers (Nhacuecha, N'Sona and Chatala) amounts to 10,137 inhabitants and represents 8.7% of the population of the district of Caia. The most populous one of them is Nhacuecha, but it includes an area along the ER213, distant from the axis GaDe-Li, which belongs to the axis Caia-Sena. The total area amount to 450 km² while the average density is equal to 23people/km². Compared with the District, the data of GaDe-Li axis show sparsely populated area, and a growth of population far above average. Along the ED1 there is a fairly homogeneous population. The settlements are distributed on both sides of the road. The only exception is represented by the agglomeration at N'Sona-Chatala, which is configured as an area of increased density of population, offering even more services.

4.2. Water supply

The water resource is a significant presence in proximity of populated areas. The wells along the axis are not built in masonry, but are ephemeral structures that can change location. Often they are only holes made in the sand near the river. Most of the wells are equipped with a manual pump. However, these wells have some problems: the distribution network is not homogeneous if compared with the population and there are vast populated areas covered by malfunctioning wells. These areas are mainly located between Nhacuecha - N'Sona and between Nhachilaua - Licoma. In poorly accessible areas, the wells have difficulty servicing related to the lack of maintenance, as well as the difficulty of finding replacement parts. Moreover, often the well water is being contaminated because the pumps take water only from the superficial layer. The wells are divided in three classes (Fig. 5):

- 1 = functioning
- 3 = to restore
- 5 = to build.

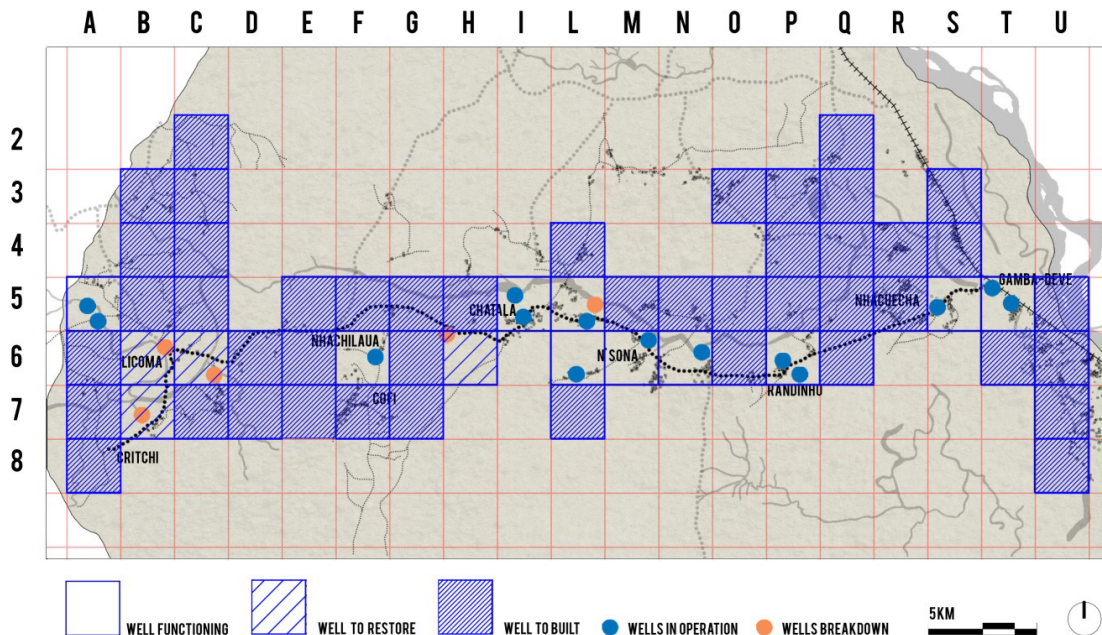


Fig. 5. Water supply along the axis

4.3. Health facilities coverage

Along the 44.5 km of development of ED1 both public and private services are distributed. Among the first public services there are schools and small health centers (Centro de Saude e Posto de Saude). The health centers network in rural areas is structured on three levels, starting with the most peripheral there are: Posto de Saude, Centro de Saude and Hospital Rural.

- The first one is at a basic level, to ensure primary health care needs and providing some basic drugs.
- The second one, at an intermediate level, is the structure on which the rural health network is based and requires the presence of qualified health workers.
- The Hospital Rural is the most complete local structure. It hosts more wards, and medical staff is specialized in many areas of medicine such as surgery.

For health units, the area concerned has a satisfactory distribution in terms of location and the presence of facilities in the area. Along the axis there are health units at Gamba-Deve, Randinho, Chatala and Licoma. Among these, the facility Randinho only is a Posto de Saude, while the others are Centro de Saude.

The only Rural District Hospital, where the complicated births and sicker patients are transferred, is to Caia. The work performed by “Doctors with Africa–CUAMM” is particularly significant for the District Hospital in Caia: the first Italian organization that invested in the promotion and protection of the health of African populations. Alessandra Cattani, a surgeon of CUAMM worked for the construction and launch of a new hospital in Caia and for staff training. Now, thanks to Alessandra Cattani, the district has a real hospital and not merely a "health center".

The ranking of health facilities was divided into three (Fig. 6):

- 1 = the existing facilities of intermediate level (Centro de Saude)
- 3 = the existing structures of basic level (Posto de Saude)
- 5 = health facilities yet to be built.

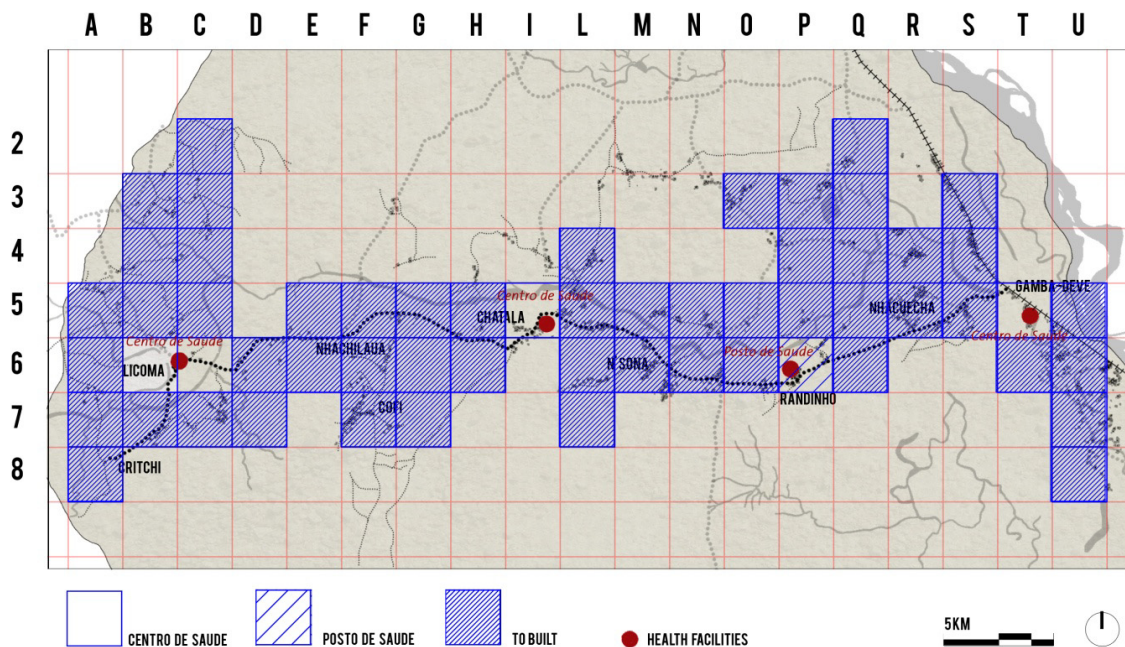


Fig. 6. Network of health facilities along the axis

Along the axis there are:

- Centro de Saude of Gamba-Deve: is considered part of the axis Caia-Sena, but also families of Nhacuacha, Conge and Randinho also gravitate to this center, which is currently one of the best equipped of the area, although there is no allocated health staff, but only one hospital assistant;
- Posto de Saude of Randinho: is a health facility support, no staff is constantly present, neither health nor attendant.
- Centro de Saude of Chatala: is the referral facility for the wide area that includes Randinho, N'Sona, Chatala, Nhachilaua and also for some families living across the river Mepuze. It was built recently and is quite well equipped. Here a nurse and an attendant work;
- Centro de Saude of Licoma: is theoretically a construction like that of Chatala but, as in Deve, no health staff is allocated. However, there is an attendant.

The population that is distributed in the Centro de Saude of Gamba-Deve and the Centro de Saude of Chatala amounts to approx. 30% of the population on the axis GaDe-Li; while in the Posto de Saude of Randinho and the Centro de Saude of Licoma is around 20% (PDTU 2012).

The distribution of services generally depends on the presence of the population. However, some exceptions might occur. In particular, the network of health facilities is absent in the settlements of Nhachilaua and Cofi. Along the axis, there are more populated areas covered and areas not covered by the services. The coverage currently provided by health facilities to the population is quite critical. It is observed that 24% of the population along the axis has neither a complete support of qualified staff or access to health facilities, and only 42% have incomplete health coverage. A big problem of health units is the shortage of well-prepared medical staff next to the low availability of medical and pharmaceutical supplies.

4.4. Access to the health facilities

The access to the health facilities should be estimated according to the time to reach them. The time people should spend in reaching a health care is divided in five classes:

- 1 = reach the health facility within 5km
- 2 = within 10km
- 3 = within 15km
- 4 = within 20km
- 5 = within 25km

For other factors (primary schools coverage, access to primary schools, local markets coverage, access to local markets, mills coverage and the access of mills) the methodology used was the same that was applied to health facilities (see all the maps attached at the end of the paper). It tried to give an uniform assessment for all factors to define a reliable model. The ten maps were compared, and it was identified a rank score for each factor. The rank score range was divided into classes:

- a = 0-10
- b = 11-20
- c = 21-30
- d = 31-40

and for each class, some squares have been identified where it was possible to define the weights.

By multiplying the ranking weight with the score of each square we obtain the “stress” areas. The result of the comparison between the maps is summarized in the following table C (the full table is attached at the end of the paper).

Table C. Identification of the “stress” areas

FACTORS	RANKING WEIGHT	A5		A6		A7		A8		B3	
		RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS	RANK STRESS		
Population density	13	4	52	5	65	5	65	5	65	4	52
Water supply	18	1	18	5	90	5	90	5	90	5	90
Health facilities coverage	15	5	75	5	75	5	75	5	75	5	75
Access to health facilities	20	3	60	2	40	3	60	4	80	4	80
Primary schools coverage	8	5	40	5	40	5	40	1	8	5	40
Access to primary schools	8	4	32	3	24	2	16	1	8	4	32
Local markets coverage	5	5	25	5	25	5	25	5	25	5	25
Access to local markets	5	4	20	3	15	2	10	2	10	4	20
Mills coverage	4	5	20	5	20	5	20	1	4	5	20
Access to mills	4	4	16	3	12	2	8	1	4	3	12
STRESS SCORE	100	40	358	41	406	39	409	30	369	44	446

The stress areas are showed in the last summary map. The map identifies the different levels of stress and the areas in which to act (Fig. 7).

- The scores are divided in six classes:
- Very high risk = more than 430
- High risk = 381-430
- Medium risk = 331-380
- Scarce risk = 281-330
- Low risk = 251-280
- Without risk = score less than 251

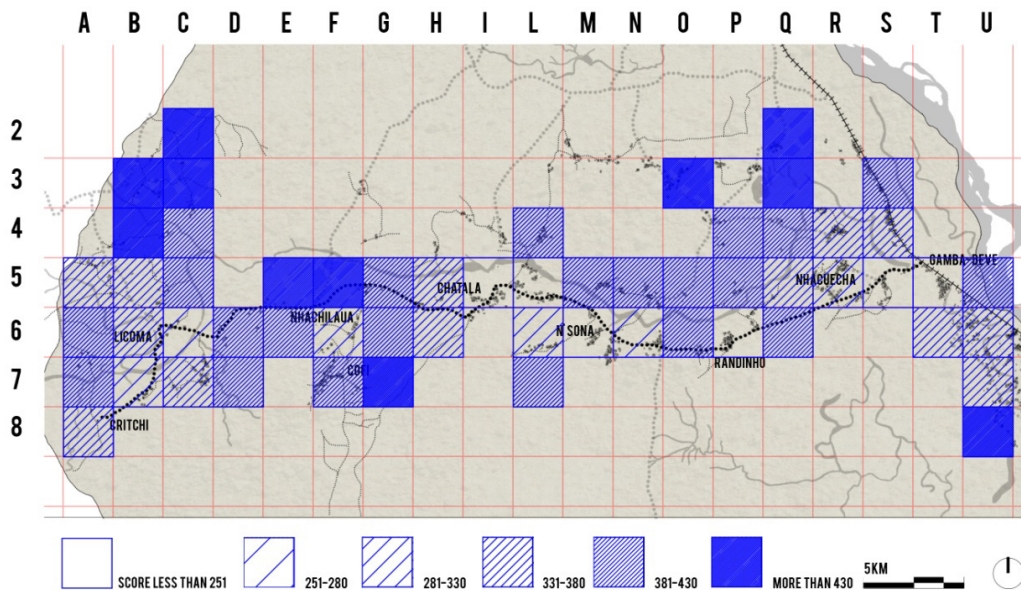


Fig. 7. Environment Stress Map

5. Results

The areas in which the services are located, are the result of a series of factors that overlapping together. For all these factors, as shown in Figure 8, the greatest concentration of services are places in Nhacuecha / Gamba-Deve, N'Sona / Chatala and Licoma (Score less than 251 and between 251-280). Licoma reveals a good amount of facilities: two schools, health center, mills, a number of protected wells. Chatala / N'Sona work in complementary way: in Chatala there are the largest number of services and in N'Sona there is the greater and the better school on the axis.

The cluster Nhacuecha / Gamba-Deve is characterized by the presence of both commercial activities and for the presence of public services. This cluster at the same time, rest on the axis Gamba Deve - Licoma that on the major axis Caia - Sena, and it gathers around him two schools and a health center. The three clusters of Nhacuecha / Gamba-Deve, N'Sona / Chatala and Licoma are well located if compared to the presence of the population.

The Environment Stress Map highlighted that the level of criticality of the populated areas external to the clusters, is due by the lack of services, especially the time needed to reach the central places. Nhachilaua and Randinho, and other areas which are located between the clusters, are part to a functioning system, but the facilities must be boosted and expanded. These areas have the problem of access to schools, basic health care facilities and local markets because the transportation and the road infrastructure do not allow families to join them in a reasonable time.

The problem of water supply is the most critical. Access to clean water is in fact one of the basic emergencies in these areas. It is globally more than one-third of households currently living away from protected sources; and above all there are large areas like Nhachilaua and Randinho, where access is completely forbidden. Here the key issue is to increase the number of sources and distribute them in the territories, in order to ensure access to the greatest number of people.

The distribution of services leaves some of the populated areas discoveries. The families of these areas, have to travel in the farthest facilities, but often they have to resort to the use of alternative services (as in the case of the use of traditional medicine in the total lack of public health services) or give it up (as in the case of school leaving) [9].

The figure 8 shows the families that live in the most critical situations. They are settled out of the cluster, between Chatala and Licoma and especially in the area of Cofi (score between 381-430 and more than 430) far away from the axis GaDe-Li. Therefore, the solution is to improve the connectivity of areas, thus ensuring travel times smaller and therefore more direct and better access to higher grade schools and health facilities. We have to work in these problematic areas for a possible allocation of the services to improve the living conditions and the wellbeing of the population.

6. Conclusion

The methodology applied in this research was useful for identifying the most deprived areas of the developing countries, in particular in the case study of Mozambique. The areas with big problems must be developed and improved for locate the Primary Health Care facilities. This health system planning can be applied in developing countries that have the same characteristics: from sub-Saharan Africa to the rural areas of Latin America. Therefore, the next step of the research will be to apply this method to a case study of Latin America, in particular through a site survey and data collection in Brazil in rural areas of Salvador de Bahia, in order to compare the two case studies. The direct experience on site allows me to interact with doctors and users of health care facilities to understand their needs and requirements. The data collected and the data analysis (analysis of case studies, defining priority and strategies, objectives and requirements of primary health care facilities) lets me to define guidelines for the health architectural prototype to respond to new medical and social need. This research tries to demonstrate that the influence of architecture can give a contribution to the method of contextualization not only related to the architectural form, but even to the constructions process.

References

1. World Health Organization. *Atlas of Health Statistics of the African Region 2014*. Brazzaville, Republic of Congo, Regional Office for Africa: AFRO Library Cataloguing-in-Publication Data; 2014.
2. Chizzoniti D, Cattani L, Moscatelli M, Preis L. Primary Health Care. Structures For The Developing Countries. In: ARCHDESIGN '15, DAKAM (Eastern Mediterranean Academic Research Center). *Current Trends And Methodologies On Architectural Design*. Istanbul; 2015. p. 117–135.
3. Feikin DR, Nguyen LM, Adazu K, Ombok M, Audi A, Slutsker L, Lindblade KA. *The impact of distance of residence from a peripheral health facility on pediatric health utilization in rural western Kenya*. *Tropical Medicine and International Health*; 2009. 14 (1). p. 54–61.
4. Kleczkowski BM, Pibouleau R. *Approaches to planning and design of Health Care Facilities in Developing Areas*. Geneva: Division of Strengthening of Health Services, World Health Organization; 1983. 4 (72). p. 01–84.
5. Kleczkowski B M, Nilsson. NO. Health care facility projects in developing areas: *Planning, implementation, and operation*. Geneva: World Health Organization; 1984. p. 1–87.
6. Minervini C. *Abecedario del cooperante, World in Progress*. Torino: Politecnico di Torino; 2008.
7. Orofino E. *Primary Health Care Centres Under Conditions of Limited Resources: A methodology for an integrated planning*. Torino: Edizioni C.L.U.T.; 1983.
8. Rahman S. *Health Facility Planning and Design: Priorities of the profession and Urgencies of Local Needs*. Singapore: Regionalism Architecture, Concept Media/Aga Khan for Architecture; 1985. p.162–166.
9. Rama I. (Bertola P, Diamantini C.). *Sviluppo Rurale e Assetto del Territorio in Contesti in Via di Sviluppo: un Pro-getto Attuativo del Piano de Uso da Terra in un Distretto Rurale del Mozambico*. Trento: Università degli studi di Trento, Dipartimento di Ingegneria Civile, Ambientale e Meccanica; A.Y. 2012-2013.