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A Multidisciplinary Approach as an Assumption for Design Sustainability in Developing Countries

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A Multidisciplinary Approach as an Assumption for Design Sustainability in Developing Countries

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Abstract. The research proposal (framed within the Polisocial Award 2015-2016, a competitive call for research and social responsibility of Politecnico di Milano) concerns a project application experimentation to verify methodology that can be repeated in contexts similar to that under consideration, with the aim not so much of defining prefabricated modules that can be proposed in an undifferentiated manner and detached from the context and environment in which they are inserted, but rather to develop a useful method in a conscious design practice of new interventions. The project focuses on Mongue, a location in southern Mozambique located on a promontory at the end of the peninsula in Inhambane bay. We intervene on Mongue not only for its specific prerogatives, but also because it is considered as an exemplary point of transcalar application of a methodological proposal of analytical and design intervention of a more general nature, which can bring to the attention some general objectives that are considered important for Mozambique as a whole. The title Mo.N.G.U.E. is also an acronym for Mozambique, Nature, Growth, University, Education, which are the themes addressed by the research project: the theme of nature, environment and landscape, associated in Mozambique with a condition of both fragility and potential, addressed locally with the Municipal Ecological Park project; the theme of growth, understood as qualitative development; the university as the engine of the country's economic and civil development, expressed through the project of a research center dedicated to environmental issues linked to the Pedagogical University of Maxixe; widespread education that today also extends to childhood, with the project of a nursery school for the Mongue community. The results of the research project were not only made possible thanks to a transcalar approach, concerning an analysis of the African and Mozambican, as well as local context, but also were founded on multidisciplinary assumptions, thanks to which it was possible to define different project levels in order to arrive at a common goal. The collaboration of the architectural, urban, territorial and landscape field – together with conservation of historical buildings and existing heritage issues, technical structural and bioclimatic topics, environmental and energy sustainability, economic enhancement and financial sustainability, management and maintenance of buildings – has provided the research project with an added value of general interest: the possibility, through an operational synthesis that overcomes the distinctions of separate approaches, to consider the complexity that affects, at all scales, not only the specific case examined, but in general all the spaces of our living. Through the transcalar and multidisciplinary approach, it was possible to define a broad territorial and local knowledge framework and a project masterplan which, with the aim of pursuing real sustainability at the methodological level, was based on the basic themes of architecture making: the relationship with the soil, climatic conditions, available resources. A project that bases its assumptions on this, naturally leads to the configuration of sustainability, in terms of material resources and as a response to the present and traditional uses.

1. Introduction

The paper presents a multidisciplinary research by design experienced in Mozambique[1] (sub-Saharan Africa), specifically in the southern part of the country – Inhambane province – focusing the locality of Mongue, within the Maxixe City District and overlooking the Inhambane bay, on the Indian Ocean.

Mo.N.G.U.E. became also the title of the research, summarizing through an acronym its main topics, related both to the whole country (*Mo.zambique*) than strictly connected to the development project and the design solution for the area.

The first topic is *N.ature*, intended as a great potentiality to be preserved and not as a resource to be depleted: the research focused particularly on environmental and landscape peculiarities of places, reflecting on the sustainability of natural resources. The second theme is *G.rowth*, a quick growth of the country to be faced with long-term strategies and not only with tools to solve emergency conditions: the research planned a complete process to be made step by step and to give medium and long-term opportunities for the communities, beyond the today needs of the Mongue people. The third theme is *U.niversity*, conceived as a precious engine for economic, as well as civil development of the country, the idea that the project improved. As a matter of fact, one of the crucial problems of Mozambique is the training of teachers and professors. The last topic, strictly connected to the university, is *E.ducation*, or the social importance of the educational facilities especially for children, facilities not sufficient for now in the country. The research faces these issues by working on the project and institution of a Municipal Park, an eco-center, university spaces linked to environmental themes and a nursery school for the community.

The project involved two important local actors that participated together with the multidisciplinary team of Politecnico di Milano: Universidade Pedagogica Delegação de Maxixe, cofounder of the research, and Congregazione Sacra Famiglia who has actually in Mongue one of its religious and social settlements. All these contributions have been fundamental to integrate additional specific skills as well as an extraordinary knowledge of the place.

2. A multidisciplinary and multidimensional approach

The fragile site of the Mongue peninsula condenses many of the critical and potential issues that affect the whole Mozambican and sub-Saharan area, as the Mo.N.G.U.E. acronym suggests. Given its complexity, the place implied the experimentation of a research by design that considered multidimensionality and multidisciplinary as necessary assumptions to structure a sustainable approach to urban and architectural solutions.

In the first instance, a multidimensional view, as a way to connect the local condition to the general framework of a country, was also necessary to depict the peculiarities of the site. Passages between different scales were dialogical: from the whole country to the Inhambane region, to end up in the Mongue peninsula. Analysis and design processes benefited from different contributions regarding the investigated themes and conducted in a multidimensional sense.

The transition from large to small scale and vice versa was intertwined, as already anticipated, with the connection of different issues, to outline a final multidisciplinary framework in which the contributions of the single topics were no longer separated but found a necessary synthesis in the project itself. Starting from thematic mappings concerning bioclimatic and environmental conditions,

[1] The research is framed within the Cooperation, Experimentation and Social Development Projects founded by Politecnico di Milano through the competition Polisocial Award. Mo.N.G.U.E. was one of the winners of the 2015-16 edition.

sources of energy supply, settlement methods and construction techniques, the research outlined a knowledge framework that was the basis of an analytical-interpretative process that acted as input to the design process. In the same way, the design process itself looked back to the analytical part to question it and implement it with new issues linked to the peculiarities of the place.

2.1. A "participatory" multidisciplinary

"a design briefing that is perfect from a *participatory* multidisciplinary point of view, that defines an attentive framework, a systematical input of reference for the designer; and then it turns out that the translation of this into real requirements to be assumed for the design becomes the moment of more complex and difficult solvability, to the point that every designer, whatever design solution he elaborates, passes it off as an optimal answer to the original requirements. So the key point is exactly how to create this integration that we defined with the slogan 'multidisciplinary in the definition of requirements', how to create in instrumental, operational, terms that express the analysis, that fundamental assumption that becomes a point of reference and real input to the design process" [1]. The Mo.N.G.U.E. project, embracing a "participatory" character of multidisciplinary, acknowledges a role of direction and synthesis to the architectural design, in which the other different fields of expertise converge: interior and open spaces design, urban planning, landscape design; conservation of historic buildings and existing heritage; construction techniques; bioclimatic, environmental and energy sustainability; economic enhancement, financial sustainability, management and maintenance of buildings. In this sense, the architectural design of even a single part feeds on all the skills put in place in the knowledge and analysis phase.

3. Specificities of the Mongue peninsula: a fragile scenario

The investigated area is the Mongue peninsula, a well-defined territory detached from the rest of the region by the Nhanombe river – to the west – and by the national street N1 – to the south – while the rest of the borders face the Inhambane bay sea: the rural locality of Mongue is located precisely in the final part of that peninsula.

With the aim of identifying the peculiar characteristics of the development of the Mongue peninsula, such as the relationship between infrastructure and built environment, the role of electricity distribution in the urbanization and the fragility and potential of the vegetation and heritage system, analytical maps were the main tool for the researchers[2].

An in-depth analysis of the density (figure 1), never done before in the site, shows clearly that the whole territory suffers from unmanaged urban tensions: Mongue represents today a precious but fragile rural scenario mostly because is threatened by the growth of the city of Maxixe's peripheral areas, that are expanding in the peninsula without any attention to the preservation of the specificities of the place.

The same map also shows that the settlements are denser close to the main road and to the power line. The dirt road runs along the edge of the whole territory; the power line instead, serving only the bay side, follows the road in the south part of the peninsula, while in the northern part it runs toward the center of the tip to end in the Mongue site. A map of the facilities (figure 2) shows their location along the road to the bay side, especially where the two lines overlap, covering only partially the area. The lack of an efficient development strategy is evident also in the number of local facilities for the population: they are absolutely insufficient.

[2] All the analysis and maps of the peninsula was elaborated starting from a Portuguese historical map, dated 1971, made by the Direcção Provincial dos Serviços Geográficos e Cadastrais, Missão Geográfica de Moçambique. The maps were then implemented with information collected by direct surveys, Bing aerial images or specific international database.

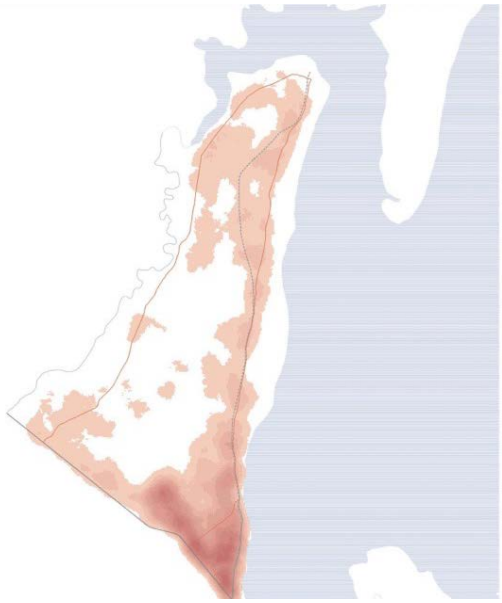

Figure 1. Building density [2, 3]

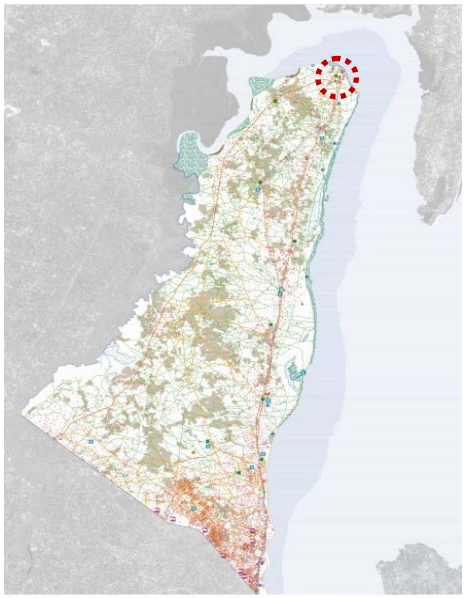

Figure 2. Natural and anthropic elements of the territory [2, 3]

Regarding the vegetation, it is composed mostly of coconut palm, tall and thin trees planted in big areas without obstructing the view of the landscape, together with mango and western anacardium that are instead massive trees providing shade places under their branches.

The map of the vegetation density (figure 3) shows another real problem of the site: green areas close to settled parts are rarefied, due to primary domestic activities such as cooking and heating. Denser parts correspond instead to mangroves areas, one of the most valuable elements of the site, growing both along the coastal line than along the Nhanombe river, especially at the estuary. They spread in tidal spaces, generating a precious intertidal ecosystem linked also to wet and lagoon areas located between the road, in a higher position, and the sea of the bay or the river below.

But the most peculiar elements of the peninsula, also in environmental terms, are two water sources, considered as sacred places for local people. The lush vegetation that surrounds and protects them is the *floresta sagrada*, to which inhabitants are devoted. Specifically, the sources are in the final part of the peninsula, close to the Mongue settlement (figure 4).

The tip of this territory is the most precious part also for the presence of a Christian missionary settlement dated back to the second half of the XIX century, historically important because it was the first in southern Mozambique. There are two historical buildings (figure 5): the Sao Josè church, abandoned and decaying, and the mission house, partially used as kindergarten for the community, despite being in decline. The site represents an important heritage for the whole country, being one of the rare historical evidence outside the urban context.

Figure 3. Vegetational system and natural elements [4]

Figure 4. Environmental and landscape elements [3]

Figure 5. The old Sao Josè mission

From a multidisciplinary and multidimensional interpretation of the fragile existing scenario and its precious resources, together with the awareness of the more general issues affecting the country, the research focused on a development strategy for the peninsula and a design solution for the enhancement of the Mongue site.

4. A development strategy for the peninsula

4.1 The institution of a Municipal Park

The institution of a Municipal Park was the main action for a sustainable development of the peninsula. Starting from a basic proposal by Universidade Pedagogica the research worked on analysis and possible scenarios for the site.

Specific goals of the protected area are: the conservation of biodiversity, the preservation of the environmental and landscape specificities, the preservation of the traditional heritage, the prevention of soil consumption and the promotion of general awareness on environmental and landscape issues.
The Park corresponds to the peninsula – excluding the Maxixe's expansion – and provides three areas with different levels of protection and different regulations for existing building and future development (figure 6). The strengthening of the rules is directly proportional to the preciousness of

the landscape, conceived as the result of the complex relation between anthropic actions, natural phenomenon and historic values.

Consequently, the final part of the peninsula, with the locality of Mongue on top, is the most valuable one and should be therefore the most protected: as the map shows (figure 7), the site included a unique building heritage and two *floresta sagrada*, together with traditional settlement spreading within the bay, a rich place in terms of landscape and cultural values. The idea is not to have new settlements here trying to focus and enhance the Mongue site.

The coastal line and the Nhanombe river basin should have a medium level of protection: tidal space with wet areas and lagoons, together with mangroves, represents another fragile ecosystem to be preserved. New settlement here must be regulated, trying to maintain the visual relation between the main road, on the higher level, the horizon and the see.

Finally, the inner part of the peninsula, from the main road to the center, could be the one with fewer restrictions about the future settlement, allowing the expansion of the periphery of Maxixe in a sustainable and controlled way.

The idea of the Municipal Park draws a new important scenario for the future of the Mongue peninsula, not only to have a balanced and regulated growth of the settlements, improving the lives of the communities, but also to promote the preciousness of these places in the rest of the country, where today they are mostly unknown. This means, for example, working on the enhancement of the relation between the area and the Universidade Pedagogica, already present with some activities, but also improving sustainable touristic opportunities.

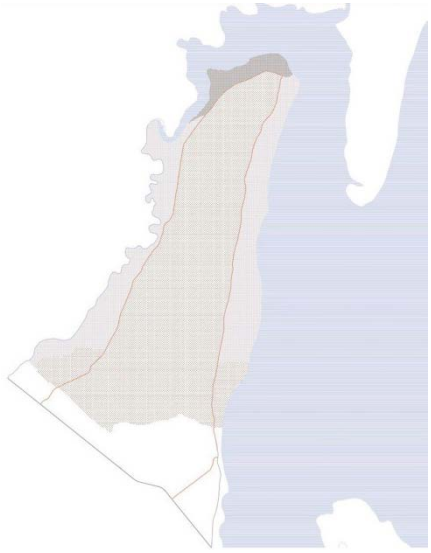

Figure 6. Natural elements and buildings

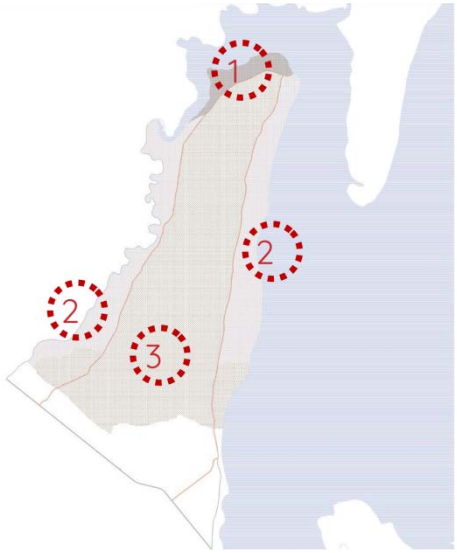

Figure 7. Municipal park protection areas

Connecting a landscape vision and a development strategy to a design solution specifically for the area of Mongue, two are the main action to support the idea of the Municipal Park: firstly the design of a park and research center dedicated to environmental topics and connected to the university; secondly the renewal of the new mission not only as a spiritual place but also as eco-center with accommodations for researchers and tourists.

4.2. Existing heritage and environmental analysis as inputs to a sustainable design
The tip of the peninsula is precious for the presence of a Christian missionary XIX century settlement, constituted by two historical buildings: the Sao Josè church and the mission house.

The architectural design of even a single part feeds on all the skills implemented in the cognitive and analysis phase.

For example, the study of the existing architectural heritage – composed by two categories: traditional buildings, which characterize all rural places, and buildings of colonial origin located in specific agglomerations, for example the Mongue mission, or usually in the small urban centers – not only represented a necessary step in the transmittable knowledge framework, it was also the fundamental precondition for any hypothesis of intervention on the precious existing buildings on the site, the base for any design phase. It was conducted through a deep survey, on site but also before and after the inspection, it consisted in a literature research and in a photographic and geometrical survey. One of the main results was the definition of an abacus (figure 8) to define and catalog the traditional materials (adobe, pisè, stone material, bricks, straw, canisso, reeds walls, plasters, wood), the more recent ones (concrete blocks, metal sheets) and the related construction techniques that were a fundamental input to the design process.

In the same way, the environmental, energetic and bioclimatic analysis, starting from the national context, studied climatic data (such as average rainfall and climate areas) and different sources of energy. It operated on the Mongue site with the analysis of sun and wind contributions both on the quality of buildings and open spaces. Through the use of a microclimatic matrix, the study interpreted how traditional construction systems interact with energy flows and generated spaces with appropriate features linked to the environmental ones of the site. Nevertheless, not only was this discipline's contribution useful to widen the knowledge framework of this place; it also constituted the fundamental starting point to define a sustainable approach to the architectural design of both interior and open spaces (figure 8).

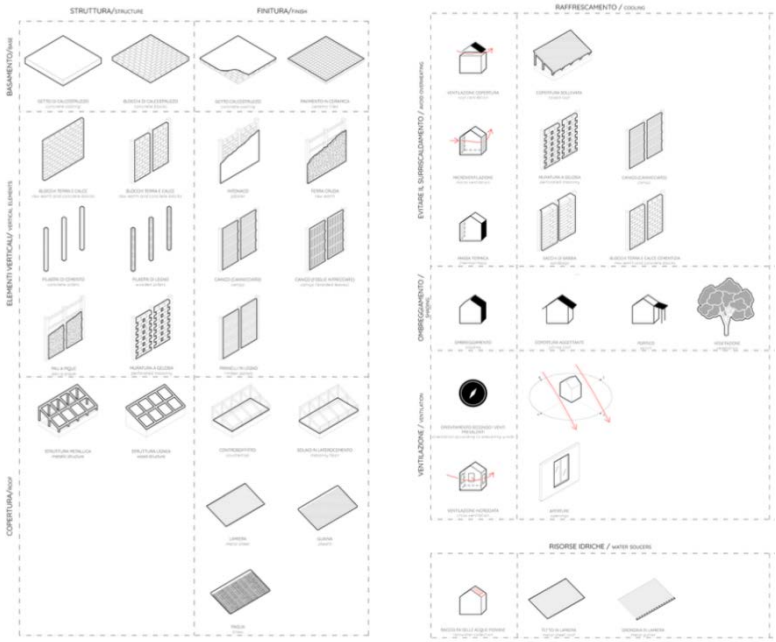

Figure 8. Materials and techniques and bioclimatic strategies abacuses

The architectural design of buildings and open spaces for Mongue, even in their individual parts, merged different knowledge of construction techniques and materials in order to favor the best

bioclimatic conditions; the investigation of the necessary energy supply and the economic impact makes the design solution sustainable; and the interpretation of the morphology of the place assured the effective enhancement of the landscape of the peninsula.

5. A design solution for Mongue

5.1. Sustainability as the aim of a multidisciplinary methodology

Through this multidisciplinary methodological approach once again it emerges how sustainability is the essence of the project that obliges us to consult different knowledge to be implemented in a concrete way. This means re-establishing the project starting from the basic themes of architecture: the relationship with the soil, the climatic conditions, the available resources, is the key expressed by designers who have worked in these places. “One aim of my research and design activities is to use materials and develop traditional techniques and settlement principles that are already familiar to the local communities. I take note of even the smallest expressions of my land and people… Each new building is a part of a larger and more complex design… this sort of conduct ranks me among ‘sustainable’ designers, but it is only a western label, I design exclusively with a sense of responsibility…” [5]

Kéré poses an essential theme: the architect has civil responsibility for the knowledge of the earth and the people who inhabit it with its traditions and ways of life. A project that bases its assumptions on this naturally leads to the configuration of sustainability, in terms of material resources and response to the uses and customs present. This is how research has recognized as a primary need to structure mapping of the foundations of a context at the service of a conscious project, on the one hand, the environmental and landscape features, on the other the characters, materials and techniques of the existing building. The analytical methodology, with which priorities and relationships are established, becomes the design of the space.

A general theme of sustainability, which has guided the approach to the project from the beginning, is an economic principle which can be found in involving all the existing structures in the new expansion system and in their systemization, on the one hand, reducing demolition and transformative actions to a minimum, on the other registering that spontaneous growth linked to the urgency of necessity within a recognizable design. This principle also supports the recognition of a precise identity of the place that its community over the years has assumed and made its own.

5.2. Reading of the site: landscape and built environment

The reading of the altimetry highlights the presence of three main levels linked to the three areas of intervention, within these the recognition of practicable sub-areas and their relative identification margins (walls, escarpments, tree masses, coast, etc.), defines the importance of the soil, its shape and its design as the basis of the project. The maps of the routes and their characteristics establish the plot of the routes and relationships already present.

Vegetation areas and land surfaces divided between the different categories of draining soil and those (few) of impermeable soil, highlight the importance of a strategy on the theme of water. The consulted climate tables (Atlas de Mocambique, Editora National de Mocambique, 2009, World Maps of Koppen-Geiger climate classification) insert the Mongue peninsula in the tropical climate zone, with monsoon winds and subject to cyclones. On the one hand, long seasons of drought suggest the need for rainwater collection, on the other the absence of a water management system leads to a design of the soil and buildings capable of protecting the building from the abundant rains that characterize the area at certain times of the year. Climatic information intertwines, terrain conformation and relief of the present infrastructures: absence of an aqueduct, of a sewage system, mapping of the current roofs of the present buildings and of their possible disposal / collection systems of water.

The mission with its pavilion shape, to which over the years a large porch that runs on the whole perimeter and a service wing have been added, defines an “L” shaped volume that insists on a masonry base with which the Portuguese colonists guaranteed the settlement a homogeneous level and a higher compared to the decline towards the sea. Inside this “L” composition stands the church of Sao Josè which acts as a pivot between the various levels of the ground. Its presence together with that of large shading trees animates the space in front of it. The state of conservation of the mission and the church, which was already quite precarious, was seriously compromised by the cyclone Dineo of 2017. Below the basement support walls, there are, in adherence to the historic wall, a cement plate with a canvas metal cover, a small building containing a kitchen, and a layout of a foundation for a new building in complete abandonment. The framework of the existing building is completed by the sheds for carpentry used as laboratories by Universidade Pedagogica and the Congregazione Sacra Famiglia’s new mission settlement consisting of different volumes, placed on a raised base, connected together by a long and wide porch.

The topics of analysis are not limited to an image of existing conditions accompanied by quantifiable literature data, but they identify criteria of interpretation useful for the definition of new volumes to be included, to their articulation and relationship with the existing ones, to their inclusion in the context. The bioclimatic matrix described offers the first suggestion for the correct positioning of the new buildings. Starting from this, the masterplan is structured assuming the landscape thematic reflections of the analysis, the observations on the construction techniques used, the abacus of available materials. The pursued sustainability objectives can be summarized in some architectural criteria that have been applied in all new buildings: nursery school, research center and new eco-lodge. Together with this, a principle of the economy since the beginning has guided the approach to the project in involving all the existing structures within the new extension system and putting them into a strict relation, on the one hand, reducing to a minimum the demolition and transformative actions, on the other hand, framing within a recognizable design the spontaneous growth caused by to the urgent needs. This principle also supports the recognition of a precise identity of the place that the community over the years has assumed and made its own. The functions analysis and their related square meters, the spatial articulation, the definition of the materials, the construction techniques and the equipment pass through the study of architectural cases belonging to the international panorama of sub-Saharan Africa constructions, considered significant. This has allowed us to draw up more contextualized parameters that can be shared with local communities.

5.3. General building principles: the role of climatic agents and the relationship with the soil

The design of the specific architectures starts from the primary act of a solid basement, taking a cue from the existing basement that dissolves in the natural slope. This concept is a consolidated way of building, entrusting to the new artificial soil the role of protection from water and sand and the definition of a distance and a flat surface on which to set new buildings. A reference area is built for the new volumes, emphasizing the act of circumscribing and including the open space within the overall articulation.

The volumes placed in the basement are positioned in compliance with the wind trails aiming to intercept the ventilation benefits. The architectures are conceived by small units to facilitate the passage of the winds between one and the other and not to block this permeability with a unitary front. An element is defined for each body that works by capturing thermal mass, integrated with the design of vertical margins and the fixed and mobile equipment that make up the places of living. Above the new volumes, there is a covering system inclined and detached from the volume to draw a large "visor" as a protection from the sun and the rain and to intercept the air currents to cool the upper part of the building and disperse the accumulated heat (figure 9). Furthermore, large porticoes spaces are structured to interact with the enclosed space and to increase the pertaining shadow band of the building, which is verified in the most unfavorable conditions. In the individual blocks, the openings

are placed on the opposite side to create a cross-ventilation that covers the entire interior space without generating unventilated cones and always a brise-soleil strip is inserted which detaches the ceiling from the walls to facilitate an internal horizontal cooling in the point of greater heat accumulation. Together with this, the design uses some perforated walls (jealousy) to obtain diffused micro ventilation.

Figure 9. Bioclimatic principles applied to the kindergarten design

5.4. General principles and specific case: the conservation and reuse of Sao Josè Mission and Church
Regarding the historical building, the project has identified a possible balance between maintaining the original architecture and redeeming the problems of environmental comfort, particularly of the Sao Josè church and the colonial house mission. The proposed approach has already been articulated in terms of enhancing and preserving techniques and materials, themes that are inextricably linked to architectural choices.

Regarding the church, the need to restore a collapsed roof has provided the opportunity to set a slight detachment between it and the walls in respect of the original profile and height for the heat spillage. The openings are screened by brise-soleil with movable flaps on the west side and by a wooden slats structure placed inside which interprets the spatiality of the room, embracing the faithful area and the altar with an “L” shaped sign and helps to keep away the direct sun rays without compromising the size and the rhythm of the openings on the east side.

The design declined sustainability principles through different disciplines areas and different scales using consciously the local resources and optimizing the bioclimatic comfort.

6. Conclusions

The architectural design and the open spaces of the new buildings for Mongue, even in its individual parts, summarize these contributions drawing on the repertoire of construction techniques and materials, combining them in order to favor the best bioclimatic conditions, calculating the necessary energy supply and the economic impact in order to make them sustainable, interpreting the morphology of the place, the landscape in which it is inserted.

The project assumes the objective of moving between the tension towards an improvement and necessarily transformative conditions of the places in respect of nature and landscape that constitute the substance of this territory and supporting an explicit resistance to the change in the uses of space, ways of living, deep-rooted traditions. “This is a strange world, a world of approximate modernity and ancestral resistance [6].” What is not renounced is a reading and an overall design interpretation firmly believing that a systemic design and the result of a multidisciplinary work brings new opportunities for development and growth providing to the local community reasons to stay in Mongue.

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