Technical and Culturally Sensitive Solutions to Foster Sustainable Housing in Southern Angola

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ABSTRACT

Studying housing solutions demands a multidisciplinary concern in order to come up with comprehensive answers able to account for physical, social and cultural needs. It is, therefore, fundamental to bring up those needs into the housing creation process.

In the City of Ondjiva, in Southern Angola, as throughout the world we can observe a lack of habitability in its slum areas, associated to the existing economic conditions. In most cases the settlement isn’t provided with basic infrastructures, does not respond adequately to the climatic demands, which leads to the development of unhealthy environments. Additionally, the house in the city follows European or contemporaneous models which don’t produce culturally oriented answers for the local inhabitants. As a result, the poorest housing areas are characterized by two major inadequacies: constructive and cultural.

This proposal intends to bring into the discussion the need for architectural solutions that are culturally sensitive (user-oriented), as solely technical solution appears to be detrimental to the diversity of ways of life characteristic of contemporary cities. Furthermore, it intends to alert to the need of exploring new technologies in order to turn the expertise accessible to the housing construction current actors, in a context of great poverty.

The goal of this proposal is to create an innovative IT tool, an Expert System which will integrate both results from environmental-behavior studies of a specific cultural group, and sustainable design solutions. It will be produced as a tool to help in the design of individual housing profiles and consist on the construction of a System of Relations between three pre-established group of settings, cultural, everyday life activities and architectural, in order to find a multidisciplinary response for the problematic of housing inadequacy and lack of constructive, comfortable and hygienic conditions.

INTRODUCTION

This paper is based on a research done under the PhD program in Architecture at EPFL and IST, focused on the search for alternative solutions to foster sustainable housing development in Southern Angola. The main goal of this research is to improve housing design and construction processes in slum areas, where self-building prevails; it explores the use of new technologies in order to make expertise accessible to the housing construction current actors, in a context of great poverty. The research is addressed to the case study of self-built housing in the City of Ondjiva in Southern Angola, giving special attention to the cultural aspects of the Kwanyama People (local majority group) and to the region’s climatic conditions.

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It stands on the following premises: The poorest housing areas in the City of Ondjiva are characterized by two major inadequacies: cultural and constructive. It is therefore, urgent to find adequate cultural and technical solutions to foster sustainable housing construction.

Ondjiva, as a City, was implemented in 1915 by the Portuguese military forces and it was designed and developed according to European models as well as the housing models within the City. After almost one century it can be observed that the urban areas have developed in complexity and dimension. Levels of acculturation have also increased, but despite this process of change since 1915, the existence and search for traditional housing models persisted; strong traditional traces are still present all over the city, particularly in the poorest housing areas where traditional values prevail, reflected in daily practices and in the living space. Simultaneously the housing construction in the City poorest areas lacks of sufficient habitability conditions due to the lack of construction knowhow and due to the economical conditions in which the majority of the population arrives at Ondjiva, not allowing them to hire a constructor or to have access to better construction materials.

Cultural inadequacies

There is a great body of literature on Ondjiva and the Kwanyama region which brings to the attention, among cultural, socio-economic and migration issues, facts about the construction of vernacular housing, to be considered in this work (Estermann 1961, Monteiro 1994). There is however no information on the issue of slums in the City of Ondjiva, besides the government urban plans and reports which present a general overview on the main construction and architectural characteristics in the City (Government of the Province of Cunene 2005).

In the City of Ondjiva, self-built houses correspond most of the time to two main aspects: an urgent need for shelter (built according to the scarce economic resources) and to the perception that each one has about what should be a “better house”. Usually a better house corresponds to the houses of the wealthier people, houses constructed with more durable materials and following standard typologies (European models are the most followed). As a result, a self-built house in the poorest areas is generally a parallelepiped simply subdivided in the possible number of divisions (the most common are 2 or 3 divisions as shown in Figure 1).

Figure 1 Examples of housing construction in the poorest housing areas of Ondjiva

Nevertheless, if not in terms of house form, we find a lot traditional traits within the City, especially in the exterior arrangements and in the way people inhabit both the interior and exterior spaces. For example, the internal layout of the house consists mostly on bedrooms, which for the most traditional people, are only used to sleep at night; during the day, the interior of the house is rarely used. Instead, there are other structures that are constructed in the exterior of the house to be used during the day, which replicates the traditional habits of a vernacular housing: covered structures which serve as living rooms, named Okatala (even if sometimes there is an internal one,) or external kitchens, also with special specificities, named Epata. Therefore, where the main house building (generally a family house is constituted by more than one building) tends to follow the city social patterns, annex structures are the ones often built for specific traditional proposes or activities. As such, the main building assumes a “false centrality”, a symbolic and representative centrality, while the annex structures embrace the real family needs, tasks and everyday life practices, full of traditional and cultural significance. This conflict of social aspirations and customs (on one side the desire for wealthier houses, according to the
Contemporary society patterns and on the other side the persistence of traditional values and practices leads to great incoherence in the self-built housing structures and spaces.

**Constructive inadequacies**

Along the general lack of infrastructures related to the economic conditions, most of the buildings do not respond adequately to the climatic rigorous demands, offering unhealthy environments.

The climate of the Kunene province, where the City of Ondjiva is located, is essentially of the semi-arid type, with the rainy season coinciding with the summer months (when the average temperatures are higher). The average temperatures in the region are close to the ASHRAE Comfort Standards (ASHRAE, 2005), having an annual average temperature of around 23°C. However, in terms of maximum daytime temperatures, these are often outside conventional comfort boundaries, as well as the large temperature variations between night and day, reaching amplitudes greater than 15°C. The absolute minimum value recorded for Ondjiva is -2.3°C in June 1944 and the maximum values of 40.5°C and to 39.9°C were achieved in November 1941 and September 1964, respectively (Govern of the Kunene Province, 2005). Daytime temperatures around 30°C or more are frequent, with a drop to 10°C during the night, meaning that extreme conditions are verified, which can potentially lead to (excessive) energy consumption through the use of HVAC - unless oriented bioclimatic design strategies are applied.

In a study made under the Sure Africa project's investigation (http://www.sure-africa.org) the conventional comfort zones of ASHRAE were overlapped with the zones of influence of the various passive techniques based on research conducted by Givoni (1969). The results showed that according to its climatic characteristics, Ondjiva is under the influence of four passive cooling techniques such as day and night ventilation, thermal inertia, evaporative cooling and humidification. There is a period where heating is needed, which can be obtained in a passive way by taking advantage of solar energy, for example by orientating the building according to the sun projection or by a correct sizing of the glazed surfaces (Correia Guedes and Aleixo, 2011).

The current self-built buildings in the City usually do not present any of these characteristics. On the contrary, they commonly have no enough natural ventilation, no sufficient inertia, adequate shading or a correct solar orientation. The solar orientation is random except when it is related with traditional aspects, placing the main entrance at East. **Figure 2 show** the thermal and humidity performance of 3 different housing buildings within the city, for the period of one day; the respective buildings, among 17, were monitored with data loggers, measuring the interior and exterior temperatures and humidity values in intervals of 30 minutes, between June and July of 2013.

![Figure 2](image)

**Figure 2** Temperature and Humidity monitoring of three buildings in the City of Ondjiva
These buildings represent the worst, medium and the best types of self-building construction in the City in terms of thermal comfort. The first one, at left in Figure 2, corresponds to an urgent need for shelter and it is composed of one room only, built with zinc boards, fiber cement boards and wood or pick to stick structures. The second one, in the middle, corresponds to a medium solution, built with handmade cement bricks and uninsulated zinc boards for the roof. The third one, at right, corresponds to an improved and phased construction, which started in 2000, with the construction of two single rooms; in 2001 a small interior kitchen and w.c. were added and in 2005 the living room and one sleeping room were built. The building materials differentiate from ruins remains (stone, bricks, etc) in 2000, handmade adobe bricks in 2001 and cement bricks in 2005, and the roof is made of simple zinc boards with no insulation. The exposed measurements correspond to the part constructed in 2005.

As shown in Figure 2 the 3 buildings have a weak thermal performance. Work made on building performances analyses for the City of Ondjiva (Correia Guedes, Aleixo and Pereira, 2011) show that some of the best practices for construction are:

1. Building optimum orientation: E-W axis orientation;
2. Minimum glazing distribution to East and West facades, 15% to 30% maximum of glazing areas in South and North facades, horizontal and vertical shading devices on East and West facades and horizontal ones on South and North facades are passive strategies which improve the building behaviour;
3. Rammed earth walls on existent buildings have better performance than the usually used concrete block without insulation;

In summary, the house construction in the city doesn’t present oriented answers for either cultural (social, community and everyday activities aspects) or the buildings’ comfort needs. The buildings where the largest part of the population lives in Ondjiva, particularly in suburban areas, are still very poor, with low levels of habitability; most of the times, they are buildings that respond to an urgent need for shelter, not being constructed to last and which lack of almost all the support basic infrastructures. This brings us to the next point: “what is needed?”

THE NEED FOR WHOLE AND MULTIDISCIPLINARY ANSWERS

Solely technical solutions can be detrimental to the diversity of ways of life characteristic of contemporary cities; interior comfortable spaces will not be enough if they won’t allow the continuity of cultural specificities. For example, the houses built recently in the City by the Government for the community do not offer proper external shaded spaces for group reunions, exterior kitchens, separated dining spaces, separated husband/wife sleeping rooms neither respond to the strong hierarchies within the family. These are specificities of traditional cultural patterns that when neglected may have serious results (Rapoport, 1969). Indeed, it is in the outside space that the most traditional activities take place and annex structures are often built by the inhabitants to meet the specificities cited above.

There is an urgent need to bring whole and multidisciplinary answers to the housing processes in the city of Ondjiva, in particular to the self-building one, instead of trying to stop those processes or change their current actors. Only by reaching the individual actors is it possible to find a global answer for the improvement of the living conditions. As we suggest, it is fundamental to relate culture to the built environment on the search for culturally oriented housing solutions; but the central problem resides on how is that relation established and in the variables that are applied in the relation process: How to define the settings that make up culture? How to understand the world views and values standing behind what is called culture? How to understand which values should or not prevail in the future housing design? And finally, how to relate culture with technology?

Culturally Sensitive Approaches and Technological Answers

Culture has been one of the main concerns in the study of housing since the 1960’s when several authors began looking to the built environment as a result of many culture influences. Assessing culture is particulary relevant when trying to analyse and evaluate its impact, in this case, on housing.
The Environmental-Behavioural Studies (EBS) model from Amos Rapoport represents an important tool in analysing which factors influence the house form, allowing to evaluate those factors and to measure them in order to understand how the build environment (housing) responds to their inhabitant’s specific needs. The EBS model from Rapoport breaks down the influence of culture, on one hand as a group of social variables that can be measured within a System of Relations, and on other hand as an expression of lifestyle and values which leads to the activities happening in a specific space. For the author, the design of one space where a certain activity will take place corresponds to the specific arrangements which need to be done for the activity to happen, paying attention at the same time at how the activity is done, the meaning of that activity for the culture and its social or ritual significance (its latent aspects) (Rapoport 1988). The goal of Rapoport’s EBS model is to provide a framework for the understanding and study of the group of settings which compose the Built environment, and for the establishment of a system of relations between those settings and the latent aspects of activities, leading finally to the “housing profile” (final result).

Existing works on culturally oriented housing studies are not yet completely applied to housing design. Indeed, the existing research is more focused on housing evaluation rather than new housing conception processes (see Khattab 1993 and Sungur & Cagdas 2003). On the other hand, there are multidisciplinary approaches on housing development, but almost all of them stand in one-to-one participatory relations between the architect and the future inhabitants (UNHabitat, Diébédo Kéré). That is perhaps the most correct and productive approach but it is difficult to implement in a context of massive self-building production, at least without changing its current actors. Designing for each individual is a difficult, if not impossible, task to achieve and it is impossible to think that it would be economically viable. Therefore there is an urgent need to think on alternative solutions to improve the existing poor housing conditions in the poorest housing regions in the World; not only multidisciplinary solutions but accessible solutions and of easy application in the context of self-building housing in slums. How, then, to come up with a multidisciplinary solution easily accessible to the self-builders in a context of poverty and architects absence? How to share the knowledge?

HOW TO MAKE THE KNOWLEDGE ACCESSIBLE TO THE SELF-BUILDERS IN A CONTEXT OF POVERTY AND ARCHITECT’S ABSENCE?

First, in order to develop integrative and oriented design, it is fundamental to understand which procedures are more appropriate to share specific information, and how to make this information comprehensive and fully applicable (Friedman 2003; Akrich 1987). As Yona Friedman suggests, other languages than sole formal one of architecture must be found, which must be simple (understandable and easy to use), significant (direct, clarifying which consequences are implied in one decision made according to the plan described through that language) and interpersonal (discard form expressions that can have different meanings to different persons) (Friedman 2003).

This proposal intends to build up a similar System of Relations to the one proposed by Amos Rapoport, which will relate three pre-established group of settings, cultural, everyday life activities and architectural, in order to be able to give specific answers to the housing construction. Plus, it intends to bring the System of Relations to the future inhabitant and the future inhabitant to the System of Relations, turning it user interactive, which is possible by the creation of an Expert System, an IT tool that will embed and support the System of Relations. It is important to remember that we are working in a context of architect’s absence and where the house planning procedures do not include a prevailing housing design. Therefore the search for alternative solutions is based on the following postulate: if we can’t have experts orienting everyone’s house construction, we can at least try to make the expertise accessible to everyone. It is in this sense that the Expert System is created; it shall be able to replace the expert and transmit the knowledge to its users, in a simple, significant and interpersonal way. The Expert System will allow simulating specific housing profiles – at the same time bio-climatically optimal and culturally sensitive – as a way to combine the advantages of a face to face participatory process and an improved building procedure.
The development of an Expert System

“An Expert System is one in which human Expert knowledge about a specific domain is encoded in an algorithm or computer system” (Luger 2004); “the core of an Expert System is the knowledge-base, a database in which the main domain-related intelligence is encoded. Such a database is typically populated using the knowledge of one or more human Experts (…) In addition to being an informative stand-alone resource, the knowledge-base is a critical component in the Expert System” (Lee and Andersen 2009). The knowledge base will be constructed according to the available data resources, that is either heuristics either experimental, either qualitative either quantitative. It will also be based in optimization methods or algorithms for building design decisions, as the genetic algorithm (GA) (Goldberg 1989). In the proposed Expert System the user will be guided through a step-by-step process in which programmatic and constructive directives definitions are gradually decided towards the user’s goals while respecting the pre-established System of Relations between cultural, activity systems and architectural variables. As stated, this system is meant to be user-interactive, flexible, and oriented to the specific case of Kwanjama People building their houses in the City.

The **concept behind the System of Relations** is the systematization of the architectural thinking process when conceiving a house for a particular user. It is fundamental to fully understand the cultural and personal context in which the user lives to better understand the needs and wills towards his future housing; this is, to be able to define the group of settings (aspects) which compose the built environment and therefore the architectural form.

The System of Relations – one of the most fundamental research question at stake - will be reflected in a decision “tree” that after inserted in the Expert System and according to the user’s input, will lead to the final Housing Profile (group of culturally, architectural and personal oriented directives for the housing conception). It constitutes the Expert System’s knowledge base and it is built on the principle that every aspect/variable, within the climatic and constructive, cultural and activity system’s contexts, has an architectural implication. The set relations are translated into a decision tree, which is constructed by accomplishing the following steps, as shown in Figure 3:

**Step 1** – Defining the **aspects/variables** within the Kwanjama culture; aspects of the people living in self-built houses in the City and their everyday life practises, of the construction procedures, climate and local environment (social, economic and urban);

**Step 2** – Understanding which **architectural implication** can each aspect/variable have;

**Step 3** – Defining the **group of aspects/variables** within each architectural implication (as the group of settings that compose the architectural form);

**Step 4** - Defining which **relations** within each group of aspects will influence the architectural form;

**Step 5** – Defining the **procedures** that will allow, ultimately, establishing the System of Relations.

![Figure 3 Proposed steps to create the System of Relations](image)

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<tr>
<th>Step 1</th>
<th>Step 2</th>
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<td>Aspect 1</td>
<td>Aspect 1</td>
<td>Implication A,B,C</td>
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<td>Aspect 2</td>
<td>Aspect 2</td>
<td>Implication C, D, F, G</td>
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<td>Implication A, C, E</td>
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**Step 4**

- Implication A: Aspect 1 and 4 or 5
- Aspect 1 and 5
- Aspect 1 or 4
- ...
These steps allow constructing the System of Relations, which takes the path of a decision tree, as shown in Figure 4 (a); in the decision tree the departure point is the step 3 (the step 1 and 2 allow achieving to this point) in the sense that the departure point is an architectural implication (house form, division, partition, roof, material, glazing, shading, etc); to arrive to the concrete parameters of that architectural implication or form, all the aspects/variables influencing the architectural form will be inserted in the tree. According to the user’s opinion the aspects/variables within the decision tree will be accepted or refused, and only the validated ones will be related in order to establish the final directives for the construction.

![Decision Tree Diagram]

Figure 4 Part of the Decision Tree (Olupale: traditional living room) and (b) example of the Expert System layout (Onü: traditional main entrance; Oshinhanga: traditional living room for children)

The Expert System final layout will take the form of a query, as shown in Figure 4 (b), in which the user can be an active participant in the decision of his own oriented housing profile. In order to facilitate the understanding of what is being asked in the Expert System and to help the user decide, almost all the aspects or implied decisions will be illustrated through schemata as shown in Figure 4 (b). The expected Expert System’s output will be a group of directives for the oriented housing design. Its’ expected result does not intend to reach the final design of the house and it does not intend to contribute with possible housing models because those models could later be at risk of being applied as standard models and spread without respecting the ideal of housing that responds to particular activities or particular latent aspects of those activities. It is intended, though, to help people choose among a vast group of possibilities, based on rigorous studies, and to orient them in a more sustainable construction of their house. It is made for a context of architect’s absence and where the house planning procedures do not include a prevailing housing design. If one of this Expert System’s outputs would be floor layouts or
other technical drawings, these wouldn’t, most probably, be used by the common inhabitant (he wouldn’t know how). Plus, one fact supporting the feasibility of this proposal is the one of the existence of a close collaboration between the administrative housing office and the local population; almost every one desiring to build a house, goes first to the local administration to ask for a land plot. Unfortunately this relation stops here, most of the time, and the inhabitant builds the house without regard to any constructive or architectural rules. Nonetheless, the existing dialog suggests that a computer tool to be used by the poorest housing area’s residents wanting to build a house would be of easy implementation at the local administrative habitat’s office (since the majority of the concerning population do not have access to a personal computer).

CONCLUSION

More than a tool, the Expert System is expected to constitute a method which allows translating the environment behavioural studies concept from Amos Rapoport into direct applicable solutions for a culturally oriented housing design combining it furthermore with bioclimatic considerations. It intends therefore to constitute an alternative in the development of better living conditions in contexts of poor housing conditions, such as the ones of Ondjiva, through the application of a multidisciplinary approach. The Expert System will allow a more culturally and bioclimatic oriented self-construction and will bring new possibilities for the housing policy development, either among government institutions, NGO’s or inhabitants. Therefore, the meaning of this research is in its contribution with solutions that may deliver in the future, better or more appropriate housing in slum contexts, where the self build houses lacks mainly of an oriented guiding and supervision.

ACKNOWLEDGMENTS

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