Eco building schools in remote places | Case study: Cunene, Angola

Bruno Marques, PhD
Universidade Lusíada do Porto
arqbrunomarques@gmail.com

Ângela Pinto, MArch
Universidade Lusíada do Porto
angelacorreiapinto@gmail.com

Manuel Guedes, PhD
Instituto Superior Técnico
mcguedes@civil.ist.utl.pt

ABSTRACT

The need for more environmentally responsible practices is unquestionable in the scientific community and the construction is responsible for a large part of energy consumption and consequently for the environmental degradation. It is the architecture’s duty to modify this panorama, intervening in a way that is conscious and alert, both environmentally and socially, following the development of societies and their emerging needs. This paper aims to develop an intervention strategy, in an underdeveloped region, more specifically, in Cunene in southern Angola, projecting a model of pilot schools, low cost and with low incorporated energy costs, duly adapted to the climate specificities. The Cunene is an Angolan region which obtained most of their livelihood over time with the livestock. However, like so many other places, it lacks of educational structures that enable its development and that provide higher levels of learning to the community. The project includes the use of local ecological materials such as earth and bamboo. Enabling people to participate in the entire construction process, by moving knowledge to enable the development of the local economy, particularly in the production of adobes. Therefore, the community and the man have an active key role throughout the project. The land is withdrawn from a nearby project site, by appeal to human labor instead of the machine. In the case of bamboo, it is anticipated planting a species that best suits the local climate and construction. The whole proposal is designed so as to respect the three basic pillars of sustainability: economy, environment and society. Allowing these locations to progressively develop and so that social justice can be found.

INTRODUCTION

The present case study is located in the Cunene region, in the southern border of Angola. This choice is directly related to the evident lack of educational infrastructures in the region, as well as the high number of children outside of the school system and with the conviction that it is fundamental to invest in education in order to develop populations that reside in remote locations. It is essential to the decrease of illiteracy among its people and vital to the local and regional development.

According to various studies, most of the poor population on earth lives in rural settings. In this sense, the education of the population becomes extremely important and the community must participate in this process, becoming the foundation of the local development, while promotion civic and educational developments.

GENERAL FRAMEWORK OF THE ANGOLAN TERRITORY

Angola is located on the west coast of Southern Africa, bordered by the Republic of Congo to the north, to the east by the Democratic Republic of Congo and Zambia and Namibia to the south, making a land border of 4690 km. To the west it is bordered by the Atlantic Ocean shipping line corresponding to 1650 km long. (1)

The Angolan territory corresponds to a total area of 1,246,700 km2, dividing them into 18 provinces, which in its turn are divided into 163 municipalities subdivided into communes.
The official language is Portuguese, spoken mainly in the cities. However there is a panoply of other languages used by its inhabitants, being distributed by well-defined geographical areas. The better-known languages are Umbundo, Quimbundo and Quicongo.

According to the last census in Angola, which dates from 1992, it was estimated at 10.31 million inhabitants, mostly from rural areas - about 6.159 million inhabitants - which corresponds to 59.7% of the total population.

The oscillations of the population have always been a constant in Angola, especially during periods of civil war, that caused constant displacement of the population, migrating to cities or emigrating to neighbouring countries.

Currently there is a steady exodus of younger people from rural to urban areas, in search of better quality of life, particularly due to the growing job search. So it becomes even more evident the need for emergent interventions in remote areas, unprotected and devoid of infrastructure resources, as well as becoming increasingly depopulated. This migratory population exacerbates already serious problems of uncontrolled growth in the suburbs, where extreme poverty is evident, showing serious housing, health, employment and illiteracy issues.

Several studies show that the majority of the African population is young with low education levels, a result of various factors - including the Civil War action - as well as economic and social factors, on which the action of the state is not sufficient to meet the current needs.

The climate in Angola is divided, generally, into two seasons: wet and hot summer, corresponding to the months from October to April and winter (known as cacimbo), corresponding to the months of May to September, dry with lower temperatures.

The morphology of the Angolan territory develops about 60% in highlands, which naturally influences regional climates. Cumulatively, we can see the influence of the cold Benguela current and the coastal breezes. All these factors are responsible for small local variations in climate, although the average annual temperature is high throughout the country.

**Education in Angola**

Focusing this document in our area of research: primary schools in remote environments, more specifically in the Cunene region, we realize the organizational logic of education in Angola.

The Angolan education system is divided into three levels: primary, secondary and tertiary. However, in order to reduce the deep levels of illiteracy and lack of education of a large population, noted mainly in rural areas, the subsystem of adult education emerged.

According to Trade and News Magazine, "22% of Angolan children of school age are out of school in urban areas. In rural areas, the estimate is 44%. Failure at school measured by the sum of the rates of repetition and dropout is extremely high, reaching figures of around 50% for 1st and 2nd grades. 42% for 3rd level of Regular Education. Regarding the dropout rates, the statistics presented indicate that 12.5% of children drop out of school in urban areas and 25% in rural areas (...) " (3)

It is noteworthy that the few schools operating in remote areas, hold serious construction problems, not being provided with the basic conditions for an adequate level of education. Many of these classrooms are constructed using solutions of "wattle and daub", using only local materials easy to obtain. However, the lacks of constructive knowledge, either endogenous or technical, have limited the quality and number of suitable classrooms.

Serious socio-economic problems, seen in this country, such as extreme poverty and social inequality are due largely to an inadequate education system, the result of prolonged civil war, and also due to the lack of physical structures and educational resources that enable a way of integrating active citizens in local and regional growth.
The lack of adequate primary schools subsequently condemn the formative and educational capacity of its citizens and inherently stall the growth of the country.

In remote or rural settings, this reality accentuates migration to the big cities, forcing this population to survive in the suburbs, deprived of employment opportunities or minimum health conditions, whereas if provided with adequate training in their unique environments they could secure better livelihoods and resiliency within their communities, thus enabling local development of consistent and sustainable manner as an alternative to migration to cities.

**IMPLEMENTATION OF THE PILOT PROJECT**

The proposed project intends to develop as a model for regions with the same geomorphological, social and human characteristics, duly adapted to the constructive specificities of each place.

It is located in the Catholic Mission of Okaunatoni in Cunene, southern Angola. And due to its difficult access, where most of the roads that connect to the mission are made of sand and because it is situated about 30 kilometers from the nearest locality - Xangongo, the resources and labor become scarce and difficult to obtain; there is an absence of construction companies operating in the local, or the ones that eventually mobilize to these places present honorary fees incompatible with the most disadvantaged populations. These factors, in addition to those that will be mentioned later in this article, reinforce the need for a project made by people, using locally available materials and easy construction.

The considerations / limitations with the surroundings of the project, with local populations or climate conditions are some of the criteria to be taken into account in formal conceptualization of the design solution. We intend to develop a solution that is functional, educational and acts as an empowering tool for a constructive change paradigm based on locally available materials.

We intend to use locally extracted materials, with local labor, and give men and women leading roles throughout the construction process, contributing to a more active and participatory architecture. Therefore, the communities will be taught new valances that will enable them, in the future, be able to
build their own houses as well as doing its maintenance, without being limited to the will of the government, which little supports these more remote communities.

The architecture has a key role in developing a methodology grounded in research and construction methods validated laboratorially, which will optimize techniques and local resources to build sustainable buildings at a low cost, such as the present study. The construction of pilot schools, with subsequent measurement and validation will ensure access, quality and educational equity to local populations.

The architect gains a role on this project that becomes more than an agent of change, beyond the designer role, contributing to the socio-educational integration of people and hence the sustainability of the most remote locations.

The aim of this work was to define innovative principles and essentially structural design recommendations for building cost-effective pilot schools for the regions of sub-Saharan Africa, anchored in bioclimatic principles and constructive, economic and environmental sustainability, addressing the specific conditions of each target region.

Main Planning Principles | Case Study

In this proposal we develop a series of bioclimatic principles that claim, through a rational use of natural resources, to better integrate the school building on site as well as reduce the costs of future maintenance of the same, ensuring comfortable and properly balanced environments, adapting available to local and improving their technical reality resources, so enabling them to prolong the life of the buildings.

Immediately we will consider the actual shape of the building, including its design. The solar orientation, natural ventilation and the correct choice of materials are essential principles for an integrated and properly adapted architecture.

The program of the proposed building is relatively simple, consisting only of two blocks of classrooms and a separate block with their sanitary facilities and a covered outdoor living space. Trees are to be planted in the patio, so as to ensure greater shading of buildings and, on the other hand, to ensure a slight cooling of the temperature. The shape of it will also be a simple consequence of the program itself and the choice made on the construction of the building: local materials and local labor.

The buildings will be deployed on a slightly raised platform floor level, thus protecting them from the risk of flooding - very common in the region - and secondly, to avoid the excessive wear and degradation caused by the action of water on the foundations and walls of adobe. This way the foundation and plateau will be built, if possible using stone, and in its absence, using repellent mortar in order to consolidate and stabilize, if exceptional circumstances of flooding may occur.

Figure 3 Organizational schemes of pilot school, Cunene, Angola.
The walls in raw ground work as support to a structure of bamboo which will anchor the coverage of the building, coated by sheet metal. Adequate ventilation of the building will be ensured by gables, releasing the wall of the casing, thus contributing to the cooling of indoor spaces and to reduce moisture levels, asserting the air quality and comfort.

The school will be located under the guidance recommended in Figure 5. These studies as well as showing the solar path in Ondjiva, during different periods of the year, show us which is the optimized solar orientation for this region.

Figure 5 - (a) “stereographic diagram for Ondjiva, showing the solar path in the various periods of the year” (b) optimized solar orientation for Ondjiva (5 ° C)” (4)

The special configuration responds to the better orientation of classrooms, oriented in east / west direction, with the biggest facades turning to north and south, getting the best sun protection as well as lighting. Similarly, the toilets are placed intentionally so that setting the assembly to solar radiation throughout the day and year, as it may function as a natural sterilizing action of such areas that require greater care and control of fungi. It was also ensured a covered patio to the east, as well as outdoor galleries to ensure sheltering from rain and solar radiation to users throughout the year.
As mentioned earlier, this study serve as a prototype intended to be "replicated" in other places, with human, social and economically similar characteristics. Most importantly, we must bear in mind that "new projects" have to meet with the real needs of populations and adapt to the context in which they are entered, including solar orientation, the wind regimen, the labor and locally available materials. Therefore, it will be enabling a better adaptation of the shape / design of the place where the constraints will be installed.

**Applied Materials**

The earth as a building material has been the subject of some reluctance in the target countries of study, as its use is associated with a stigma of poverty and insecurity that people want to avoid. However, it is essential to realize that this preconceived idea is anything but reasonable and realistic. Initiatives to improve these communities should meet their needs, and earth is a material that fully meets the needs of the community, with economic and environmental advantages and ease of application with hand-local labour benefiting from this.

It is a local, natural, recyclable, non-polluting and foremost reusable material. A building on earth can simply stop being and the material returns to its origin being returned to nature without intervention or expenditure of energy or human action, characterizing the earth as a material with a closed cycle. Although besides these qualities, many other criteria lead us to choose the land to the detriment of other materials.

In hot climates, such as Cunene, issues relating to thermal inertia of the materials are very relevant and should be taken into account when designing a school building. The earth has the ability to regulate and smooth the external temperature fluctuations, maintaining the coolest spaces in warmer periods and in turn, maintaining milder temperatures when the weather cools, particularly during the daytime and night time periods.

The soils in Cunene region are very sandy and as such they require a binder material that unifies the mixture and makes it cohesive, capable of being used for construction. Consequently the addition of other materials in order to correct this situation is required. It is expected to be mixed lime or cement, whichever is easier and convenient to purchase on site.

Despite the obvious durability that buildings have on earth, simply because there buildings constructed with use of this material continue to leave your testimony in our landscapes, studies have been shown that the addition of other stabilizing components prolong their good conservation and avoiding construction issues, their natural erosion, particularly that caused by water.

**Figure 6**  "Stretches of rammed earth walls exposed for 20 years to atmospheric agents: (a) wall, stabilized with 5% lime earth; (b) on the ground without wall stabilization (mixed soil); (c) Wall ashore without stabilization;" (5)
The study corresponding to Figure 6, aims to demonstrate that the addition of stabilizing elements, such as lime, protects the walls exposed to weathering, from the erosion that is naturally subject. Consequently the stabilizer prolongs the good condition of the building, providing more stiffness and durability.

Since the buildings on earth are already being disseminated in much of the territory and becoming a current practice in these environments, it is intended that the community re-acquires the right knowledge, and adjusts its implementation and that consequently there is a constructive improvement of these practices. It is not intended that these techniques are vernacular revival, but rather, to adapt to new realities to constructive development. For all that, and the current resistance observed in these locations due to the onshore construction, we propose the application of plasters in order to address the weaknesses of the material.

Traditionally, in Angola earth constructions are already built with thatched roofs, but this material presents some weaknesses at the expense of others, especially in their natural susceptibility to the possibilities of fires. Cumulatively, the use of the stem for several years, has led to its gradual disappearance, not being available in construction sites, implying major shifts to its acquisition. Still contributing to the cause of the abandonment of this material, the current population has new rhythms of life that does not allow them to do the right and necessary maintenance to keep the stem in good condition.

In contrast to stem use, we propose the use of sheet metal. This material allows for a lighter support structure, since the material itself has little weight. Its displacement and application is relatively simple and does not require maintenance during the lifetime of the building.

Even though it is not a local material and considered sustainable in origin nor incorporation associated with energy, it is affordable, durable, lightweight, flame retardant, low cost and easy to transport. The application of the coating material enables to lighten the supporting structure and by their individual dimensions of each sheet cut together, the weak points of rain and wind action.

To the support structure it will use the coverage at the expense of the bamboo wood, commonly used in the region. The bamboo has a relatively rapid growth compared to other materials, within 2-3 years it can be extracted from the site and is mature enough to be used in construction. We intend to proceed with the planting of a species in a nearby location that best suits the local weather conditions and has the height, diameter and thickness suitable to be used in the construction of the building.

Unlike wood, which requires a much longer process of growth and still requires the use of machinery to cut and modelling, thus incorporating more energy in its transformation and the consequent need for more expensive and complex equipment, bamboo uses are very simple, economical and without the need of power tools, verifying a minor impact on the environment.

After the extraction of the material - and this is in the place where it will be used - there is a mechanism of preservation, which in addition can prevent rapid degradation, since the material has little resistance to micro-organisms and insects, it will increase its durability. This process can be done in two ways: by chemical or non-chemical methods. In this proposal we will use a non-chemical process where the bamboo is stored in tanks of water and could thus decrease its starch content, which will consequently make the plant more resistant to biological organisms and increase its durability. This technique of leaching of bamboo is an ancient method and used for several years in different communities to protect the material from the draining action of organisms. However, its variation is directly dependent on the durability of the species concerned and it might turn this treatment insufficient and it is necessary to add a chemical component into the water so as to make tougher materials.

One of the objectives pursued, when the choice of materials is bamboo, is to introduce new materials, with easy extraction and handling, responsive to the needs of these communities. Since there is still a profound lack of knowledge about these techniques, the population tends to reject it, even if unconsciously, so you will need to "democratize" and promote its use throughout a process of adaptation to the material, instructing the local population so it will benefit from constructive greatness of it, as well as the possibility of its using in other capacities - not only construction, but also with applications in woodworking and carpentry, with the construction of furniture.
There are already some examples of buildings in remote means, which involve the use of bamboo to make the structure of your toppings. Among them, we highlight the Handmade School in Bangladesh by the architect Anna Herringer and the Habit Initiative Cabo Delgado in Mozambique, by the architect Roswag Ziegert. (figure 7)

(a) Handmade School | Bangladesh
(b) Habit Initiative | Mozambique

Figure 7 Bamboo structure construction by the local population

CONCLUSION

Local interventions of apparently little scale have global repercussions. It is vital that we intervene locally so that the long term scenario is different, dignifying the most disadvantaged communities.

However it is essential that the scientific community realizes that behind the choice of certain materials are rooted local prejudices that must be understood and taken down or assimilated and managed for an innovative solution that can be attractive and harmless on local traditions. The blind imposition of new solutions seen as superior risks the non-assimilation and not being fully understood by the target population. All communities have their patterns and desires that must be respected and reconciled in the intervention. Concessions on certain points of intervention should be taken into consideration, as the scientific community should cooperate and not solely teach, share knowledge and not just impose.

Photographic examples of schools considered "bio" and "eco" in remote environments advertised as examples for the scientific community are constant in failure in their places of deployment, for they were not assimilated by the population, resulting in innocuous buildings without result in pilot examples for the region. Certain orthodox and rigid solutions without added local inputs resulted in unique and beautiful examples, but not replicated, either by training difficulties of the population, or simply by their lack of identification, assimilation and understanding of forms of use, habits and customs.

It is our understanding that a sustainable conceptual solution for the measurement and scientific validations should be downstream of understanding anthropological and socio-cultural assimilation, and incorporate local religious architecture in the draft. This should just be a reflection of local and scientific assignments and reconciliations.

Acting locally avoids successive massive displacement of populations to cities and consequently decreases the informal, illegal and uncontrolled development in the outskirts of cities. Remote, inhospitable and prone to decay stands can gain new lives with this kind of interventions, that are beyond architectural, becoming social and economic transformations.

ACKNOWLEDGMENTS

The first autor, Bruno Marques, is supported by FCT – Fundação para a Ciência e a Tecnologia: Post-Doctoral Research.
REFERENCES


