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GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MASTER THESIS

VERNACULAR ARCHITECTURE AND ITS APPLICABILITY IN CONTEMPORARY BUILDING DESIGN IN HOT AND ARID CLIMATE: CASE STUDY OF NATIONAL PARK OF MALI

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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science in Architecture.

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ABSTRACT

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While vernacular architecture is at a state of decline and about to be replaced, modern society nowadays is losing some connection to cultural traditions and integration of users in process of designing. The concept of sustainability in reference to vernacular architecture is reviewed in this thesis which tends to investigate the potential and implementation of this aspect of vernacular architecture in contemporary architecture. So specific examples of vernacular architecture, identified in the regions of Timbuktu and Mopti (Djenne and Bandiagara) from Mali with hot and arid climate, were selected and explored, to understand the strategies adopted in these settlements and their performances over a long period of time. Investigation continues in the region of Bamako with a mixed-use complex "National Park of Mali" as case study and composed of a group of contemporary buildings, connected to either traditional principles or local material, to determine any technique resulting from the Malian vernacular architecture that has been integrated. A survey is done based on a hundred of user's perception who have frequented each this National Park. As will be shown the results of the survey suggest a set of reasons why principles of vernacular architecture should be integrated in the present scenario.

Key Words: Vernacular architecture, Contemporary architecture, Sustainability, Hot and Arid climate

ÖZ

SICAK VE KURAK İKLİMLERDEKİ ÇAĞDAŞ BİNA TASARIMINA GELENEKSEL MİMARLIK VE ONUN UYGULANABİLİLİĞİ: ALAN ÇALIŞMASI NATIONAL PARK OF MALI

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Mayis 2017

Geleneksel mimarlık etkisini kaybetmekte iken, günümüzde modern toplum, kültürel geleneklerle ve tasarım sürecinde kullanıcıların entegrasyon bağlantısını kaybediyor. Bu çalışmada geleneksel mimarlığın sürdürülebililik konsepti açısından, modern mimarlığa uygulanma potansiyeli incelenmiştir. Sıcak ve kurak iklime sahip olan Mali'deki Timbuktu ve Mopti (Djenne ve Bandiagara) bölgelerinde belirlenen geleneksel mimarlık örnekleri incelenerek, bu bölgelerde uzun yıllar boyunca uygulanmış stratejilerin ve bina performansları irdelenmiştir. Çalışmada Bamako'daki kompleks "National Park of Mali", Mali'nin geleneksel mimarlık yaklaşımları ve prensipleri ve lokal malzeme kullanımı açısından alan çalışması olarak incelenmiştir. Çalışmanın bir sonraki aşamasında National Park hakkında 100 kişi ile anket yapılmıştır. Anket çalışmasıyla geleneksel mimarlık prensiplerinin günümüz mimarlığına entegre edilmesi gerekliliği ortaya konulmuştur.

Anahtar Kelimeler: Geleneksel mimarlık, Modern mimarlık, sürdürülebilirlik, sıcak ve kurak iklim

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Fatoumata Maïga

İzmir, 2017

TEXT OF OATH

I declare and honestly confirm that my study, titled "VERNACULAR ARCHITECTURE AND ITS APPLICABILITY IN CONTEMPORARY BUILDING DESIGN IN HOT AND ARID CLIMATE: CASE STUDY OF NATIONAL PARK OF MALI" and presented as a Master's/PhD Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions. I declare, to the best of my knowledge and belief, that all content and ideas drawn directly or indirectly from external sources are indicated in the text and listed in the list of references.

FatoumataMaïga

Signature

.....

June 8, 2017

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ABBREVIATIONS

ABBREVIATIONS:

DEFRA Department for Environment, Food & Rural Affairs

UNESCO United Nations Educational, Scientific and Cultural Organization

AKDN Aga Khan Development Network

AKTC Aga Khan Trust for Cultures

CHAPTER ONE
INTRODUCTION

1.1. Research Problem

After the use and development of numerous design principles in the conception and construction of their surroundings, cultures within continental Africa have got the opportunity to see the implantation of some notable buildings designed around the continent. Especially with the help of architects who are mostly African and have been educated abroad such as Diébédo Francis Kéré a German-trained architect from the small West African town of Gando in Burkina Faso. The originality of each of those new buildings (due to climatic conditions and cultures) but with the same principle (modernity) has permitted the emergence of a new trend consisting of the combination of local solutions with the most appropriate western ideas which is not widely common in the continent yet.

This architectural style seems to drive the attention of the public mostly on the importance of the aesthetic of buildings, due to its need to modify certain traditional methods in a better way constantly for the perfection in the finishing details of local materials used so that it can fit to the modern actual era. In reality it focuses mainly on the sustainable aspects of both vernacular and contemporary architecture without compromising each other according to the climatic region concerned to which they all depend in somehow and have in common.

Nowadays it became essential for architects to have a look on vernacular architecture, left unconsidered at its just value for a long time ago, around the world but in terms of sustainability to keep it modern and apply it easily in contemporary buildings. Because it's a must to learn from the past in order to have a better future as well as an obligation to know about the culture of a country before the conception of any project on that territory for not losing the national identity. Especially in Africa this must be applied because of the colonization it has suffered from. James (2011) reported that in "Africa

projects tend to carry either a primitive aesthetic or a high-tech curtain wall to mirror the Western notion of progress" (Para. 9).

Where the necessity for any Local population in the intention to achieve development, to learn which sustainable features of their traditional architecture can be adapted to the just needed and tiny portion of new technologies in modern architecture. So that they may keep their identity intact and minimize their impact in the causes of global warming and in return to protect themselves from it.

1.2. Aim of the study

This research focuses mainly on the investigation of climatic responsive design strategies of vernacular architecture in a region with harsh conditions such as hot and arid climate. In order to find out exactly which sustainable building systems and materials from ancient cultures, with the same climatic conditions and still existing despite the massive inattention on them since the arrival of new technologies in the western countries, can be adapted for a contemporary use. As citizens, professionals, teachers and parents of the next generation, it's relevant to mention our common responsibility towards a critical reflection, and a responsible engagement for each of us, to be more active towards the sustainable development of our society. However at this time the academic interest in the sustainability of vernacular architecture has grown noticeably because the concept of sustainability is not a new or innovative term as many of us think, but this concept is already illustrated through the vernacular architecture in different zones of the world. More overall the lessons that can be learned from studying vernacular architecture can help us not only to further the conservation and retrieval of this architecture already in existence but to rethink new architecture in the light of what have been learned. Then on the other hand the study aims in enabling a raise of awareness among local populations from African developing countries and beyond about the importance of vernacular architecture, sustainable and economic issues.

1.3. Significance and Scope of the Study

The study largely concerns the sustainability of the modern and vernacular architectural strategies of hot and arid countries with as an example Mali and would first benefit the African leaders and populations. Because Africa is one of the most

vulnerable regions to the variability and the change of climate like the Arctic, small islands and Asian mega deltas. Then the study will enable researchers not only to improve it for hot and arid regions but also permit them to use and adapt it for regions with different climatic conditions and with the possibility to suffer prematurely from the global warming like the ones mentioned above. But again it's in Africa that the study is best suited in view of its underdevelopment too. Accordingly the study will provide designers with the knowledge and tools of how vernacular architecture can be used in an incredible manner with solutions developed smartly and work both culturally, climatically, materially and economically and be seen as unique as its own with the increasing problems of poverty, dwindling resources and unfavorable economic atmosphere.

1.4. Methodology

Except this chapter consisting to introduce the study, the following chapters divide it into four parts. The second chapter named as sustainability in vernacular architecture rely on the literature review of sustainability on an international plan and vernacular architecture in hot and arid climates zones in the world. Their definitions and strategies are discussed by doing so within the framework of architecture which represents the link between them because sustainability is a concept applicable in many fields.

The third chapter introduces geographically and climatically a west-African country known as Mali and deals with three of its vernacular architecture Timbuktu, Djenne and Bandiagara by focusing on their strategies. These particular regions placed both under the protection of UNESCO, have been chosen for their touristic attractions and popularity resulted from the trans-Saharan trade at the time of the empires in west-Africa. In fact this trade, where they have played important roles such as major centers of commerce between blacks and Arabs, had an important impact on their architectures and religious beliefs. The characteristics of each region's architecture were grouped independently in different tables and then compared one to another later to deduce the main elements that are influencing the vernacular architecture of Mali. This doesn't only gives credibility to the previous chapter on the fact that vernacular architecture is generally based on climate, culture, environment and material but it permits also to identify which sustainable aspects of these vernacular architectures can be integrated into modern houses.

This is where the chapter four comes in with a suitable project as case study “National Park of Mali” located in the capital of Mali and conceptually designed to reflect the identity of the country through the combination of vernacular and modern architecture. This Park as a project of Diébédo Francis Kéré, whose concern is to develop the principles of sustainable architecture in the African context, was selected due to its sustainable issues responding humbly to the needs related to thermal comfort, while allowing the valorization of local resources and the diffusion of simple and efficient techniques. In other words it’s illustrating an example to follow. Thereby in pointing out all the architectural features and strategies of that project in reference to sustainability, pathways will be free in spotting all the similarities with the three Malian vernacular architectures studied before. Additionally an online survey questionnaire about the same project ending the chapter four is conducted but this time for producing reliable and valid results proving that this study has a well-founded purpose of being pursued and simultaneously raising the awareness of the respondents.

While the chapter five includes the conclusion part of the thesis, the main data of this thesis, literature review was collected as based on multiple sources such as books, conservation reports, information from websites and analyzed by comparison.

CHAPTER TWO
SUSTAINABILITY IN VERNACULAR ARCHITECTURE

2.1. Sustainability

Sustainability considered as a global concept nowadays seems have started to evolve considerably since the moment when people started having interest in environment after the Second World War trying to discover if as a human being we are the main responsible for the problems affecting our world such as global warming for instance which is gaining momentum from day to day through pollution and waste (Kongebro, Jørgensen, Nielsen & Strømann-Andersen, 2012).

> The term remains elusive to many, and while a number of definitions exist, they give little indication of how to apply principles of sustainability in practice. Moreover these definitions differ slightly, one from another, and in any attempt to implement sustainable development it is essential that the meaning of sustainability be understood (Sassi, 2006, p.1).

Sustainability as an old term and due to its complexity is still unable to be simply and clearly defined and therefore makes it difficult also for sustainable development to be properly defined at its turn by most of the existing disciplines in the world.

> The range of contexts in which the phrase 'sustainable development' is now employed is very wide. In research, it seems to offer the potential to unlock the doors separating academic disciplines, and to break down the barriers between academic knowledge and policy action. It does this because it seems to draw together ideas in ecology, ethics, economics, development studies, sociology and many other disciplines (Adams, 1990/2009, p.5).

However the sustainable development which might be a pathway to achieve sustainability has been defined by Brundtland (1987), through a report of the United Nations world commission on environment and development named as 'Our Common Future', in a way that seems to suit everyone as it's a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

According to the same report “three integrated behavioral trajectories are necessary to achieve a sustainable future- ecology, economy and social equity” (as cited by Tanzer and Longoria, 2007/2008, p.2). In other word sustainability rely exclusively on three distinctive pillars inseparable from each other which refers respectively to the society, economy and environment. Sassi(2006) confirms that “the principles of sustainability aim to address the problems of environmental degradation and lack of human equality and quality of life, by supporting development that is sustainable in economic and social terms and is capable of retaining the benefits of a healthy stable environment in the long term”(p.2).

In addition to this ‘triple bottom line’ there is the need to follow four key objectives or instructions care at the same time in the world as a whole for achieving sustainability and so that each of us will be able to have a better quality of life:

> – Social progress which recognizes the needs of everyone;
>
> – Effective protection of the environment;
>
> – Prudent use of natural resources; and
>
> – Maintenance of high and stable levels of economic growth and employment.
>
> (DEFRA, 2002, p.13).

2.1.1. Sustainable Architecture

These times it’s quite normal and frequent to see in the field of architecture or design the presence of sustainability especially since this one is addressed to various disciplines. This is due to the fact that the building sector is primarily responsible for the production and emission of CO2 compared to the sectors of industry and cars. Indeed it is recognized that CO2 represent a real danger for the whole world since it is detrimental to the environment mainly to the ozone layer. The deterioration of which conduct to global warming on our planet.

“But it should be widely known that buildings are the single most damaging polluters on the planet, consuming over half of all the energy used in developed countries and producing over half of all climate change gases”(Roaf, Fuentes &Thomas, 2001, p.1).

> The fourth assessment report of the intergovernmental panel on climatic change (IPCC) state that significant global impacts on ecosystems and water resources are likely at global temperature rises of between 1 and 2°C, and that net negative impact on global food production are likely to occur at temperature increases from 2-2.5°C upwards, compared to pre-industrial levels. The IPCC report also says that up to 2050 substantial global emission reductions of at least 50% below 1990 levels are needed, with additional global emission reductions beyond 2050, moving towards a zero carbon economy by the end of the century. This is the only way to keep the temperature increase to 2°C, which is considered to be the maximum we can afford without incurring catastrophic consequences (Butera, Adhikari & Aste, 2014, P.1).

Thus, from now on, for the well-being of everyone, future buildings, not to say urban planning, must be taken into account and closely monitored by architects who have always had all the responsibility of those buildings on their shoulders. Roaf, Fuentes and Thomas (2001) also believe that "What is certain is that we must act now to reduce CO2 emissions globally and that one of the most effective sectors from which to achieve rapid reductions in emissions is buildings" (p.8).

It was after this that the world of architecture gradually saw the appearance of houses built in such a way to respect the environment from the conception to the construction and even during their use by the people called to inhabit them. And without further delay this new way of proceeding gave birth to what we call sustainable architecture following passive design strategies.

2.1.2. Sustainable Design Principles

Since passive architecture obeys to different strategies (fit to place and purpose taking advantage from local climatic resources so that the buildings can heat and cool itself) a large amount of options is available.

But luckily the classification of the so-called solar architecture into a passive and active categories has permitted to demonstrate that the solar energy is mostly used for space heating in solar passive buildings. Then passive buildings are relying on sun in order to achieve passive heating but without neglecting passive cooling which still has a chance to be a part of those buildings through shading, ventilation or thermal mass for instance. Bauer, Mosle and Schwarz(2007/2010) state that "Cooling happens either via cool surfaces inside the room via cooled air"…"since heating and cooling functions

according to the same principles, it makes sense to use the same surfaces for both heating and cooling purposes"(p.113).

In fact three main passive solar systems taking advantage to solar radiation actually exist and are named respectively as direct gain, indirect gain and isolated gain.

- Direct Gain, Indirect Gain and Isolated Gain systems

While the aim is to heat the main living spaces by concentrating the majority of the building's glazing on sun-facing façade in both direct and indirect gain systems, the isolated gain system or sunspace is a room designed to collect also heat for the main part of a building but as well as to serve as a secondary living area. In general the direct gain system differs from the indirect gain one through the location of a thermal mass which is positioned on the floor. (Fig.1)

"The floor should be of a high thermal mass to absorb the heat and provide thermal inertia, which reduces temperature fluctuations inside the building" (Smith, 2001/2005, p.56).

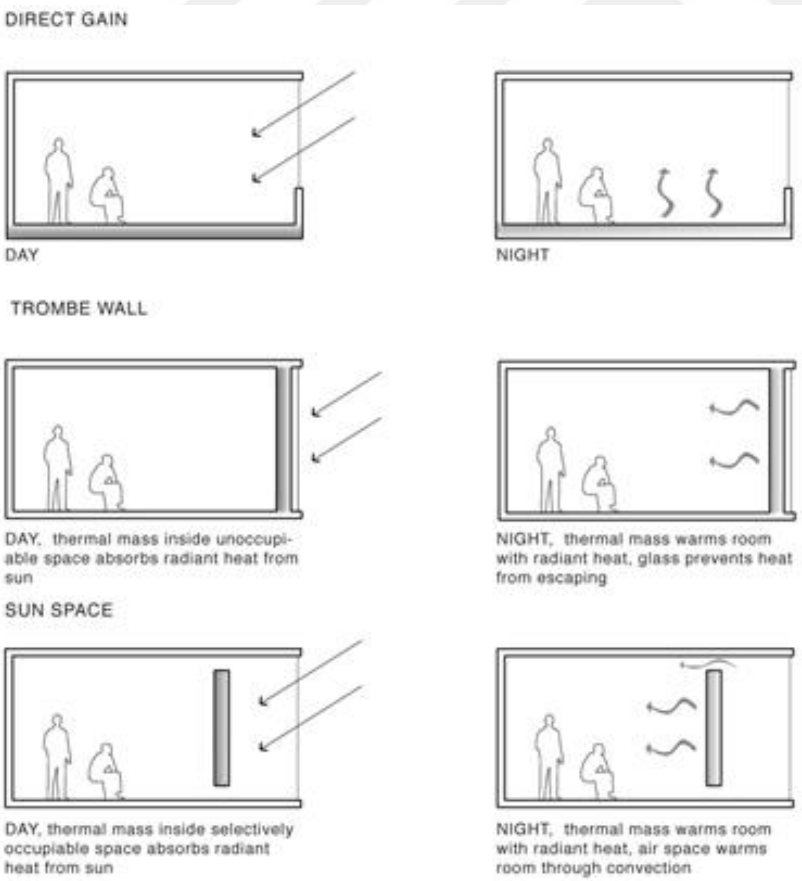

Figure 1. Solar Gain Heating (n.d).

So in the indirect gain system also called trombe wall system the main space of the building is heated with an indirect daylighting due to the thermal wall placed just behind glazing facing towards the sun. But it should be noted that trombe walls, for their lake of aesthetic since they supply heat without light and view on the outdoor, are not widely used among the three prime solar design technologies.

- Daylighting

Taking advantage of daylight, which is a natural light from the sun, for sustainable architecture is indispensable either in a cold or hot climate regions. Because natural sunlight promotes health with visual comfort and save energy in contrast to artificial lighting. The most problematic aspect of daylight is glare which needs to be controlled by atrium, light shelves, prismatic glazing, light pipes, holographic glazing or again solar shading shown in the figure below.

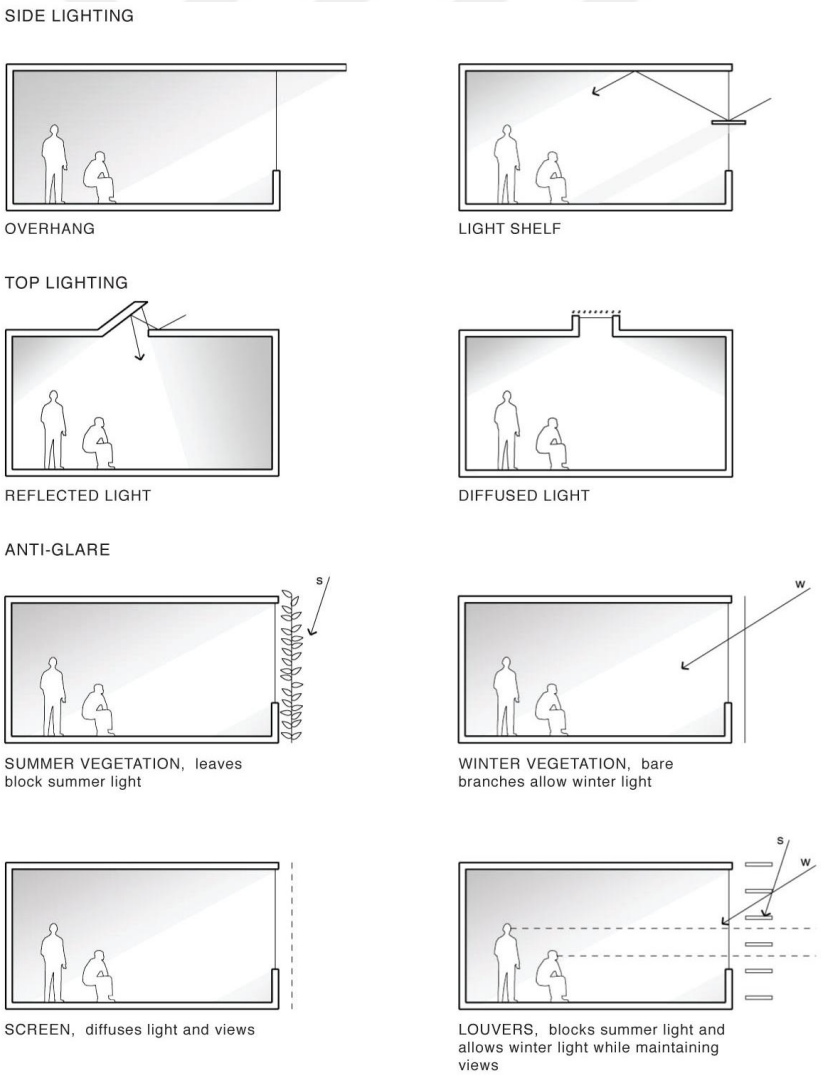

Figure 2. Daylighting (n.d).

- Shading

In fact solar gains are controlled effectively with sunshade outside the windows. More over all Shading is a solar strategy as its own even though it blocks rather than collects solar radiation. When using solar shading to prevent solar heating it's advised except in the north or south hemispheres to minimize glass on east and west side but in a case that the building keeps ending up with windows on these exposures then a great strategy to deal with is to plant trees (Fig.3). Shadings can be fixed or operable systems as well as composed of horizontal or vertical overhangs, trellises, awnings, external shutters, louvers and arbors.

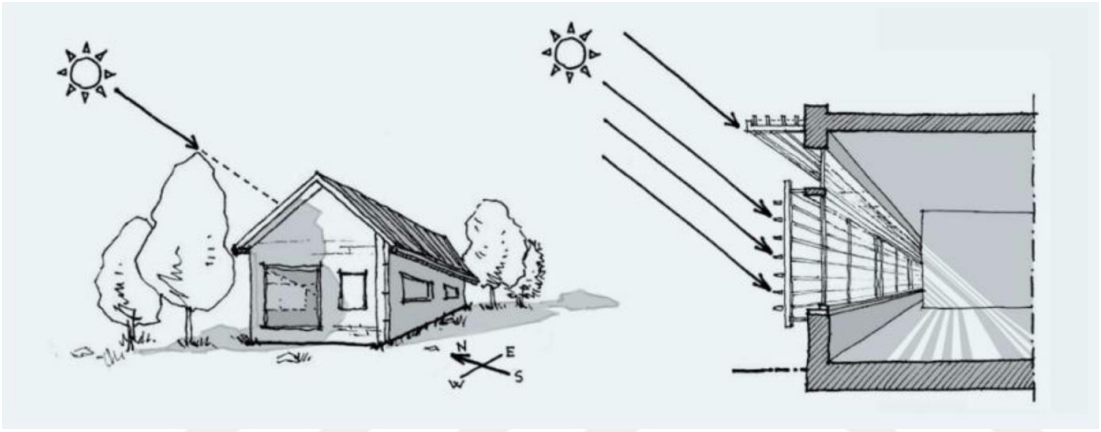

Figure 3. Shadows Cast by the Context and by Elements of the Building (Butera, Adhikari & Aste, 2014, p.91).

- Ventilation

Similar to natural lighting, in reducing the energy consumption and having a good impact on health when well executed, the natural ventilation permit to dissipate interior heat sources and substance loads such as bad smells, harmful substances and CO2. Passe and Battaglia (2015) explain that "Ventilation describe the means to introduce fresh quality air into a space and extract exhaust, stale, polluted, or odorous air out of the space" (p.35). As far as it's known the easiest way of ventilating is that of natural ventilation via windows that can be operable .The size and type of these windows will define of course the temperature difference between outside and room air.

> When placing ventilation openings, you are placing inlets and outlets to optimize the path air follows through the building. Windows or vents placed on opposite sides of the building give natural breezes a pathway through the structure. This is called cross-ventilation. Cross-ventilation is generally the most effective form of wind ventilation (Wind Ventilation, n.d, para.8).

Then cross-ventilation (Fig.4) is a passive strategy where air flow is achieved using openings at opposite sides of a room or building. Sometimes instead of using cross-ventilation which represents a wind-induced ventilation, ventilation can be provided also through tempered-induced air movement or stack effect (Fig.4) ventilation which uses temperature differences to move air so that the hot air rises. Usually higher window openings vent rising hot air and encourage cool air flow. But unfortunately, natural ventilation can't be used, especially in extreme temperatures during winter or summer. For this reason there are no other choices apart from having recourse to mechanical ventilation with efficient heat recovery. The three strategies integrated with each other in the same building result in a hybrid system.

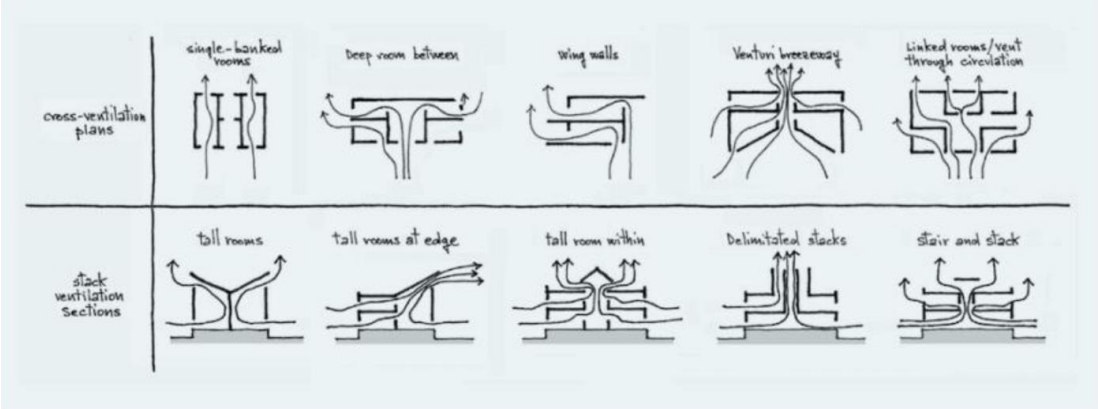

Figure 4. Room Organisation Strategies Facilitating both Cross and Stack Ventilation (Butera, Adhikari & Aste, 2014, p.77).

In addition to the previous strategies mentioned above and representing comfort ventilation, Night flush cooling also exists. It's a ventilation cooling strategy which keeps windows and other passive ventilation openings closed during the day, but open at night to precool the building for the next day.

- Energy Gain System

In fact energy demand is the reason why conventional buildings represent sector emitting the most CO2 and polluting the environment. It's for this reason heating, cooling, lighting and even ventilation are being passively produced to reduce as much

as possible energy consumption and loads in the first phase of a project called to be efficient.

> The use of energy in conventional buildings Impacts on the environment through the consumption of non-renewable resources and by contributing to global pollution through greenhouse gas emissions. Energy saving is without doubt, the quickest, most effective, and best value means of reducing greenhouse gas emissions and offers a major contribution to combating climate change (Brophy & Lewis, 1999/2011, p.36).

Active solar strategies also assist passive ones to supply most of the low-grade heat requirements for domestic hot water and space heating too in a case passive solar heating is not possible. Renewable energy resources such as sun and wind can be used again in generating directly electricity through photovoltaic (PV) panels and wind turbines illustrated in the following figure.

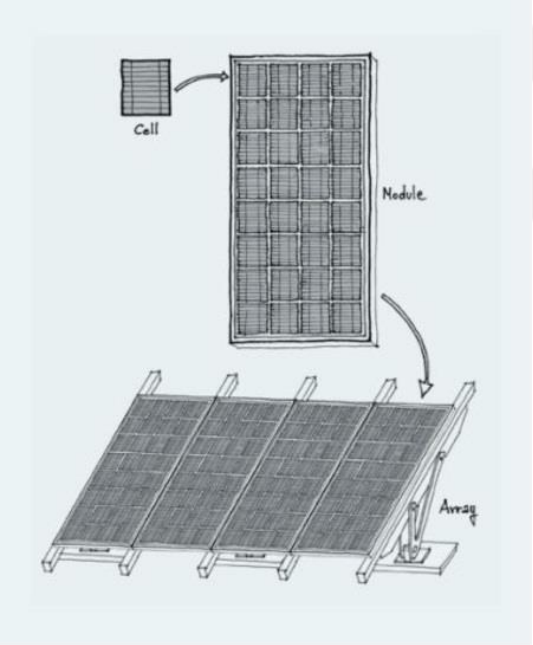

Figure 5. Cells Combine in Modules or Panels, Panels Combine to Form an Array (Butera, Adhikari & Aste, 2014, p.245).

- Water Management System

Less integrated in the conception of sustainable buildings, water as an important resource essential to the survival of human on earth like the wind should be efficiently managed to reduce the problem of resource depletion caused through waste.

> For many of us, water simply flows from a faucet, and we think little about it beyond this point of contact. We have lost a sense of respect for the wild river, for the complex workings of wetland, for the intricate web of life that water supports (Stelmack, Foster & Hindman, 2014, p.26).

This inconsistent interest on water management can be the fact that it's represent the last strategy always mentioned after the other types in any books and research papers. As soon as they mark it at least each architect should take them seriously and apply them in their projects if possible.

> The design of a plumbing system, must incorporate not only traditional issues of sanitation, flow, and pressure, but also environmentally based preferences for recycling waste water, use of non-utility water and different treatments for potable and non-potable water."…"non-utility" water refers to water not provided by the utility such as rainwater and graywater (Woodner, 1999, p.102).

2.2. Vernacular Architecture

Just as in sustainability, a problem of definition also persists in the vernacular architecture which attracts the attention of other people exercising professions different from the architecture but still with few points in common. The terms vernacular, folk, traditional are sometimes used synonymously. Noble (2007) claims that "One of the distinctive characteristics of vernacular architecture study is its interdisciplinary or multidisciplinary focus" (p.8). In fact the architects make use of the studies made by anthropologists, archaeologists, historians and geographers in order to understand better the vernacular architecture which is broadly defined as the structures where an architect or a specialist is not employed.

"All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of cultures that produce them" (Oliver, 2006).

2.2.1. Influences on Vernacular Architecture

In addition to man with his culture emanating from his ancestors and his geographical position which provides him with necessary resources for the construction of a shelter according to Oliver (2006), "other factors also have bearing on the kind, form, especially effects of climate which have to be controlled, modified or utilized"(p.9).

- Climate

While thick walls and small windows are preferred in cold climates for preventing heat loss, lighter materials in conjunction with door and windows designed to encourage air movement are necessary in buildings in hotter climates. Then when efficiently controlled and assuring thermal comfort, climate defines the building form and has an important impacts on vernacular architecture which is first full a cultural expression.

- Culture

Culture is the only aspect of vernacular architecture capable to struggle in maintaining alive traditional buildings with the advent of modern technology. Because through the local customs and belief of the occupants which differs from others, the specific appearance of their vernacular architecture is defined and can continue to exist for years if this culture is still existing. In fact such buildings are recognizable with some specific decorations of the facades or the interiors of the rooms which functions and organization depend on the way their owners wish to use them paying attention to the climatic conditions.

- Environment and Material

Of course in a region without the natural resources, necessary for the construction of any strong shelter able to resist the climatic conditions of that place, there is also no chance to even live there but there will always be another place favorable to settle down locally. Materials in themselves do not seem to determine form like climate and culture do but the fact that vernacular architecture is using materials that are local and building with local labor is environmentally friendly. In that way possible pollution created during transportation is reduced and no serious expense is required.

2.2.2. Vernacular Architecture in Hot and Arid climate

On the earth Artic, Antarctic, Temperate and Tropical are the four geographical zones distinguished and for Szokolay from them result also four types of climates (cool, moderate, hot dry and hot humid) spread in different places. Obviously the climates are either cold or hot and the warmest represent the last three mentioned previously. These hot climates occur only in the vicinity of the equator, between the tropics of Cancer and Capricorn. (Fig.5)

In this research the concern is essentially about the hot dry climate found between 15 and 30 north and south of the equator. Describe through direct and strong solar

radiation during the day with low annual rainfall the climatic design priorities in such regions is to protect from the sun, reduce day to night temperatures that can be extreme by being hot or cold, cool and remove excess moisture. Sometimes there is a need to prevent also from sandstorms since those hot area may include hot dry desert climates.

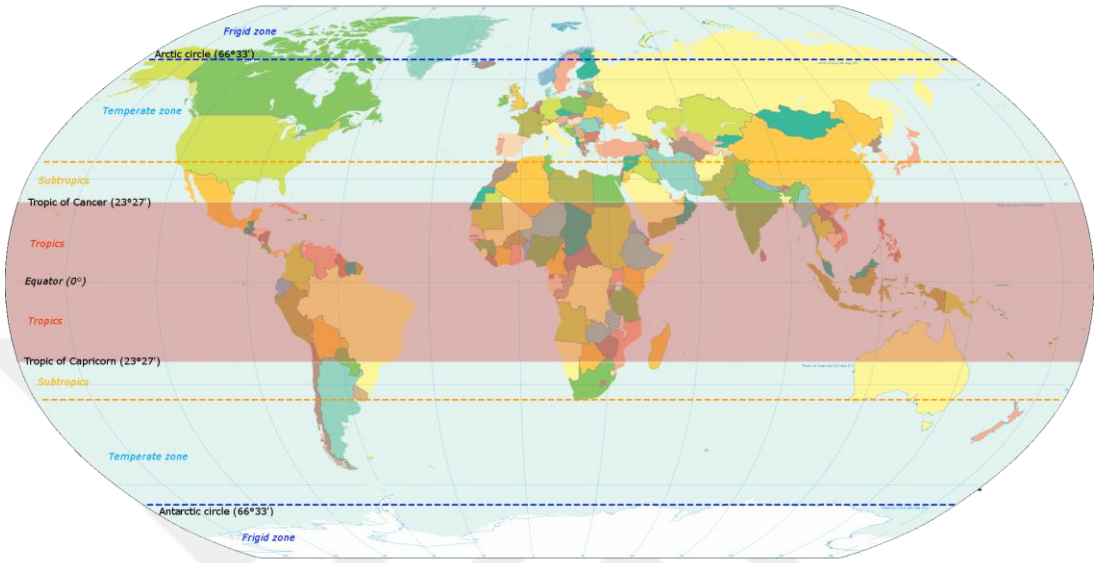

Figure 6. World Map Indicating Tropics and Subtropics (n.d).

- Courtyard

Courtyard, which can be used in cold regions and simultaneously as the most suitable building strategy in hot and arid climates where it's common, never went out of trend. This building typology is designed to control the exterior climate, while acting as a microclimate depending on its size and proportion compared to the building where it's located, but represents more over all a place of social or familial gathering.

"All courtyard across the studied cultures have one major common characteristic: they act as both social spaces and climatic spaces, and this cultural significance guaranteed the survival and revival of this building type."(Passe & Battaglia, 2015, p.131)

By definition a courtyard is any internal space open to the sky and bounded by a building in a fully-enclosed, semi-enclosed or semi-open way. It's sometimes accompanied of water source for evaporative cooling, plants and verandas known

as transition spaces from interior and exterior providing shading, indirect light then facilitating cross-ventilation to the interior spaces.

> Care has to be taken to shade the inward-facing walls of the building from direct exposure to the sun. This can be achieved by using colonnades or verandas. These intermediary spaces will act as thermal barriers…Plants and trees outside the building play a vital role when the wind is forced to pass through them, thus allowing winds to be cooled and relieved of much of their sand and dust (Koch-Nielsen, 2002/2007, p.59).

- Ventilation

Ventilation is included in the majority of strategies used in the buildings of hot and arid zones and yet the wind that can be used for refreshing may be undesirable. Because it's sometimes hot and dry, even dusty during certain periods in such areas. The courtyards so much solicited in these warm countries serve not only to diffuse indirect lights in the internal spaces but they also permit to ventilate as best they can. In addition to the courtyards and depending on the culture, some houses can either have wind-catcher (vertical or horizontal) or simply roof vents.

Ford, Schiano-Phan, Francis, Alvarez and Paul Thomas acknowledges that "The Iranian and Middle Eastern wind catcher is probably the most studied inherited natural ventilation strategy, and it has also been successfully integrated into contemporary built projects"(as reported by Passe & Battaglia, 2015, p.136).

So the most popular method after the courtyard is the vertical wind-catcher also called wind-tower. It's based on the principles of stack-effect and works by driving inside the ground floor spaces the fresh air from outside which has been captured beforehand above the building. (Fig.6)

"In warm climates the effectiveness of stack is questionable, the temperature differences between inside and out are small. Since stack is driven by temperature difference, the pressures are small. Wind-driven ventilation therefore is commonly used in warm climates" (Hyde, 2000/2007, p.75).

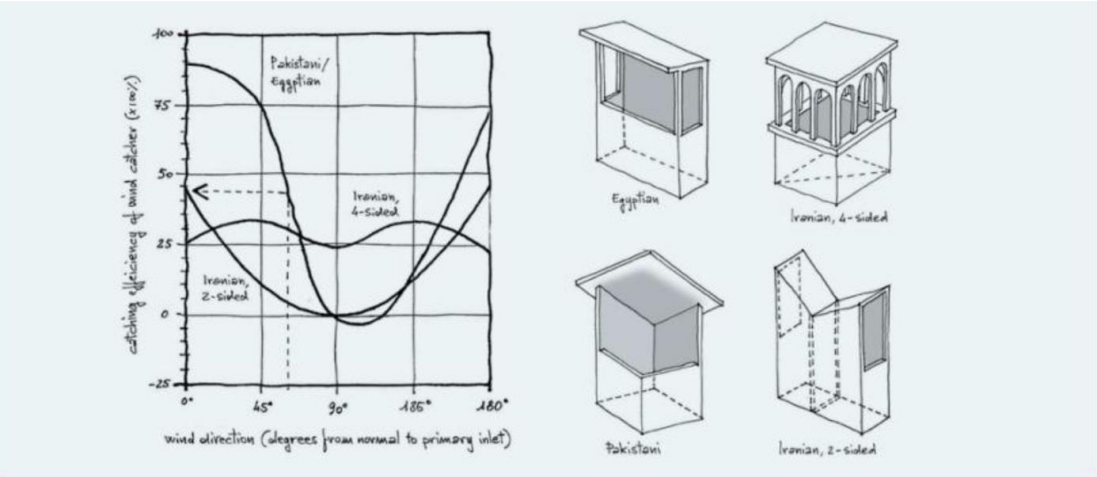

Figure 7. Catching Efficiency for Different Wind Catcher Design (Butera, Adhikari & Aste, 2014, p.78).

The horizontal wind-catcher with one or more sides open to the outdoors can be classified as cross ventilation strategy and correspond to spaces such as passage, arcade and loggia. In Pliny the younger it's described that "Inside the arcade, of course, there is least sunshine when the sun is blazing down on the roof, and as its open windows allow the western breezes to enter and circulate, the atmosphere is never heavy of stale air"(as expressed by Passe & Battaglia, 2015, p.).

Despite their advantages, wind-catchers can cause serious problems because they are favorable places to the entry of dust and when this happen roof vents (Fig.7) become practical.

> Domed or cylindrical roof air vents are employed in Iranian areas where dusty winds make wind tower impractical. These vents are holes cut in the apex of a domed or cylindrical roof and protected by a cap with openings that direct the wind across the vent (Allard & Santamouris, 1998/2002, p.240).

But roof vents are the ventilation method applied at the flat roof of the great mosque of Djenne. Contrary to domed and vaulted roofs which are less exposed to the solar radiation and traditionally present for very long periods in hot and arid regions, the flat roofs are multifunctional and perfect for regions with rare rainfall. For more precautions these roofs are nevertheless provided with shutters to avoid any infiltration after a storm especially if mud is the main building material.

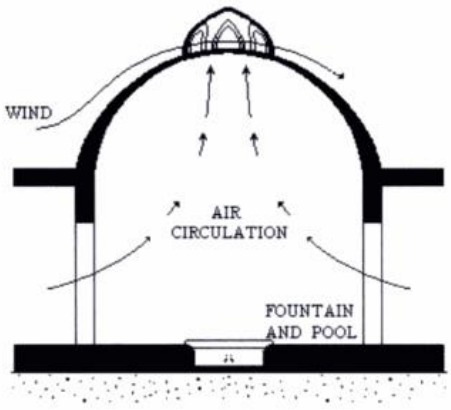

Figure 8. Airflow Patterns through a Domed Roof Air Vent (Allard & Santamouris, 1998/2002, p.240).

- Thermal Mass

The roof and the walls are the most exposed elements of a building envelope to external conditions because through them solar radiations are absorbed and transmitted to the inner surfaces. It can result in overheating if their thermal performances depending on their form, construction and materials are poor. In hot and arid region the most interest is given to the thermal mass which is a property of the building's mass capable to slow down the heat conductivity by absorbing the heat in the day and release it during the night.

> A building in a warm and dry climate is usually a compact heavy mass structure that modulates outdoor temperatures, with small windows to reduce solar gains to the interior of the space but that allow some ventilation for night cooling (Pablo La Roche, 2012, p.120).

Thicker or again massive walls are recommended in hot and arid climates where "earth has always been the most prevalent building material" according to Minke (2006, p.11). Other materials than earth like natural rock and stones are commonly used for their thermal mass property too.

- Openings

Openings are similar to courtyards in admitting inside the internal environment of a house natural lighting and ventilation from external conditions. But the design of openings in warm and arid regions is critical because they are often sources of glares and passage of unwanted dusty winds. The solution is to reduce their amount or sizes

and be careful in which directions they are placed according to the sun path and wind directions.

“The intense Mediterranean sun is met with by placing few and narrow windows in the outside walls of traditional North African houses …” Noble (2007, p.204).

But there is another traditional and efficient device from the Arabic countries, and therefore from Islamic architecture. It’s the mashrabiya (Fig.9 & Fig.10), a perforated wooden window according to a geometric plane consisting to maximize natural ventilation and to diffuse internal light.

“A perforated screen, normally made of wood, intended to conceal the private indoor spaces from the public domain within a house, giving view advantage to those inside”(Nitzan-Shiftan, 2012, p.73).

Figure 9. External view of Mashrabiya: House of Suhaymi, Cairo, Egypt (n.d).

Figure 10. Internal view of Mashrabiya: House of Suhaymi, Cairo, Egypt (n.d).

CHAPTER THREE
VERNACULAR ARCHITECTURE IN MALI

3.1. Location

Mali is a landlocked country with an area of 1,240,192 square kilometers (478,839 square miles) located in the western side of the African continent. The neighboring countries at the total number of seven are respectively composed of Senegal and Mauritania (west); Algeria (North); Niger (East); and finally Burkina Faso, Ivory Coast and Guinea (south) as seen in the figure below.

Figure 11. Map of Mali and its Administrative Regions (n.d).

Formed by one district and eight regions (Fig.11) which are distributed between the three natural zones (**Sahara**, **Sahel** and **Savana**) the country generally flat, however known for some of its mountains and plateau, is traversed by the Niger and Senegal rivers (Where is Mali, 2016).

3.2. Climate

In reason to the presence of the zones mentioned above three types of climate are eventually observed in Mali according to the Köppen climate classification: Desert climate; Semi-arid climate; and Tropical wet and dry climate which are illustrated in the following figure.

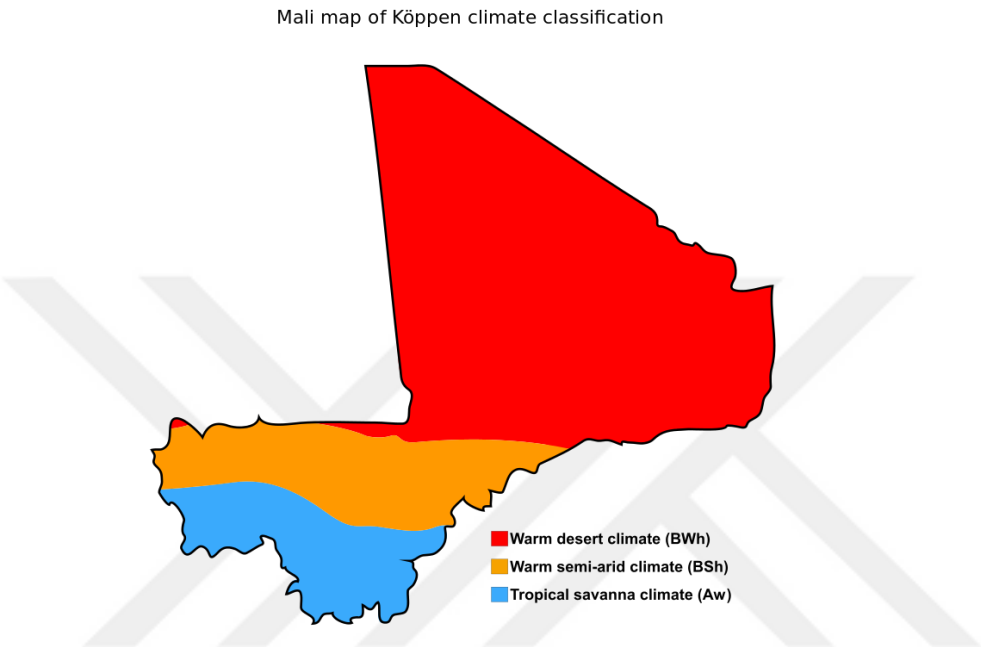

Figure 12. Climate Classification in Mali (n.d).

These climates not looking rigorously different from each other make without a doubt Mali seen as a country with a hot and dry climate basically. But the other reason might be the fact that the Malian Sahara own a larger superficies compared to the other two zones or again simply because of the position of Mali according to the equator line which pass through it.

“The majority of the surface area of Mali is taken up by desert and semi-arid land known as the Sahel, while in the southern areas there are subtropical Savana grasslands”(Velton, 2000/2004, p.35).

The dry period which stretches from November to June is transitioned through the month of July into the rainy season which runs from June to October. While the months of March to June correspond to the warmest months of the year, however those from December to February remain the most pleasant and thus favorable to tourism (Eric & Manaud, 2007).

3.3. Types of Vernacular Architecture in Mali

Mali owes its rich and diverse culture to the greatest empires and kingdoms of western Africa that previously covered its lands. The best known were the Empire of Ghana, the Empire of Mali (Fig.13) that the country adopted the name when taking its independence in 1960 and finally the Songhay Empire.

Figure 13. Empires of Medieval West Africa (n.d, p.135).

Each of these three empires participated in trans-Saharan trade, which consisted of trade between North and West Africa in the Sahara Desert. This commercial contact between blacks and Arabs from the east has led to the advent of Islam in animist black Africa. Result the majority of the current Malian population is Muslim. Nevertheless, animism is still practiced by the Bambara, Malinké, Bobo, Songhay, Senufo, Dogon and other ethnic groups. But the most important of these is the Dogon people who didn't want to convert to Islam in the past and then have taken refuge in the famous cliffs of Bandiagara for developing a traditional architecture out of the ordinary.

The cities of Timbuktu and Djenne, which were major centers of trans-Saharan commerce, also possess architectures proper to them. Timbuktu long inhabited by Moroccans who failed to fully capture what remained of the last great empire of the

West Africa (the Songhay Empire) that they coveted so much, has an architecture of adobe houses with beautifully crafted portals. While Djenne stands out by the beauty of its architecture in earth and especially by the great mosque of Djenne considered like the biggest monument in banco in the world (Histoire, n.d.).

3.3.3. Timbuktu

Figure 14. Aerial View of Timbuktu (Dia, n.d).

- Historical Development

The city of Timbuktu located in the Desert of Sahara owes its evolution to its strategic geographical position which brought it covetousness and thus its occupation by diverse cultures in turn. People were continuously going there notably for the trans-Saharan commerce but as well as to acquire Islamic knowledges since the sovereign El Haj Kankou Moussa / Mansa Moussa (Empire of Mali) in return from his pilgrimage to Mecca, accompanied by an architect known as Abu Ishaq Es Sahali, had the brilliant idea of transforming Timbuktu into a spiritual center by building a prestigious university, mosques and Koranic schools (Reynolds, 1999).

A proverb from a famous scholar Ahmed Baba (1556-1627) in Timbuktu says that "The salt comes from the north, the gold comes from the south, the money comes from the country of the whites, but the word of God, the learned things and the pretty tales, they are only found in Timbuktu"(as reported by Sidi & Joffroy,2010, p.38).

This poet and architect Abu Ishaq Es Sahal created then new styles by incorporating building features from Arabic origins into traditional buildings made of earth already

existing and which were the first structures of Timbuktu constructed by African architects from Djenne. (Architecture, n.d.).

Timbuktu in reality consisted only of tents belonging to the Tuaregs at the beginning of its creation. This is the reason why it is not surprising to cross certain tents in its current urbanism which is varied naturally and in perpetual change (Sidi & Joffroy, 2010).

"Timbuktu has been since its foundation a city in earth and has therefore undergone evident transformations, given the formal metabolism inscribed in the genetic code of earthen architecture" (Bertagnin & Sidi, 2014, p.27).

In any case the earthen houses, as well as the tents did, gradually are giving way to new houses made of stones (Al-Hor), which was just used only on the façades of earthen houses exposed directly to the wind Sahel- Hew, the desert wind blowing from the north-east to the south, a harmattan laden with ocher sand and dust contributing to the erosion of the buildings made by earth.

- Features

The Buildings from the old center of Timbuktu juxtaposed closely next to each other with angled streets in order to reduce hot and sandy winds and provide some shades have an organic urban structure while the buildings resulting from the colonial French penetration have an ordered one due to an orthogonal grid with large streets (Silva, 2010).

But generally they both contain a courtyard which is an important and dominant element in hot and dry region for the reason that through them good ventilation and lighting is achieved. It should also be noted that the social life and habitat of the Saharan villages and the region of Timbuktu have an impact in the presence of courtyard. Indeed, when observing an aerial view of Timbuktu, it can grasp this mutual interaction between solid and void, identity element of the urban fabric. In a case that we are dealing with a one-storey building or no there is always a staircase leading to the upper floor usually accessible from the inner courtyard.

Actually it's true that two types of building coexist: a Basic type (Fig.15) and a Mixed type known as the Urban palace. They just differ in the number of storey and have the same material in common. But the urban palace style is also classified in two different categories in terms of materials. See Figures 16 and 17 given below.

-Basic type: ground floor (earth)

-Mixed type/Urban palace type1: one storey (earth)

-Mixed type/Urban palace type2: one storey (stone)

Figure 15. Basic Type Building in Timbuktu (Bieber, 2010).

Figure 16. Urban Palace (Type1) Building in Timbuktu (McMorrow, 2006).

Figure 17. Urban Palace (Type2) Building in Timbuktu (Sidi & Joffroy, 2010, p.27).

In this study the main focus will be only on the buildings made of stone walls in the region of Timbuktu since the ones with earth are quite similar to the vernacular houses found in Djenne.

In addition the unique entrance door of the lobby surmounted by three windows and connecting the street to the courtyard of the house which accentuates privacy; and facades with small openings decorated with metal discs in the Moroccan fashion are also observed.

According to the architectural typology the spatial organization consists of the central courtyard around which are placed the other spaces like the bedrooms arranged along an open corridor of the first floor thus creating a kind of terrace or loggia. To those is added the living room which can be present either on the ground floor or the first floor, the kitchen always on the ground floor is placed not far from the toilet and the shower which are both on the upper floor except that on the other hand the toilet is on the outside just like the oven placed in the street which is a functional structure of the kitchen.

> The one-storey houses have twelve pilasters, but those on the floor are slightly offset from those on the ground floor and end with small mitres that overhang the roof. According to the traditions preserved by the masons, the plan of the house is divided into nine parts, practically square, eight for the rooms, the courtyard forming the central square (Bertagnin & Sidi, 2014, p.33).
>
> To reduce solar radiation the houses form a rectangle oriented towards the four cardinal points, the door being oriented preferably North or South. Bedrooms are placed in the East or South-East (Heat release in the early evening), while living rooms and workspaces are placed in the West/North-West (heat release in the night) (Silva, 2010, p.14).

Regarding to the harsh condition of the region the amount of openings by house is limited in order to reduce the heat and glare. The windows having the same small size in any type of buildings also have different categories in terms of shape and function. Because at one side wooden windows with square shape are found and at the other side some pyramidal voids in walls are consisting to ventilate despite the fact that the courtyard is already doing so. To the openings are added arches used either to frame the main entrance door or placed in front of the covered terraces serving as loggia.

- Materials and constructions techniques

From its foundation to its walls of 40cm thick the urban palace is only made of stones which guarantee a certain thermal mass against the action of the heat. These stones are linked with adobe and sometimes then joined again with a mixture of adobe-cement.

The doors traditionally called Al-Galim (nails in Arabic) and the windows are made either from a wood (bois veiné) from Mopti or from a red wood (bois rouge cailicédra) from Mopti or Segou which has the advantage of being a wood naturally immune against Termite attacks. The particularity of those two elements which stayed very significant in decoration and prestige for the house of Timbuktu is that they are connected to the traditional carpentry arrived in the city with the Moroccan invasion. While the doors are distinguished by the presence of metallic plates, an iron bell and nails the windows have square mesh grating to their lower parts for a good luminosity as shown in the figure below.

Figure 18. Courtyard in Timbuktu (n.d).

The roof always flat and surrounded by parapets with a height of 100 to 140 cm if it's a walkable one is made of different layers of wood followed by an earth-based filling. The first floor and the terrace are often covered with clay, or more rarely, with baked bricks. With the evolution of the materials one finds in certain living rooms cement floors.

> In Al-Hor stone houses there are cornices which draw horizontally the level of the floor and the terrace on the facade and determine in strict relation to the corner pillars and the main entrance door, the composition and the rhythm of the façade (Bertagnin & Sidi, 2014, p.53).

The gargoyles similar to gutter ,either metallic or made in baked bricks, are well integrated into the vernacular architecture of the historic city and used to evacuate the rainwater for preventing humidity and infiltration with the help of a proper inclination of the terrace.

Table 1. Building Characteristics in Timbuktu

TIMBUKTU			
BUILDING TYPE	**BASIC**	**MIXED/URBAN PALACE**	
		TYPE 1	**TYPE 2**
NUMBER OF STOREY	GOUND FLOOR	ONE STOREY	ONE STOREY
FOUNDATION MALTERIAL	MUD-BRICK	STONE	STONE
WALL MATERIAL	MUD-BRICK	MUD-BRICK	STONE
DOOR + WINDOW MATERIAL	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES
ROOF MATERIAL	LAYER OF WOOD *[Split Palm+Palm Frond Matting]* + EARTH	LAYER OF WOOD [Split Palm+Palm Frond Matting] + EARTH	LAYER OF WOOD [Split Palm+Palm Frond Matting] + EARTH
COURTYARD	PRESENT	PRESENT	PRESENT

3.3.4. Djenne

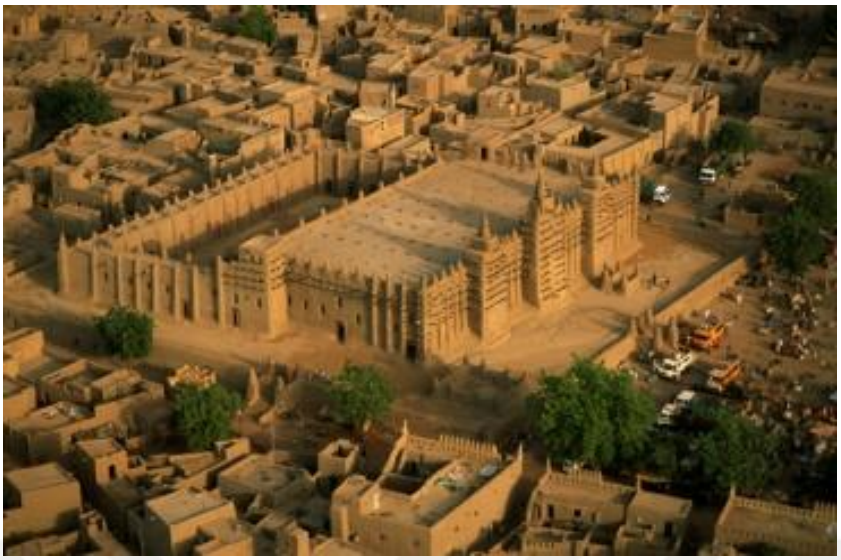

Figure 19. Aerial View of Djenne (Corbis, n.d).

- Historical development

Djenne found in the region of Mopti and considered also as one of the major centers of trade is an important city of the Niger bend. What distinguished this place from the others was the fact that Djenne was close to the rain forest region and was the first point of exchange for traders to the south (Reece, n.d).

Acting today like a blend of African and Islamic styles, Djenne either couldn't escape from the Islamization of its population since koy Kunboro a chief of the city after converted to Islam destroyed his palace in order to replace it by the great mosque of Djenne. The mosque standing on a platform and previous foundations of the old palace represent also the most famous building of the area (Petersen, 1996/2002).

This city, which enjoyed its political independence for a long time because efficiently protected from enemies since it was encircled by walls, was also conquered during the Moroccan invasion the same way like Timbuktu and later by the Empire of Tukulor which didn't have as much success as the three great empires of West Africa which precede it. (Conrad, 2005/2010)

And if the pearl of desert has a mixed architecture dominated mostly by the use of stone than earth due to the transition it has undergone, the houses of Djenne come only from earthen architecture very mastered since the beginning through mud-bricks as

building material. In any case the climate plays a major role in the choice of each region and Djenne is the most favorable place to follow using earth in their buildings.

“The area most suited to mud-brick architecture is the savannah region where there is enough water to make bricks, plaster and pies yet not too much rain to dissolve the dried mud walls” (Petersen, 1996, p.307).

- Features

Djenne, protected before from enemies through a city wall which doesn't exist anymore, is still giving the same impression through some houses very close to each other located along the river side and surrounding the city.

with its urbanism resulting from a complete earthen architecture the city, sometimes seen as an island through rising water during the raining season despite being located in height in order to adapt itself to its context, has been actively developing around its great mosque and its marketplace.

Just like in Timbuktu the courtyard remains an essential element in both religious and residential buildings and three types of houses are distinguished in general: the Moroccan, Tukulor and Plain types. The Moroccan type (Fig.20) with its windows and doors decorated as usual stand out by the absence of canopy compared to the Tukulor type (Fig, 21) which has a canopy in particular on the main facade to protect the inhabitants of the house from the Tukulor riders in search of slaves during their invasion and get rid of the torrential rains in addition. Though the Plain type, divided into two groups according to the number of floors, presents any decoration contrary to the previous types mentioned above which are very traditionally ornamented.

> Most houses are two-storey, with roof terraces that are actively used not only for domestic activities but also as an alternative street network. As there are no major separations between roofs, neighbours use the terraces to go from one house to another. Roofs may occasionally have a thatch-covered area to provide shade (Chabbi-Chemrouk, 2004, p.3).

-Morrocan type: two storey- decorations - no canopy

-Tukulor type: two storey – decorations- canopy

-Plain type 1: two storey - no decorations

-Plain type2: one storey - no decorations

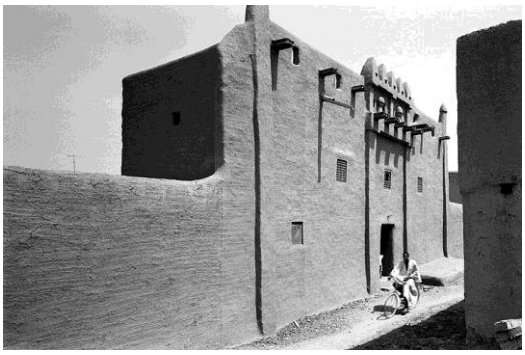

Figure 20. Morocan House in Djenne (2009).

Figure 21. Tukulor House in Djenne (2009).

In Djenne the facade is so important that one cannot speak of organization of spaces without making reference to it beforehand since it is the first element represented in an abstract way on the ground by the mason or the master of the work. The masons of Djenne who transmit the art of construction with earth from father to son belong to the same ethnic group of the fishermen present in the city.

“Interior planning is gender based: men occupy the front of the house and have a windows and doors facing out on the road; the women are at the back overlooking the courtyard and isolated from the outside world” (Velton, 2000/2009, p.168).

To understand the architecture of Djenné, explains Abdoulaye Touré a Malian architect who studies the architecture of Djenné since the years 1983-1985, it is necessary to make a detour by the Dogon architecture, where the building represents the human body and the family. In fact from the street and by knowing the necessary codes one can guess the gender of the owner of a house in Djenné.

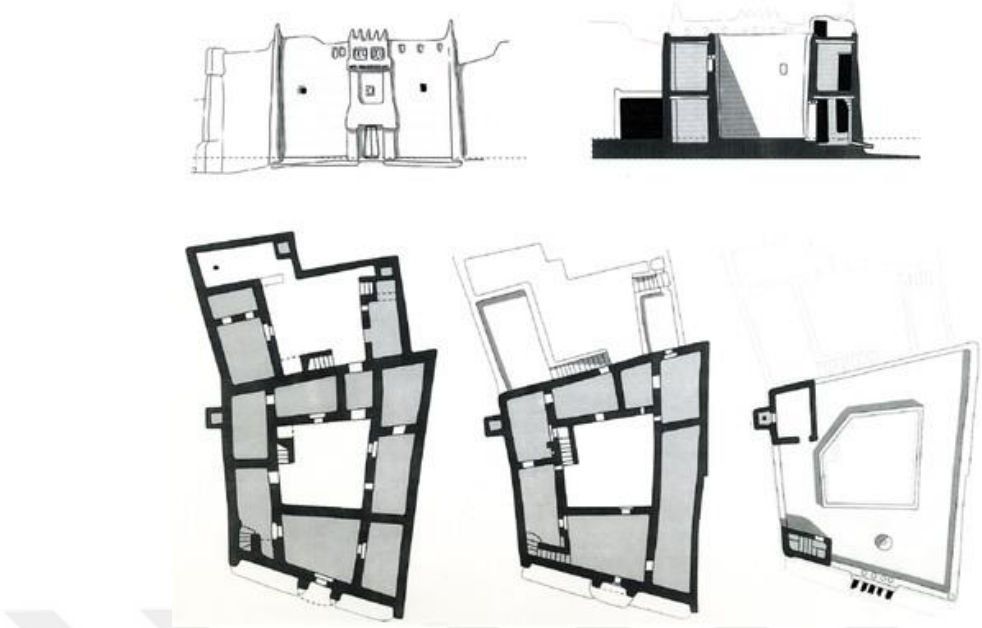

Figure 22. Typical Plans, Elevation and Section of a Tukulor House in Djenne (Chabbi-Chemrouk, 2004, p.16).

- Materials and constructions techniques

The walls as well as the foundations, pillars and pilasters are made of some mud-bricks known as “Djenne ferey” which are bind together with layers of mud mortar. The “Djenne ferey” is recognized by its cylindrical form shaped by hand and then dried or baked on the sun. This brick seems more resistant than the “Toubabo ferey” which posses rectangular shapes and have emerged with the French occupation of Djenne.

“In order to avoid the problems of water erosion mud-brick buildings are often built on stone footings or have overhanging roofs with water run-off directed into special channels” (Petersen, 1996/2002, p.198).

With regard to the type of houses decorated, some palm sticks called “Toron” projecting out from the facades are used as decoration and as scaffolding for the periodic rendering of walls since mud-bricks also requires a certain amount of maintenance usually in the form of annual replasting. So wood is the principal material for openings and horizontal structural elements such as floors, ceilings and roofs. Due to the Moroccan occupation the windows are the same type found in Timbuktu and providing privacy, good lighting and ventilation while the doors are less decorated than the ones in Timbuktu.

Drainage from roofs is ensured by ceramic waterspouts that project from the walls at regular intervals. However, spouts are only 60 to 80 centimeters-which is not long enough to keep heavy rains away from the walls-so they often have additions made from corrugated sheet metal or plastic. (Chabbi-Chemrouk, 2004, p.9).

Table 2. Building Characteristics in Djenne

DJENNE				
BUILDING TYPE	**MORROCAN**	**TUKULOR**	**PLAIN**	
			TYPE 1	**TYPE 2**
DECORATION [TORON]	PRESENT	PRESENT	NONE	NONE
CANOPY	NONE	PRESENT	NONE	NONE
NUMBER OF STOREY	TWO STOREY	TWO STOREY	TWO STOREY	ONE STOREY
FOUNDATION WALL	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]
WALL MATERIAL	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]
WALL MORTAR RENDERING MATERIAL	3 LAYERS [Mud + Rice Husks + Water]	3 LAYERS [Mud + Rice Husks + Water]	3 LAYERS [Mud + Rice Husks + Water]	3 LAYERS [Mud + Rice Husks + Water]
DOOR + WINDOW MATERIAL	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES
ROOF MATERIAL	WOODEN JOIST + FINE MUD	WOODEN JOIST + FINE MUD	WOODEN JOIST + FINE MUD	WOODEN JOIST + FINE MUD
COURTYARD	PRESENT	PRESENT	PRESENT	PRESENT

3.3.5. Bandiagara

Figure 23. Dogon Villages along the Cliffs of Bandiagara (2012).

- Historical development

The Dogon country, mainly inhabited by Dogon whose exact origins remain unknown, consist of several villages scattered among the plateaus, cliffs and plains that their natural environment offers them.

This place seems to have been formely inhabited by the Tellem culture which gave way to the Dogon after those ones have joined them through migration according to the archeologists when examining the Dogon cliffs.

Despite the fact that some Dogon have converted to other religions given the presence of certain mosques and churches in their villages, animism remains firmly inked within this people who never really cease to worship the ancestors and the spirits that they encountered as they slowly migrated from their obscure ancestral homelands to the Bandiagara cliffs.

It should be noted that it was through the refusal to convert to Islam the Dogon had to find refuge to Bandiagara notably in the cliffs in order to escape this situation and to protect themselves from future enemies at the same time.

But nowadays they begin to build more and more at the lower parts of these extraordinary cliffs which offer magnificent views of the landscape since the danger became less felt because the occupation of Mali by French bring peace to the region.

> Despite all the amazing sight to be seen at ground level, the one thing that stays with the visitor and to which the eye keeps returning, are the amazing cliff top housing from which the Dogon in bleaker days defended themselves from enemies (In the Land of the Dogon, 2010, para.18).

- Features

From its creation to the present day the Dogon country have continued to extend from south to north-east along the cliff of Bandiagara. Due to the decline in threats, the ancient villages hanging high in the cliffs were abandoned in favor of new villages located at the bottom of several of these cliffs. Despite the presence of several varieties in the Dogon architecture, the village of Ireli, registered with the patrimony of UNESCO, remains the most representative of the Dogon villages of the cliff.

In the Dogon culture several elements such as the house, the village or the universe are all organized by the same principles. Indeed their houses mixed among granaries are designed to represent the human body.

-The House

> Several building volumes (sleeping huts, granaries, a stable) have been grouped in a specific way around an inner square: the main apartment in the middle is the belly, the storage spaces at the side-parts the arms, the kitchen is the head, and the genitals are the entry. The roofs of the dwelling huts are flat, in contrast with the granaries that carry pointed roofs"… "Granaries are strictly separated according to the ownership of whether men or women (Architecture, n.d, para.3).

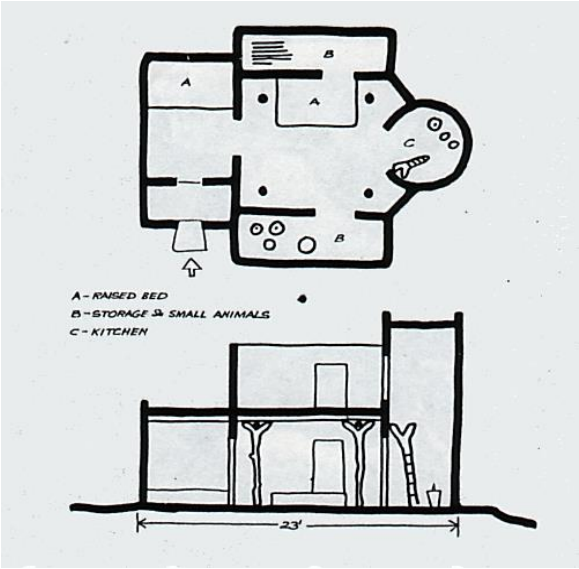

Figure 24. Typical Plan and Section of a Dogon Familial House (Merkus, n.d).

-The Village

> On the spot of the head, orientated towards the North, the Toguna (meeting place or tribınal) is to be found"… "In the 'breast and belly' the Ginna (family houses) are to be found, and on the place of the 'genitals' public sacrificial altars are located, a male and a female altar. The Punula, the houses of the women, are the 'hands', women should stay here during their menstruation period. On the place of the 'feet' a series of communal altars is to be found. On the highest spot in the village one will find the house of the Hogon, the village-eldest (Architecture, n.d, para.2).

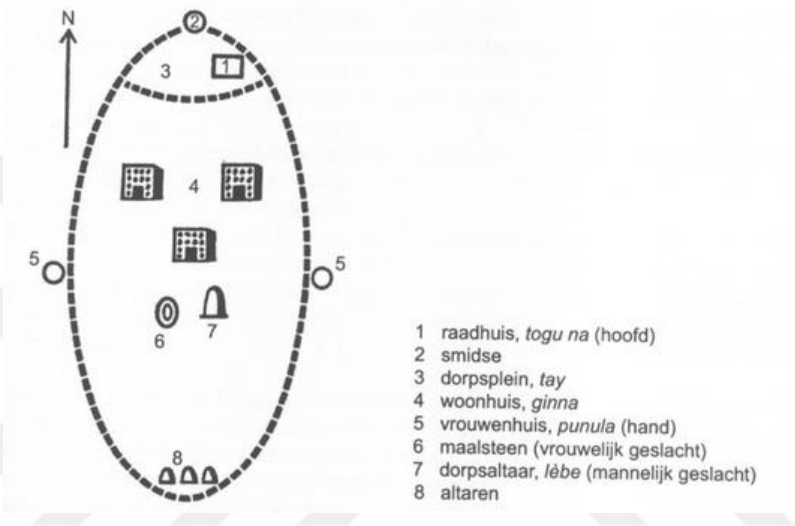

Figure 25. Spatial Organization of a Dogon Village (n.d).

- Materials and constructions techniques

As well as in Timbuktu and Djenne, Dogon architecture is also expressed through the use of mud bricks both for family houses with their flat roofs and for their granaries presenting pointed roofs sometimes surmounted or no by straws according to their owners and functions. But what is sure is that each granary, usually built from clay supported by rocks, must have at least one structure lifted from the ground in order to be preserved from termites and rodents.

The handcraft which occupies a very important place in Dogon society covers several activities such as woodcarving, ironwork, dyeing, shoe-making, basket-making and weaving. Thus the shutters and doors supposed to represent the ancestors are lavishly carved especially on the granaries but also occasionally on the houses because apparently the openings are not very appreciated in the residences where they are considered unnecessary. The figure 26 show specific samples of doors and windows in Bandiagara.

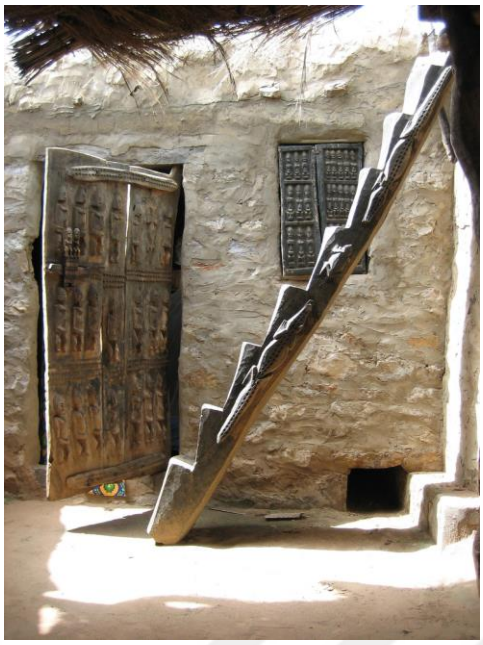

Figure 26. Courtyard in Bandiagara (n.d).

> It is interesting to note that the Dogon house has no windows therefore it is quite dark inside, the intention being that the interior is distinct, enclosed and presumably cooler, in contrast to the exterior which is light, hot and open. A man was asked during the construction of his house why there were no windows and he answered by saying Anybody who wants light can go outside. In the house it should be dark. Its better that way (Merkus, n.d, para.10).

Sometimes the niches present on the facade of residences and serving as front wall decorations are used as compartments for daily utensils and fetishes (Fig.27). More over all typical ladders are used instead of staircases in order to have access to the roof presenting sculpted gutters looking like crocodiles through the parapet. But it's difficult to perceive water flowing in this region because rainfalls are rare, so water is precious for Dogon.

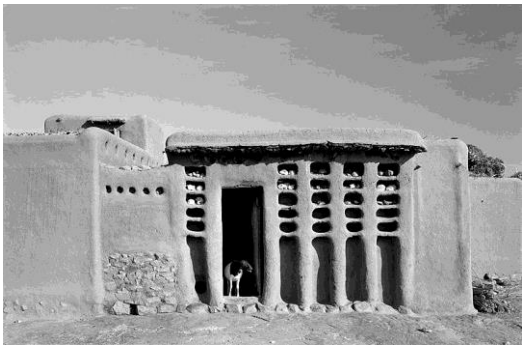

Figure 27. Dogon Familial house (2009).

Table 3. Building Characteristics in Bandiagara

BANDIAGARA		
BUILDING TYPE	GINNA	
	HOUSE OF SENIOR MALE	TYPICAL FAMILIAL HOUSE
GRANARY LOCATION	MAIN APPARTMENT	SIDE-PARTS
NUMBER OF STOREY	ONE STOREY	GROUND FLOOR
FOUNDATION MATERIAL	ROCKS	ROCKS
WALL MATERIAL	MUD-BRICK	MUD-BRICK
DOOR + WINDOW MATERIAL	CARVED WOOD WITH HUMAN FIGURES	CARVED WOOD WITH HUMAN FIGURES
ROOF MATERIAL	WOOD + EARTH	WOOD + EARTH
COURTYARD	PRESENT	PRESENT

3.4. Local Factors Influencing Vernacular Architecture of Mali

3.4.1. Climate Conditions

The climate plays an important role in vernacular architecture because it's very often the reason why certain types of local materials provided by the environment are used in the construction.

To determine the impact of climate in the choice of building material in the Malian vernacular architecture, it's just consisting to emphasize the abandonment of mud to the benefit of the stones Al-Hor in Timbuktu as a harmattan blows at times causing the erosion of the houses in mud.

The mud brick or the stone are each used beforehand for thermal cooling qualities since Mali is a warm country. And if one speaks of heat refers certainly of glare which explains a low rate of openings and their minimum sizes. The openings are always placed in order to not face directly the winds directions often dusty especially in Timbuktu and Djenne. However to ensure a good ventilation and lighting the presence of a courtyard is imposed in any hot and arid climate. Due to the rain each vernacular houses from Mali have gargoyles to avoid at least humidity and infiltration.

3.4.2. External Influences

In view of the study of the most important vernacular architectures in Mali and their commonalities, three types of external influences are retained: Islamization, the Moroccan invasion and the French colonial penetration.

- Islamization

Very often mentioned in fact Islam was established through commercial exchanges thus contributing to the rewarding image of the vernacular architecture in Mali.

His greatest success was in the Bandiagara cliffs, which would doubtless never exist if it didn't have an opposite impact on the Dogon people with their occult beliefs who preferred to continue in this way. Nevertheless, Islam did so much in Timbuktu that it didn't just made the city more popular than it was with Transaharian trade as well as Djenne, but it made Mali the cradle of Sudanese architecture in West Africa (urban or monumental architecture in raw earth) resulting from the mixing of the Arab architecture and the one already existing.

> The origin of this architecture is often attributed to the Andalusian architect (and poet) Abu Ishaq es-Sahéli, who returned with Emperor Kankou Moussa from his pilgrimage to Mecca, and who was entrusted with the realization of the mosque Known as Kankou Moussa, in Gao and the Djingareyber mosque in Timbuktu (Architecture Soudanaise, n.d)

- Morocan Invasion

The short Moroccan occupation permitted the expression of their architecture clearly on the doors and windows notably in Timbuktu and Djenne. Although the Morocan never went in the cliffs of Bandiagara however in this area some openings also are made on wood but carved and leaving human figures seen unlike those of Timbuktu and Djenne carrying metallic discs all over.

- French Colonial penetration

Colonization having brought in majority slavery and suffering, will always remain an injustice in the eyes of Africa. However it didn't affect only human beings but also architecture which can only result in a loss of identity.

One has only to see the turn taken by the urbanism of Timbuktu presenting now wide streets incapable to control the hot and dusty winds or provide shades to prove the

disadvantages of colonization without forgetting the lack of resistance of the “Toubabo ferey” compared to the “Djenne ferey” from Djenne. It was only in Bandiagara that the presence of the French colonists was beneficial since the Dogons with the time no longer felt the need to cut themselves off from the rest of the world.

3.4.3. Disponible Materials

Concerning vernacular architecture, materials which may be grouped into three basic types, stone, mud and wood are used mostly in Mali according to their abundance and varied qualities. The use of local materials, mainly earth and stone, is perfectly suited to hot and arid regions because their good heat storage capacity stabilizes indoor temperature (that remain cooler during the day and warm at night. More over all having less reflection of Sun ray or protecting against solar radiation is another benefit of using these materials that keep people’s eye healthy. And of course the wood is used in priority not only to control and filter daylight, and to reduce indoor glare but it’s used as a structural element due to the endurance it may provide.

3.4.4. Families and Traditions

The family composition and mode of function of the same society is reflected in the traditional architecture. Families are often numerous, polygamy is not prohibited, and divisions by age are very important. The houses must be large to accommodate these extended families, and arrangement of parts allows a relative independence of children against their parents.

Collective life is very important.

The houses are often organized around a central courtyard, a meeting place for the whole family where foreigners are also received, meals are taken and people discuss taking tea during evening. The rooms are arranged such that the control room to another is relatively low. Cooking is done outside, as most of the family activities. The Court therefore of paramount importance in traditional housing and one could almost say that this is actually the main space of the house.

The court is also useful in coping with the dry heat itself, and has climatic implications as well as the social and psychological ones already discussed. It gives protection from sandstorms.

Table 4. Building Characteristics in Timbuktu, Djenne and Bandiagara

REGION	TIMBUKTU			DJENNE			BANDIAGARA	
BUILDING TYPE	BASIC	MIXED/URBAN PALACE		MORROCAN	TUKULOR	PLAIN	GINNA	
		TYPE 1	TYPE 2			TYPE 1 / TYPE 2	HOUSE OF SENIOR MALE	TYPICAL FAMILIAL HOUSE
GRANARY LOCATION	NONE	NONE	NONE	NONE	NONE	NONE / NONE	MAIN APPARTMENT	SIDE-PARTS
NUMBER OF STOREY	GOUND FLOOR	ONE STOREY	ONE STOREY	TWO STOREY	TWO STOREY	TWO STOREY / ONE STOREY	ONE STOREY	GROUND FLOOR
FOUNDATION WALL	MUD-BRICK	STONE	STONE	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw] / MUD-BRICK [Rice or Barley Straw]	ROCKS	ROCKS
WALL MATERIAL	MUD-BRICK	MUD-BRICK	STONE	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw]	MUD-BRICK [Rice or Barley Straw] / MUD-BRICK [Rice or Barley Straw]	MUD-BRICK	MUD-BRICK
DOOR + WINDOW MATERIAL	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES	WOOD + METALLIC PLATES / WOOD + METALLIC PLATES	CARVED WOOD WITH HUMAN FIGURES	CARVED WOOD WITH HUMAN FIGURES
ROOF MATERIAL	LAYER OF WOOD *[Split Palm+Palm Frond Matting]* + EARTH	LAYER OF WOOD [Split Palm+Palm Frond Matting] + EARTH	LAYER OF WOOD [Split Palm+Palm Frond Matting] + EARTH	WOODEN JOIST + FINE MUD	WOODEN JOIST + FINE MUD	WOODEN JOIST + FINE MUD / WOODEN JOIST + FINE MUD	WOOD + EARTH	WOOD + EARTH
COURTYARD	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT	PRESENT / PRESENT	PRESENT	PRESENT

CHAPTER FOUR
SURVEY AND CASE STUDY: NATIONAL PARK OF MALI

Location: Bamako, Mali

Architect: Diébédo Francis Kéré

Client: Aga Khan Development Network (AKDN), Aga Khan Trust for Cultures (AKTC)

Project Type: Landscape

Project Usage: Park

Project Area: 3000 Sqm

Project Cost: 1.7 Million Euros

Year of Construction: 2008-2010

4.1. General Information about the Project

The National Park of Mali, located between the National Museum and the Presidential Palace Complex (Fig.28), was an area representing a large forest essentially composed of protected trees before the 50th anniversary of the independence of the country. Nowadays the National Park with its defined outlines is a significant greenbelt with new commercial, recreational and sport facilities as well as several entrance buildings (Fig.29). “The project brief called for the unification of the sites of the National Museum and the existing Botanical Garden and Zoo into a single cultural/ecological park of significant value, with natural and cultural attractions” (National Park of Mali, 2011, para.1).

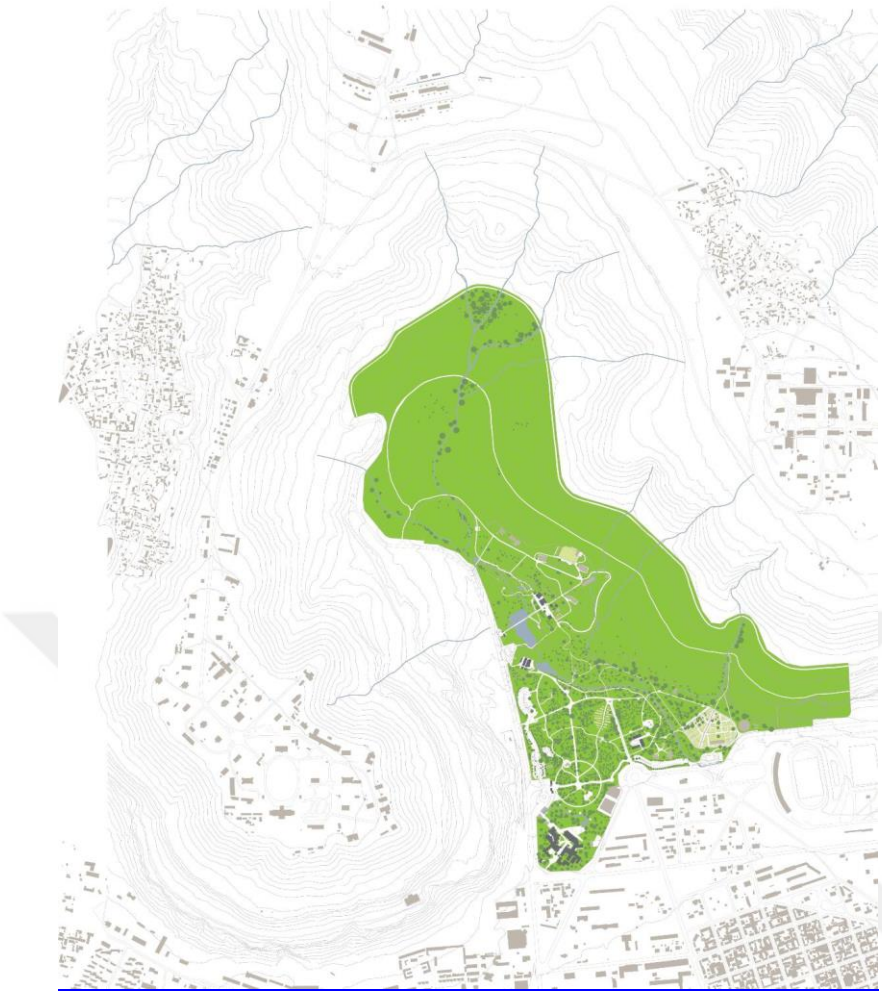

Figure 28. Landscape Plan, All Phases (Aga Khan Trust for Culture, 2011).

For the first phase of the project a primary and secondary gate, an entry building, a youth and sports center, a restaurant, public toilets and several kiosks have been designed by Diébédo Francis Kéré since he is an Aga Khan Award for Architecture recipient in 2004 who has mastered in the art of combining traditional building techniques and materials with modern engineering methods.

> The National Park of Mali, located in the capital, Bamako, reopened for the 50th anniversary of the country's independence, The interventions carried out for the occasion consisted of a landscaping project (by the consultants of Planning Partners International) and the construction of new facilities such as the National Museum of Mali (by the team directed by Jean-Loup Pivin), the new zoo (by Ivan Mata), and the four unique pieces designed by Diebedo Francis Kere: two new accesses to the park, a sports center and a restaurant.(National Park of Mali Entrance, n.d.).

Figure 29. Landscape Plan with Facilities, Phase 1 (Aga Khan Trust for Culture, 2011).

Even if Mali is mainly an arid country, Compared to the climate conditions of the emplacement of its three important vernacular architectures the Park's region is the one beneficiating mostly of rainfalls and green areas due to its Tropical wet and dry climate.

-The Sahara is a desert climate. Rains are irregular and accidental.

-The Sahel region is arid to semi-arid climate. Relatively dry (with relatively poor tropical rains)

-In the Sudanian or Savana zone the rainy season (called winter) lasts 3-5 months north 5-7 months in the south.

4.1.1. Restaurant

Figure 30. General View of the Restaurant with pond, at the Time of Park Opening (Aga Khan Trust for Culture, 2010).

The restaurant bearing the name of Balasoko restaurant and perched on top of a rocky outcrop, is divided into four blocks according to the different functions required of the restaurant (Fig.32). But still the whole is grouped apparently under two steel corrugated and inclined roofs with a nice view on a water course offered to the clients sitting from both the closed and open dining hall at the east elevation (Fig.33). In fact the concern was always to integrate the spectacular view over the Park and the nearby lake into the design.

Figure 31. Main Entrance Façade of the Restaurant (Baan, n.d).

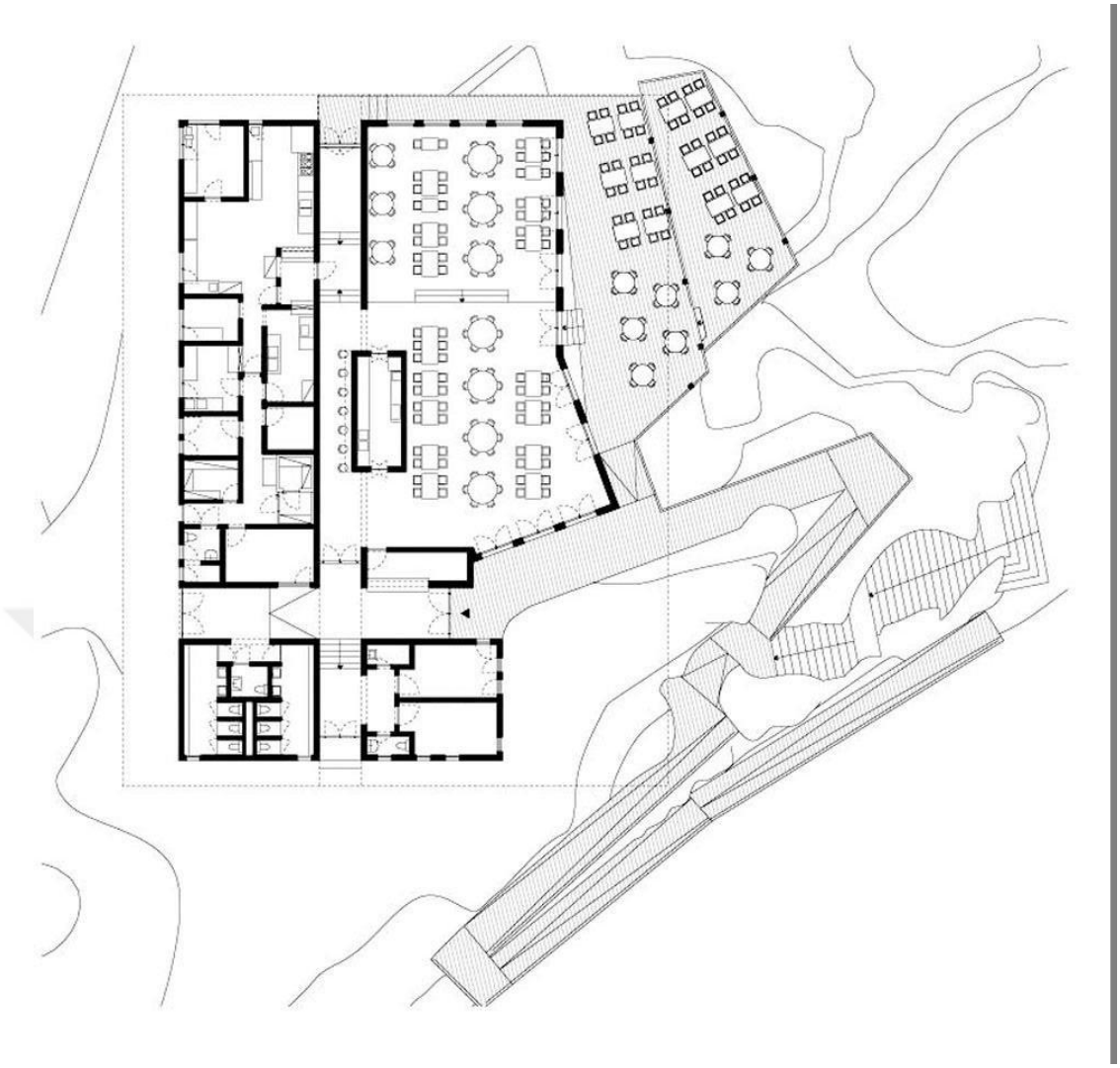

Figure 32. National Park of Mali Project: Plan of the restaurant (James, 2011).

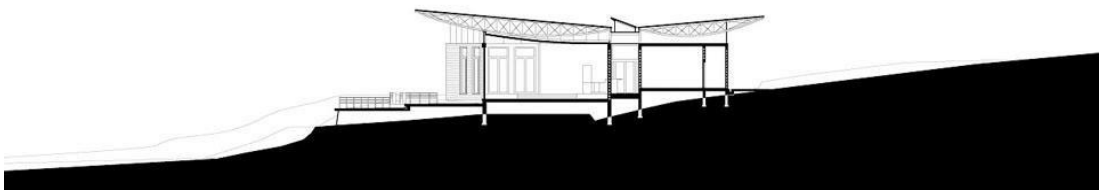

Figure 33. National Park of Mali Project: Cross-Section of the restaurant (James, 2011).

4.1.2. Sport center

Figure 34. Backside View of the Sport Center (Baan, n.d)

Like the Balasoko restaurant, the sport center also tends to have the same architectural language through its three main pavilions separated but each of them having its own extending roof in order to produce shadow in the inner courtyard which is unifying them in a semi-private way. The courtyard is accessible from each side of the sport center but is the only area to pass through before entering any of those pavilions (Fig.36). It obvious that the relationships between the interior and exterior have been taken into account with a great importance in the conception of the building especially for assuring intimacy.

Figure 35. View from the courtyard of the Sport Center (Baan, n.d)

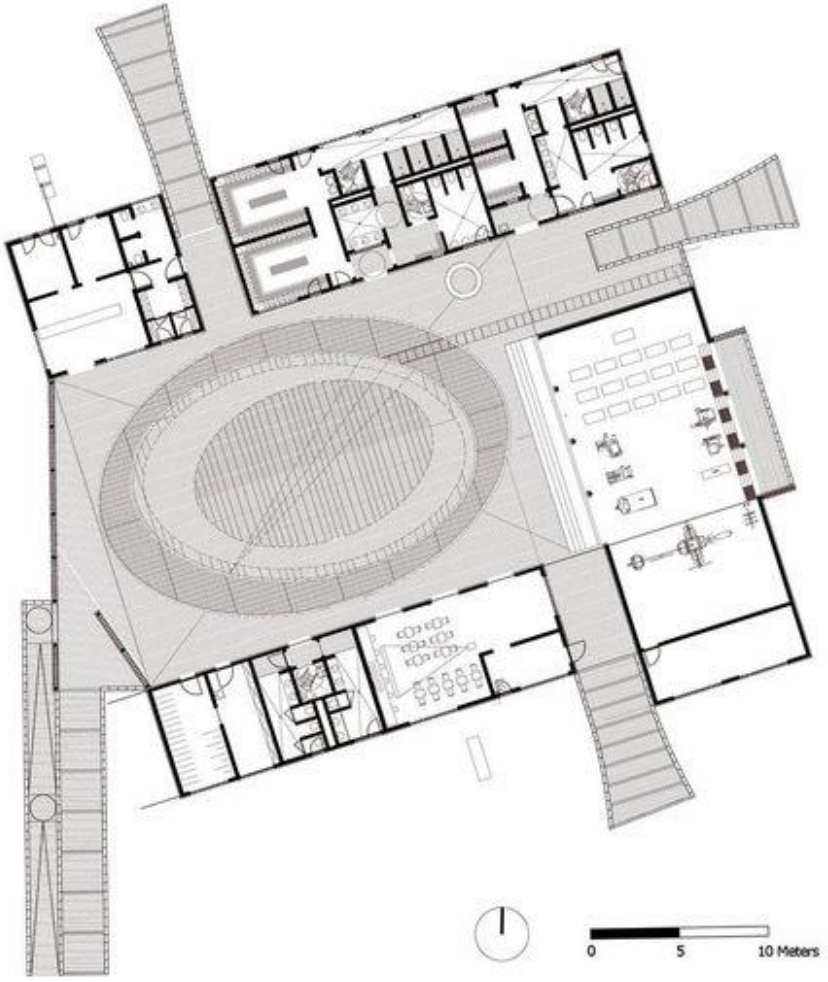

Figure 36. Plan of the Sport Center (Aga Khan Trust for Culture, 2010)

4.2. Significance and Uniqueness of the project

The presence of the technology and the tradition in the architecture of the National Park is what makes it looking original without forgetting that it's a project also built on a tight budget with modern, passively cooled sport complex and restaurant.

Thanks to base clad with vertical bands of local stones shaped in a rational way then used as wall material and the distinctive corrugated metal roof floating above the buildings both suggested by kéré it has been possible to reduce costs and reinforce ties with local material tradition. While the stones are assuring natural thermal insulation by controlling the temperature in the interior spaces, the large projecting roof surfaces shade the façade by providing natural climate control.

Michler (2011) affirmed that the masonry work was done by local workers who were specially trained to use the abundant and traditional local resource.

Besides the use of local stones as cladding in the Park's walls materials which reflects the technic of construction of some houses in Timbuktu, any coherent aspects of the influence of the varied vernacular architectures of Mali are mentioned. But with the necessary knowledges one can state by himself that both Djenne and Bandiagara also have some of their traditional manners of constructing found in an indirect way in those restaurants and sport center.

For instance the inner courtyard of the sport center as a social and climate control element is an important aspect which all traditional buildings contain no matter in which region of Mali they are constructed.

The steel-truss roofs may be very modern, advanced and rejecting all links with vernacular architecture but still their aims of providing natural ventilation reminds the same technics used in the Great mosque of Djenne where many small roofs vents are placed through voids surmounted by hand made ceramic caps possible to be open or closed as needed. They are represented in the Figure.37 just below.

Figure 37. Pillars and Roof Vents from the Great Mosque of Djenne (n.d)

And of course the construction of the restaurant on this natural topography alludes to the cliffs of Bandiagara, previously visited by Kéré since he had another project in the same region confined at him simultaneously as the project of the Park National of Mali by the same client.

4.3. Buildings Performances or Limitations

Despite the fact that the majority of each element of kéré's projects are localy produced, the Park buildings followed a different path since local engineer could not be found in Mali. Because James (2011) have stated that Kéré wanted to bring "technical prowess to Mali that can be achieved by the local people, yet such incremental advancement were at odds with the client's aspirations to produce a powerful symbol of progress" and finally it has led to the fabrication of the steel-truss roofs needed in Turkey (para.10).

Moreover the roofs function as a shading device and direct rainwater, allowing also natural ventilation in each building. But since in the restaurant the client insisted on installing an air conditioning the roof vents has been made operable. (Kéré, n.d).

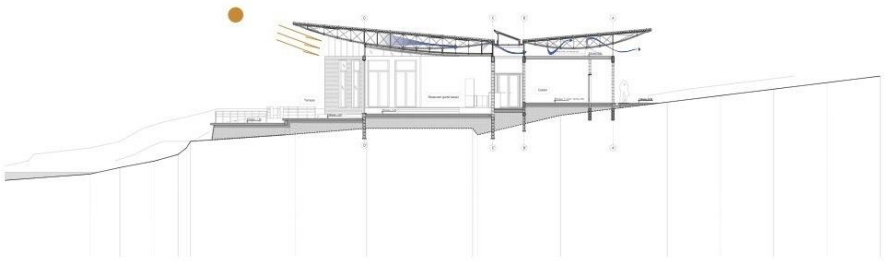

Figure 38. Section Showing Sunlight and Wind Flow directions towards the Restaurant (2011)

4.4. Survey

This report outlines a survey based on the architecture of the National Park of Mali which aims to discover the need for this country with a population of 14,517,176 habitants to apply in its urbanism a similar sustainable architecture.

Information were more likely to be answered by a majority of Malians given the location of the National Park, so an attempt was made to reach as many Malians as possible. Notably 100 persons stratified in groups of 79 students and 21 employees returned questionnaires. Most of them at 80% were between ages of 19 to 25 while the rest were divided into 7% for those aged from 12 to 18, 12% for the age group of 26 to 32, and only 1% for those above 32 years old. Apart 98% of them, a small portion representing 2% don't go anymore or never visited the Park.

Data of this online survey have been gathered by means of a self-designed questionnaire composed of 10 items. The majority of which were multiple choice, rating scales and dichotomous scales questions. It should be noted that apart from the questions 1, 2 and 3 aiming to identify the group of sample followed by the questions 4 and 5 permitting to check how the respondents have been closed to the facilities of the National Park, the survey with the remaining questions covers three conditions. In fact the survey, intending to raise also a public awareness especially the young one about the importance of vernacular architecture through its sustainable issue, in the first place seeks to clarify the rate of influence that vernacular architecture have on the local population. This is illustrated through questions 6 and 7, which seek to verify awareness about local materials and question 8 which simply verify knowledge about vernacular architecture of the country by its inhabitants. The second condition enlighten the western attitude that ignores the vernacular architecture through question 9 obviously testing the attitude of the respondents towards contemporary architecture. Finally the third condition representing a healing part which confirms in question 10 that with the help of sustainability many problems might be solved and simultaneously checks again awareness of population about this issue. Since the questions have been designed in Survey Monkey, a web survey tool, the anonymous participants received them through a web link shared on Social Medias such as Facebook and Viber. Then permitting the results obtained on a period of one month (17 February- 17 March 2017) to be automatically available in the chart of choice.

For this study pie chart graphs have been preferred and used in order to visually represent and analyze by observation and comparison of the data derived from those questionnaires.

The survey's results showed that among the people who still go in the Park, maximum 86% do it rarely while the ones who go daily and frequently represent 6% each. Thereby the Park is frequented by a group of people undertaking activities such as promenade in majority at 88% and others either eating in a restaurant, doing sport or working at a total of just 12%. Even if 47% of them never entered the buildings that are found there, at least 32% entered only in the restaurant as well as only 4% in the sports center while 17% had access in both of them. So it's certain that 53% of them have seen closely the restaurant and the sports center. This allowed a total of 58 good answers in defining the types of material used in the park which were cement bricks and local stone bricks. Then those who responded at 31% for terracotta bricks and 11% for adobe bricks were wrong. But nevertheless 79% are sure that there are very few houses, approximately 21%, with architectures similar to the one of the National Park in their capital. While 70% of these young people recognize that they know little about the traditional architecture of their own country on the other hand 30% feel confident to have sufficient knowledge at least. However many are aware exactly 70% by agreeing against 4% who disagree that nowadays sustainable architectures combining tradition and modernity exist, with 26% trying to figure it out. And 76% would like to see them more integrated in their urbanism with 3% who don't approve this idea and at this time with 21% who do not take part by neither agreeing nor disagreeing.

CHAPTER FIVE

CONCLUSION

The integration of Vernacular architecture in contemporary conceptions, which struggle on their own sometimes to overcome the disagreements related to economy, environment and health, is highlighted in this thesis. Humans in their endless quest to develop have gradually turned away from the respect toward the environment, a virtue left by the first nations yet inspired by their sustainable philosophy for the land. Whereas a culture without the presence of its history is a culture without roots and most probably without meaning.

This study is undertaken by particularly examining the key strategies (features, materials and constructions technics) that have contributed to the survival of vernacular architecture despite the extreme conditions of hot and arid climates. They came up to be sustainable reflecting similar identities and functions (natural heating, cooling, lighting, shading and ventilation) present in several sustainable design principles that are used nowadays in contemporary architecture due to the solutions taken against global warming. While some have been more or less innovated over time others still keep the same concepts and forms as before such as the courtyard for instance. So it’s quite possible to combine traditional techniques with modern ones in architecture within the framework of sustainability as evidenced by the case study of the National Park of Mali. In fact it was essential to conduct the study in this country because projects perfectly illustrating our interest or aim on mixed architectures are found even if they are few and Mali is an African hot and arid country with enough, rich and varied vernacular architectures from which the West African architecture takes its origin.

The survey intending to give supports to the purpose of the thesis has been executed within the same National Park among Malians judge more susceptible to reply. And it was satisfactory and fulfilling the expectations since the results demonstrated effectively that in Mali there is a persistent lack of awareness among the young population concerning vernacular architecture as well as its sustainability. Rare (30%) are those who claim to have some notions about the Malian vernacular architecture. Around (26%) seem to be unaware of the existence of sustainable buildings reflecting both vernacular and modern architecture with (21%) unaware about the fact that they

can benefit from them when adopted in their urbanism. Which contains again just (21%) of this type of building according to another minority. It was on purpose to reach and perceive the opinion of the Malian youth representing the future of the country because, once conscious about the sustainable issues from the vernacular architecture within the framework of modernity, this can have a positive impact on the mentality of the local population. This population which neglects sometimes to include even architects in the conception of projects by restricting the participation just to either civil engineers or simple masons. Thus this outcome in general have served for the justification but also the recommendation in the necessity to implement this mixed and sustainable architecture in each developing countries, with the probable chance to be the first to suffer from the impacts of global warming and among whose youth few are familiar with their vernacular architecture. An urgent awareness must be taken avoiding at least these countries to perpetuate the same error that has been committed by the developed countries formerly and who are trying to repair their faults through sustainability in the construction's sector. And only municipalities respecting the environment with well adapted and structured construction rules can lead this awareness among local population towards designers.

Additional and emphasized research must be done in sustainability and vernacular buildings fields providing more knowledge about natural ventilation strategies for designers. Because still now at some period of the year or day passive ventilation are impossible to be fully used or undesirable in terms of human comfort and then requiring to be mechanically assisted by air-conditioner in modern houses.

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APPENDIX 1 – Survey Questions

National Park of Mali: A Probable Architecture to Take Account in the Future

This survey is based on the architecture of the National Park of Mali and aims to discover the need for a developing country such as Mali to apply in its urbanism a similar architecture.

1) **What is your age?**

o 12 to 18

o 19 to 25

o 26 to 32

o Above 32

2) **Which one of these is your occupation?**

o Studying

o Working

o None

3) **How often do you come at this place?**

o Daily

o Frequently (once or twice in a month)

o Rarely (once or twice in a year)

o Never

4) **Which activity are you undertaking there?**

o Promenade

o Eating in a Restaurant

o Physical Activity/Sport

o Working

5) *In addition to the garden spaces and other buildings the urban park is composed of a restaurant constructed on top of a rock formation and a sport center*. **Have you ever enter in any of them?**

o just in the restaurant

o just in the sport center

o Both of them

o None of them

6) **Which type of wall material have been used on those buildings when looking at them from the exterior?**

o Cement Bricks

o Terracotta Bricks

o Adobe Bricks

o Local Stone Bricks

7) **Whatever wall material which has been used in the park, do you commonly see it on the facade of other buildings in the city of Bamako?**

o Yes

o No

If yes (please specify)

8) **Do you know anything about the traditional architecture of Mali so far?**

o Yes

o No

9) **Did you know that in the architecture of the park some aspect of traditional architecture have been used and combined with modern technologies?**

o Strongly agree

o Agree

o Neither agree nor disagree

o Disagree

10) *In fact the National Park of Mali is a combination of traditional and modern architecture through sustainable design solutions for saving building cost, showing the identity of Mali and more over all overcome problems such as global warming that affects the world*. **Do you find this kind of buildings comfortable than the actual buildings found in the city of Bamako and wish to see them more in the urbanism of Mali?**

o Strongly agree

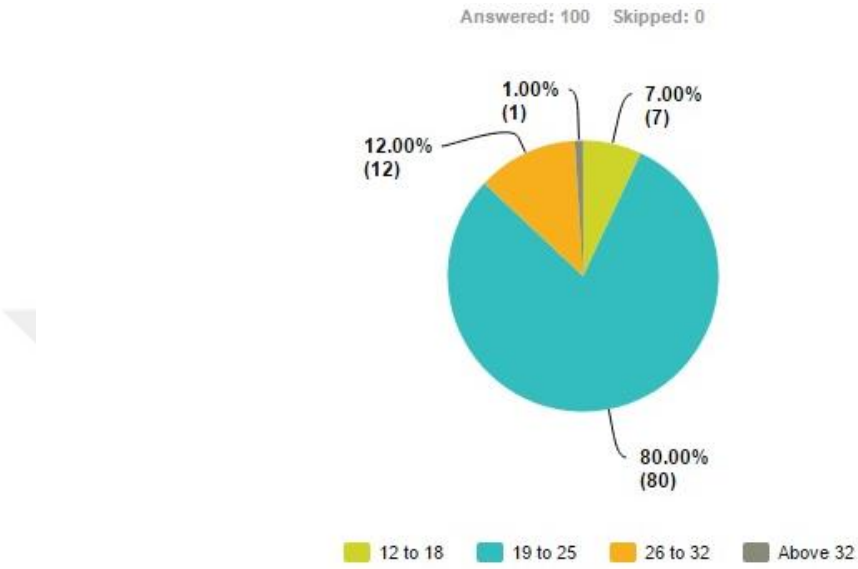
o Agree

o Neither agree nor disagree

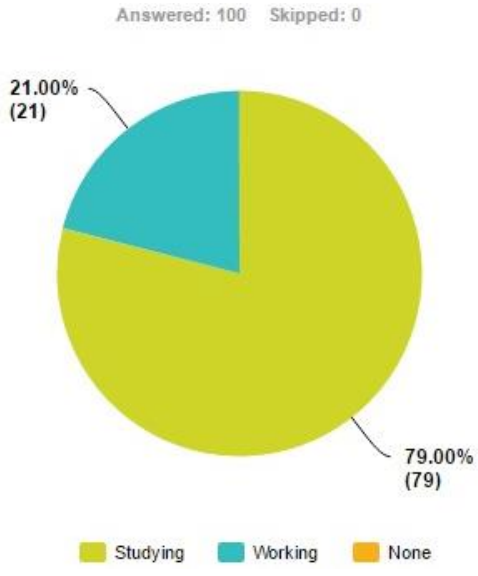
o Disagree

APPENDIX 2 – Survey Results

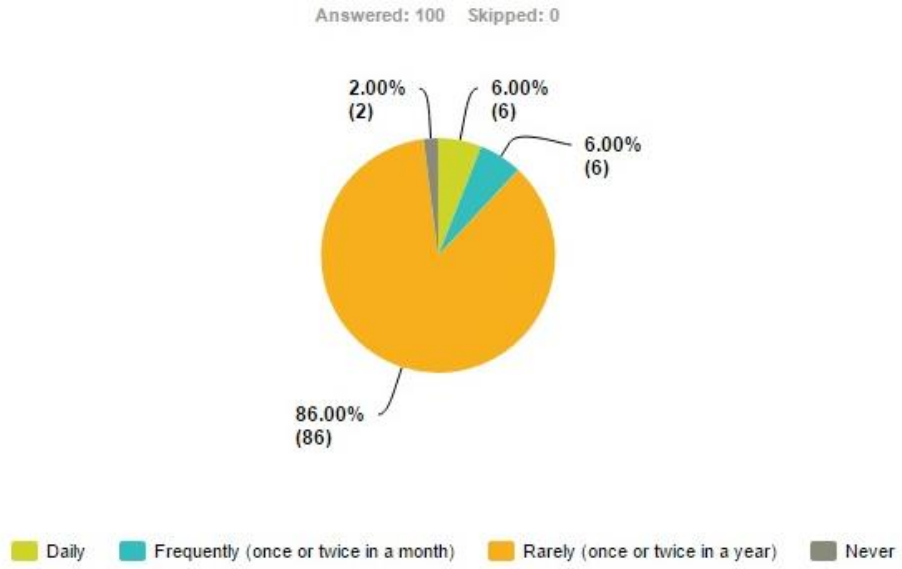
1) What is your age?



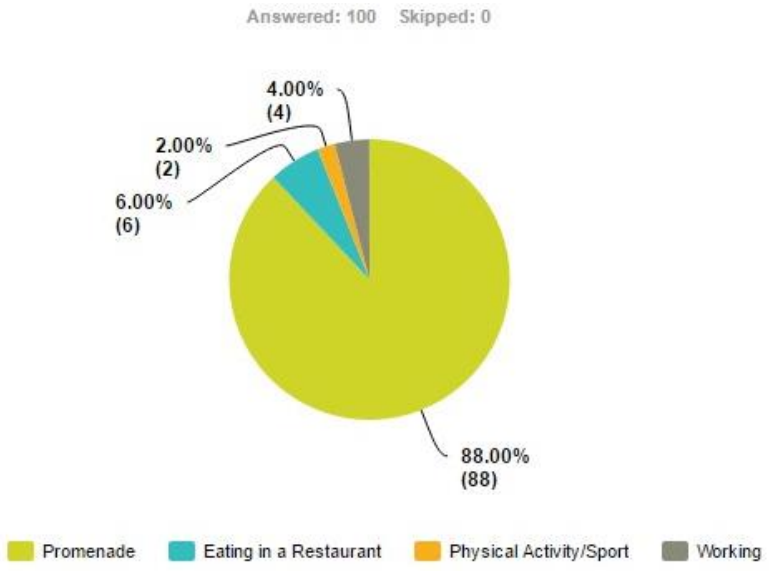
2) Which one of these is your occupation?



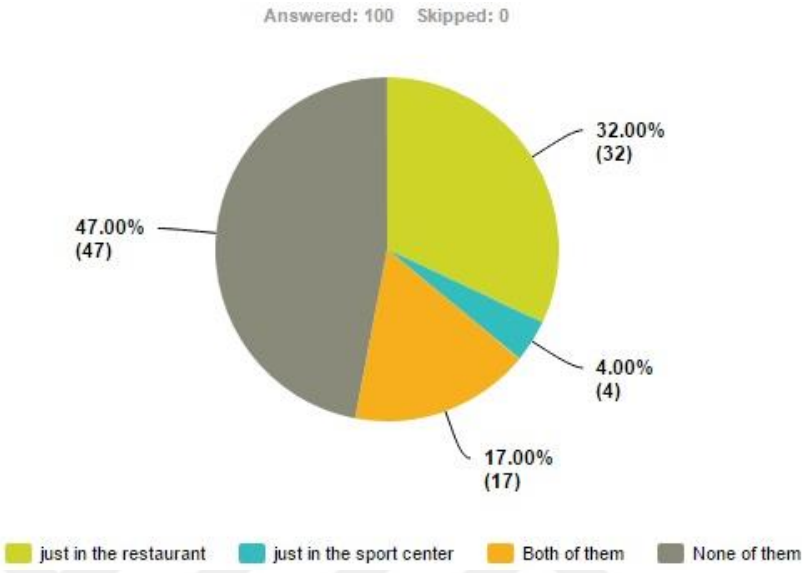
3) How often do you come at this place?



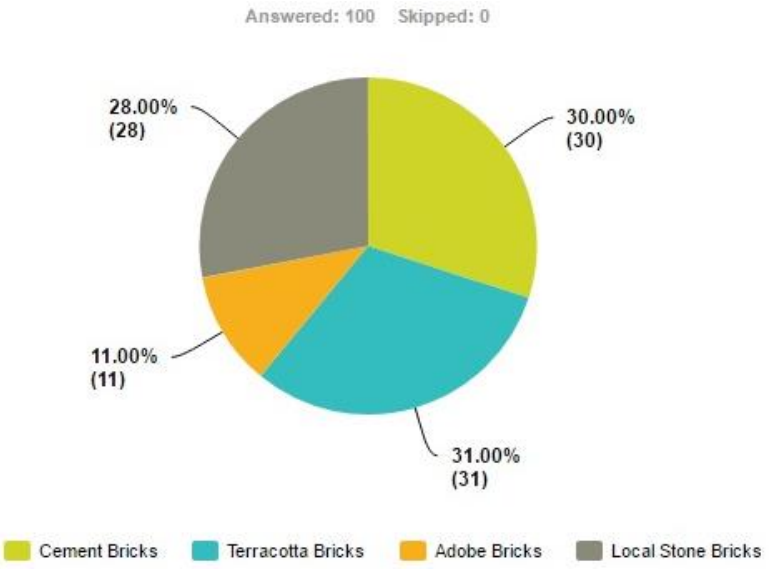
4) Which activity are you undertaking there?



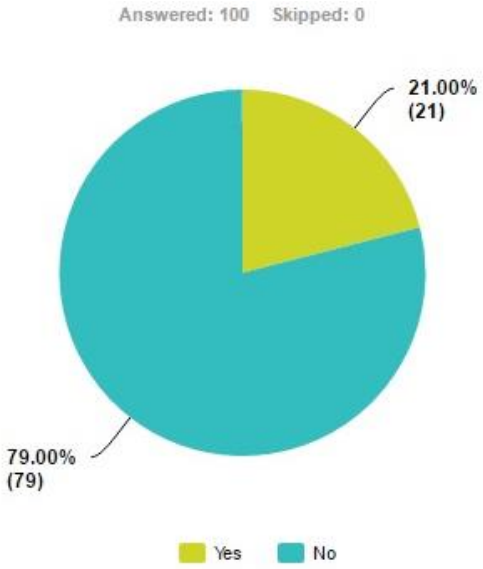
5) In addition to the garden spaces and other buildings the urban park is composed of a restaurant constructed on top of a rock formation and a sport center. **Have you ever enter in any of them?**



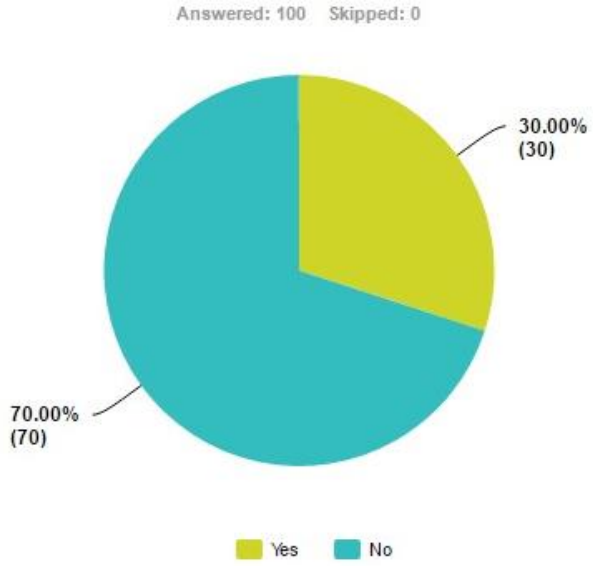
6) Which type of wall material have been used on those buildings when looking at them from the exterior?



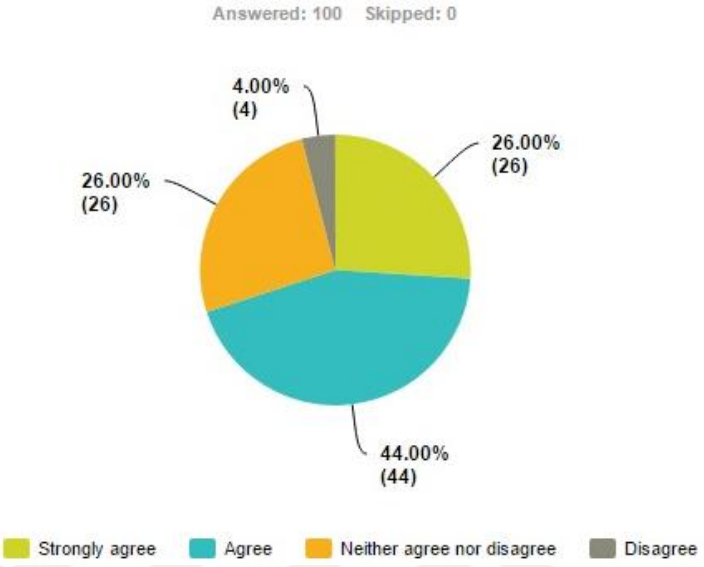
7) **Whatever wall material which has been used in the park, do you commonly see it on the facade of other buildings in the city of Bamako?**



8) **Do you know anything about the vernacular architecture of Mali so far?**



9) Did you know that in the architecture of the park some aspect of vernacular architecture have been used and combined with modern technologies?



10) In fact the National Park of Mali is a combination of traditional and modern architecture through sustainable design solutions for saving building cost, showing the identity of Mali and more over all overcome problems such as global warming that affects the world. **Do you find this kind of buildings comfortable than the actual buildings found in the city of Bamako and wish to see them more in the urbanism of Mali?**