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Adaptation of Vernacular Designs for Contemporary Sustainable Architecture in Middle East and Neotropical Region

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Abstract: **The vernacular architecture in Middle East is the product of land, the local climate, and culture. The human needs and the environment represented the most essential factors to be considered in their designs. The traditional and vernacular architecture of this region introduced many realistic solutions and devices to the local environmental problems such as the Wind-catcher, which became a common architectural feature in buildings. The wind catcher is based on a traditional Persian architectural device, which was used to create natural ventilation in buildings. However, traditional and vernacular architecture, which considered the human needs and the environment, provided many realistic solutions to the more recent modern environmental problems. This paper identifies some designs of traditional architecture of Middle East and the Neotropical region, which serve to cool the architectural interiors with completely passive systems. Thereby, we try to build a bridge between vernacular architecture and contemporary architecture, a bridge that will provide sustainability, independence, autonomy and resilience to architecture contemporary. This research includes two climes: hot arid in Middle East and warm humid climate in Neotropical region, however, the problem of bio-climatic design is similar: reduce indoor air temperature using natural ventilation systems that do not require equipment.**

Keywords: **Bio-Climatic Architecture, Vernacular Architecture, Urban Heritage.**

I. INTRODUCTION

During the 20th century the interest for urban and architectural heritage was focussed just in their valuation as cultural legacy and its conservation. The vernacular architecture was valued as tourist attraction or like source of cultural identity (Koboldt, 1995; Hufford, 1994; Tunbridge, 1984). In 21st century emerges a new landmark of interest: recovery of ancient wisdom embodied in designs, which do not need equipment or technology to enjoy comfortable temperatures, and therefore, they were sustainable. "One of the benefits of vernacular architecture is that it is able to ensure a stable and comfortable indoor environment against climatic environmental conditions" (Gil Crespo, 2014: 846). The valuation of the ancient designs, for their bioclimatic virtues begins to make presence, especially in researches of countries with tropical climate, as the works of Dominguez (2011) and Duran Aybar (2013) in Santo Domingo, La Habana and others cities of Caribbean region; Peralta (2014) in Equator; North (2012) in Peruvian Amazonia; and Gil Restrepo (2014) in Canarias Island, among others. Likewise in Middle East many researchers are working to recuperation and application of vernacular designs for contemporary sustainable architecture as Ghadiri et al (2014) in Malaysia; Ferwati (2013) in Qatar; Coles et al (2007) in Dubai; El-Shorbagy (2010) in Saudi Arabia or Mohamed (2010) in Egypt among many others.

The works mentioned are relevant because they initiate a search for solutions for tropical and arid climate through passive systems, which not need technology and by not requiring electricity or other kind of energy are independent and fully decentralized. From the economic and environmental approaches, this feature it allows that architecture enjoy a comfortable indoor climate, without requiring initial investments in equipment or expenditure over the life of the building

in electricity consumption, and most importantly: without cause damage to the environment. In addition, designs that respond to the local climate make edifications sustainable and resilient in great measure. Likewise Aflaki et al (2015) after making a thorough review, reveals that the use of natural ventilation —as in the vernacular architecture— reduces energy consumption and production of greenhouse gases, and also, reduced operation costs, increase the degree of thermal comfort and better indoor air quality.

It is important to emphasize in 20th century the call Modern Movement he gave immense solution to housing needs, especially after World War II. However, its principles ignored the vernacular tradition, and based their hopes in technology and new energy resources (especially oil). Therefore, was generated the so-called International Style, trend that ignoring the local climate, tried to reach thermal comfort through air conditioners and heating. This led to a break with the vernacular wisdom, especially with the design and his wonderful manners for acclimatizer the interior of architecture.

The paper identifies some designs of traditional architecture of Middle East and the Neotropical region, which serve to cool the architectural interiors with completely passive systems. Thereby, we try to build a bridge between vernacular architecture and contemporary architecture, a bridge that will provide sustainability, independence, autonomy and resilience to architecture contemporary. This research includes two climes: hot arid in Middle East and warm humid climate in Neotropical region, however, the problem of bio-climatic design is similar: reduce indoor air temperature using natural ventilation systems that do not require equipment or consumption of any kind of energy. In the two regions under study is analysed airflow through the building, because the indoor air movement is the key for a good design.

2. HISTORICAL BACK GROUND FOR NATURAL VENTILATION SYSTEMS IN MIDDLE EAST AND NEOTROPICAL REGION

Ventilation systems and natural cooling are as old as architecture, and are present in human settlements in warm climates around the world. Especially in regions with dry and hot and humid and hot climate, these designs have been built in diverse forms and with different materials. In Africa and Middle East the examples are numerous and varied. In Egyptian papyrus 3500 years ago these systems are represented, in Iran its use dates back 4000 years BC, in Babylon since 600 BC, and in Sri Lanka a similar concept in utilized in the primitive tents. But in other side of the world, also they used since ancient times. The Amazonian communities of South America used wind energy to ventilate their Longhouse more than 5000 years ago, and the Indians of Mochica in Peru using the natural systems by ventilate and cool their homes (Brañas, 2015; Komijani et al, 2014; Pirhayati et al, 2013; Bahramzadeh et al, 2013). The natural ventilation systems remain so far in some civilizations, but in other cultures they were lost across centuries.

2.1 Middle East:

The Muslim-Arab architecture was shaped by ancient conceptual frameworks, which they responded to climatic, urban and social conditions of environmental. This ancient heritage is clear expression of that design can generate comfortable conditions into architecture in various climatic conditions. Wind towers have been in existence in various forms for centuries as wind-catchers in Saudi Arabia, malqaf in Egypt or badgir in Persia (Iran) several shapes to catch the fresh wind across passive systems, which can be utilized as a sustainable contemporary design for cooling and ventilation purposes (Saadatian et al, 2012; Mohamed, 2010).

2.1.1 Wind Catcher:

Over thousands of years in hot arid regions of Middle Orient the traditional buildings have a wind catcher that provides ventilation and natural cooling, allow sufficient lighting without investing in equipment and energy consumption costs. “Throughout history, a wind catcher was introduced as an architectural device, which achieves thermal comfort inside buildings” (El-Shorbagy, 2010: 21). New residents do not pay attention to it in one hand and support comfort in their homes in technological solutions, in other hand many architects ignore the benefits of ancient solutions: not have initial investment neither cost of repair nor maintenance. Further, wind catcher is using in easy shape the available natural sources of energy. An example of wind catcher is shown in figure 1. It is a double wind catcher in roof.

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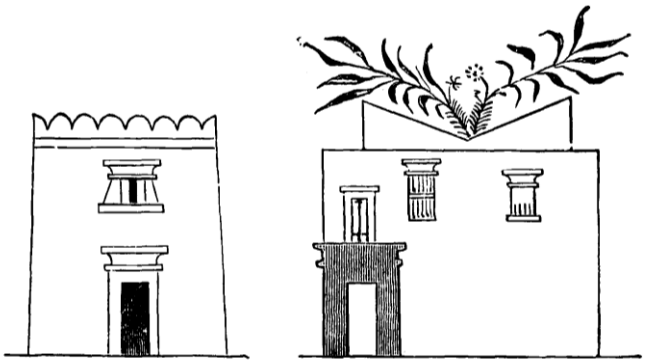

Fig. 1. Dwelling house in Ancient Egypt with wind catcher (1300 BC)

Source: *[http://runeberg.org/nfbd/0393.html]*

A common definition of wind catcher is the published in the *Dictionary of Architecture and Construction:* "A device, especially found in hot regions of the Middle East, that ventilates a house by the use of wind. A small tower on the roof contains an opening that faces the prevailing wind, which is at a cooler temperature than the interior of the house. Because the wind velocity at this opening is greater than it is at the lower windows of the house, air in the shaft of the tower is forced down the shaft to cool the house" (Harris, 2003).

2.1.2 Malqaf (Uni-directional wind catcher):

In Egypt the wind catchers is called 'malqaf' and it is shaft rising high above the building with uni-directional opening facing the prevailing wind. The malqaf catches the wind flowing over the buildings and internal air ducts it down into the spaces of the house. The malqaf dates back to very early times. It was utilized by the Egyptians in constructions of Tal Al-Amarna and in the Pharaoh houses of nineteen Dynasty in Neb-Amun (1300 B.C.). Nevertheless, in the last 50 years the Egyptian architecture ignored the malqaf, or better, not was able to integrate this passive system into the modern city, thus more than half of the urban energy consumption in the Egyptian cities is used just to satisfy air conditioning demands (Attia & De Hierde, 2009). A classic example of malqaf is shown in figure 3. It is a construction of 14th century, which has a malqaf on the left, and also a central tower for hot air escape.

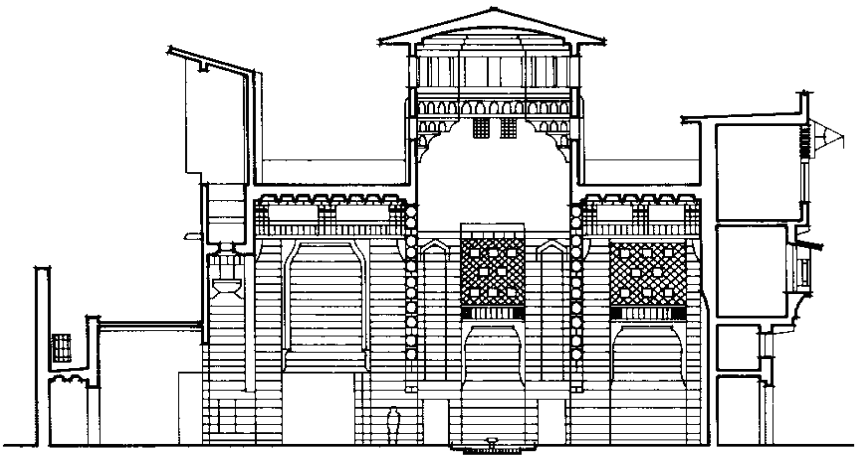

Fig. 2. Malqaf. Section through the Qã'a of Muhib Ad-Dmin Ash-Shãf'i Al-Muwaqqi, built in Cairo, about 1350. Source: Fhaty (1986) [On line: New Zealand Digital Library]

2.1.3 Badgir (Multi-directional windcatcher):

The wind catcher is called 'badgir' in Iran and the Gulf area. Badgir is a multi-directional wind catcher tower that in top are opening in all sides, which catch wind from any direction. "The plan of the badgir may take different shapes, but the square plan is the most common used one" (El-Shorbagy, 2010: 22). Normally badgir is divided by a diagonal wall and is possible to adjust by opening or closing several sides to control the incidence of breezes.

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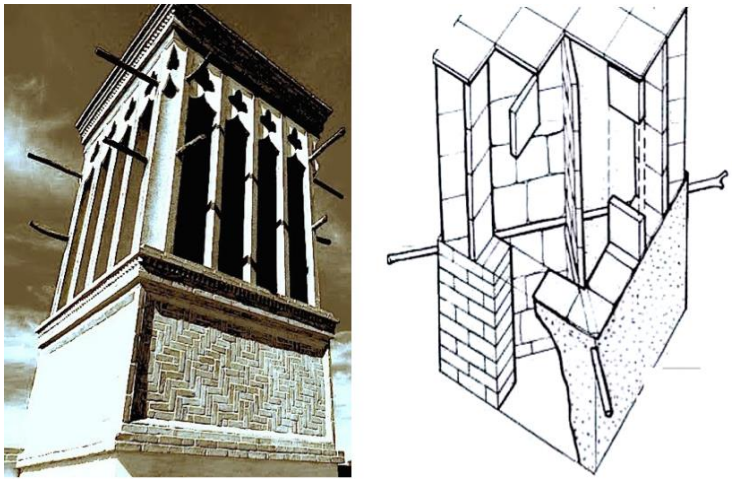

Fig. 3a. Typical Iranian badgir. 3b Detail of badgir that shown internal diagonal wall.

Source. *Roaf (1982: 62).*

2.2 Neotropical region:

The architecture of the Neotropical area is varied, because it comes from three sources: pre-Hispanic communities, enslaved African communities and European settlers, in consequence the architectural heritage is diverse and heterodox.

2.2.1 Amazon Longhouse:

The highlight sustainable vernacular architecture in tropical jungles is the Maloca. Patrimonial heritage of the ancient pre-Columbian cultures in the Peruvian, Ecuadorian and Colombian Amazon whose origins go back more than five thousand years (Brañas, 2015: 12). This large building,[1] which is still used by many indigenous communities (as cubeo, uitoto, tucano, desana and others), responds to the climate of the tropical rainforest, characterized by lush plant mass, high temperatures —between 24 °C and 36 °C—, a relative humidity which reaching 90% on average, and rainfall of until 3700 mm per year (IDEAM, 2005).

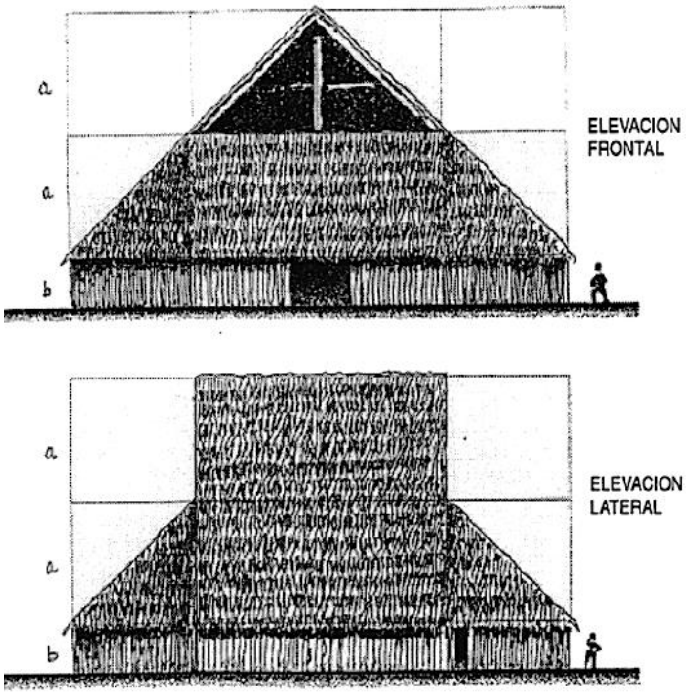

Fig. 4: Amazon maloca. Source. Marussi (2004).

[1] "The larger the maloca the more cooler it is" (Goldman, 1979: 40).

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2.2.2 Caribbean Islander Traditional Houses:

"In the preface to his *Architectural Heritage of the Caribbean*, Gravette writes: 'Nowhere else on Earth can boast such a melting pot of architectural styles, ranging from *Mudéjar* mansions to Islamic mosques, from Gothic cathedrals to Georgian great houses. The variety of architectural styles mingles Italianate and Romanesque with Baroque and Art Nouveau, while palatial Palladian mansions rub shoulders with tropical Regency halls [...] By no means least significant in the rich tapestry of the Caribbean's architectural heritage is the wealth of vernacular structures, which reflect the development of the social order of the region. From simple case and 'chattel' houses, like those on Antigua and Barbados, to elaborately embellished town or country residences, like those on Haiti and Guadeloupe, true Caribbean architecture contrasts with those early buildings, which replicate traditional European styles. It is in the detail of these locally designed structures that we see how the influence of European architecture has been adapted and refined to suit the needs and climate of the tropical Caribbean'" (UNESCO, 2003: 8).

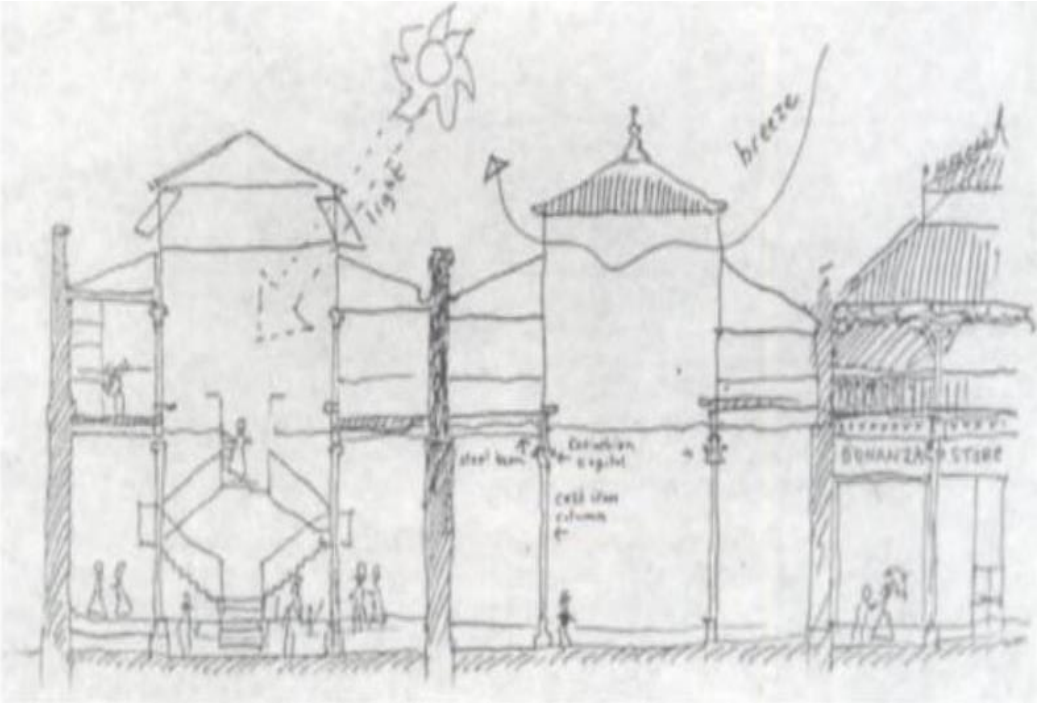

Fig. 5. Trinidad and Tobago Antillean architecture, 19th Century, Design George Brown. Sketch John Newel Lewis

Source. *Segre (2003: 65)*

During 18th and 19th centuries, Caribbean island was colonized by English, French and Dutch navigators, which leave an architectural heritage crystallized in wooden houses of different styles in the Greater and Lesser Antilles as Haiti, Martinique, Guadalupe, the French Antilles, Jamaica, Trinidad and Tobago, so as in San Andres Islands (Colombia) or Margarita Island (Venezuela) among other. This wooden houses, which are still used by local communities, responds to the climate of the Caribbean region, characterized by intense solar radiation, temperatures meddle ranging between 27 °C and 30 °C, a relative humidity which reaching 80% on average, and rainfall between 1.500 to 2.400 mm per year (Aguilera, 2010; IDEAM, 2005). This ancient heritage, which includes several systems of natural ventilation, has been integral part of the culture of the Caribbean islands (Vélez White, 2006).

2.2.3 Afro-Descendant´s Homes:

During 17th and 18th centuries, millions of people were moved since Africa till New Word. This violent change of place, failed to uproot the traditions of those who were mired in slavery. The Afro-Descendants brought to America their customs that include its architectural and design expertise. Settled mainly in the coastal regions of the Neotropical area, and built their homes using of simple but efficient way natural ventilation systems. In Colombia these black communities living on the shores of the Atlantic and Pacific oceans, under intense solar radiation, temperatures middle among 25 °C and 31 °C, high relative humidity (till 90%), and rainfall between 1.021 and 6.200 mm per year (IDEAM, 2005).

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Fig. 6. Afro-Descendant´s Home. Rural area of the Colombian Pacific

Source. *Robert West in Mosquera (2009: 64).*

Fig. 7. Afro-Descendant´s Home. Rural area in Dominican Republic

Source. *Ricardo Briones in Nuñez (2011: 13).*

3. TYPES AND SHAPE FOR NATURAL VENTILATION SYSTEMS AND TECHNIQUE OF WORK

3.1 Middle East:

All natural ventilation systems originating in the Middle East operate similarly. Wind catcher, malqaf and badgir literally are systems that catching the fresh wind or the cool breezes. Are different in its shape of to make this. Wind catcher generally is down and linked with the roof. Malqaf is independent of roof, as a small tower, and badgir is a tall tower totally independent of roof. The basic principle in all cases is the same: the pressure differential on one side of the building causes air enter the interior space, go through the building, then the cool air flows through the building decreasing the structure's overall temperature. Finally the air leaves dragging the hot air (Fig. 8 to 13).

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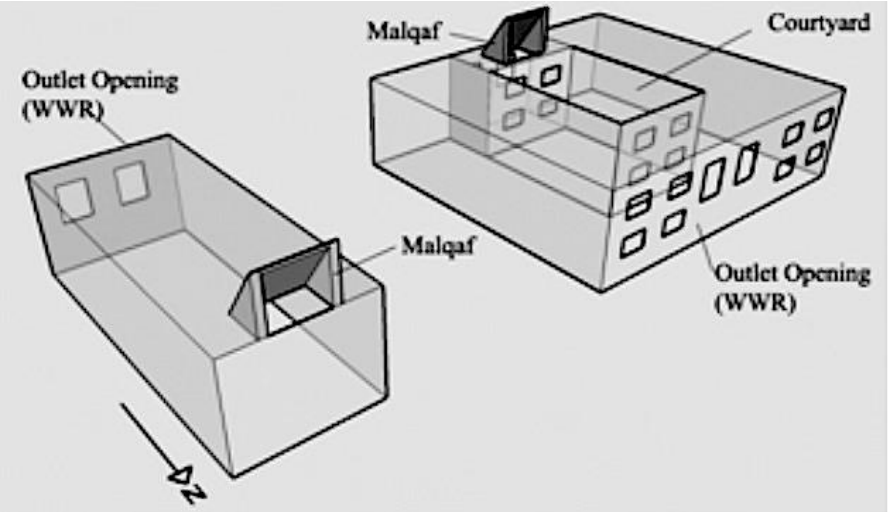

Fig. 8. Traditional Wind catcher in tow positions

Source: *Attia & De Herde (2009: 2).*

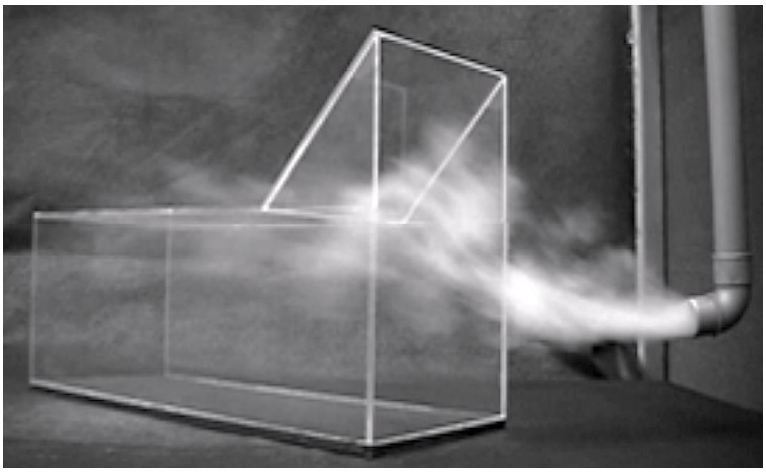

Fig. 9. Plexiglas model of wind catcher in wind tunnel

Source: *Attia & De Herde (2009: 5).*

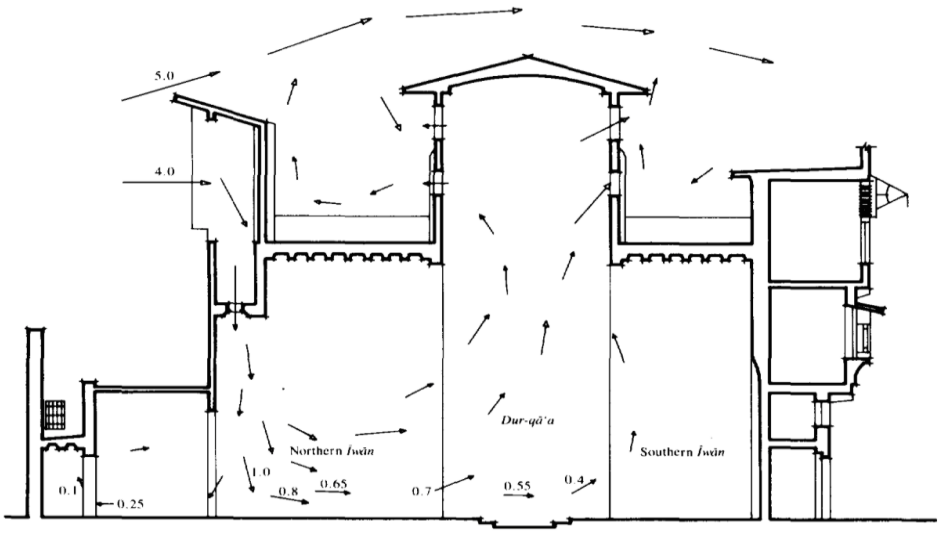

Fig. 10. Malqaf. Showing how the malqaf and tower-escape produce internal air movement

Source: *Fhaty (1986) [On line: New Zealand Digital Library]*

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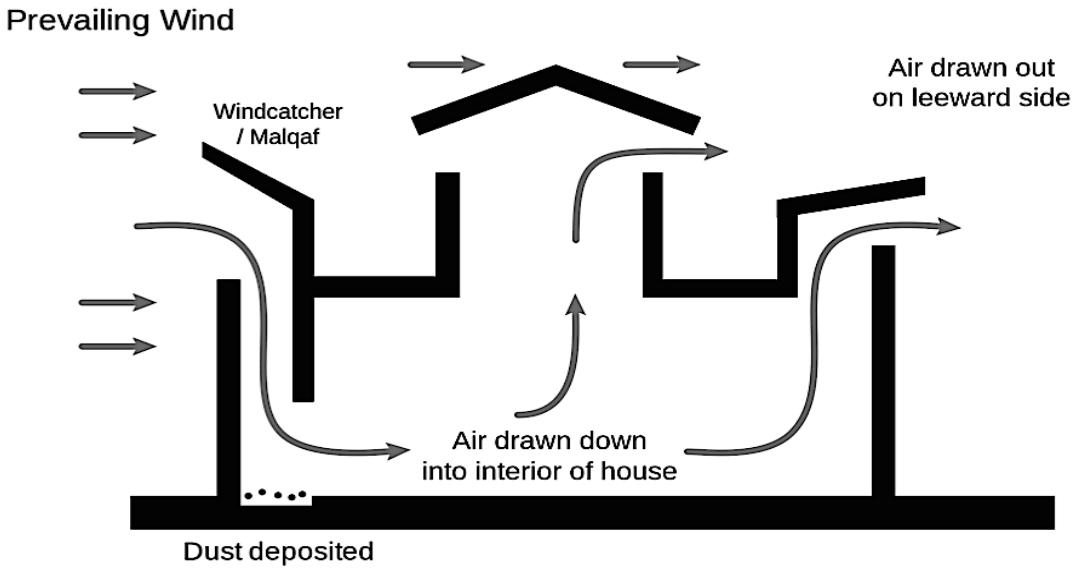

Fig. 11. Indoors air movement generated by the malqaf

Source. *https://commons.wikimedia.org/wiki/File:Malqaf.jpg*

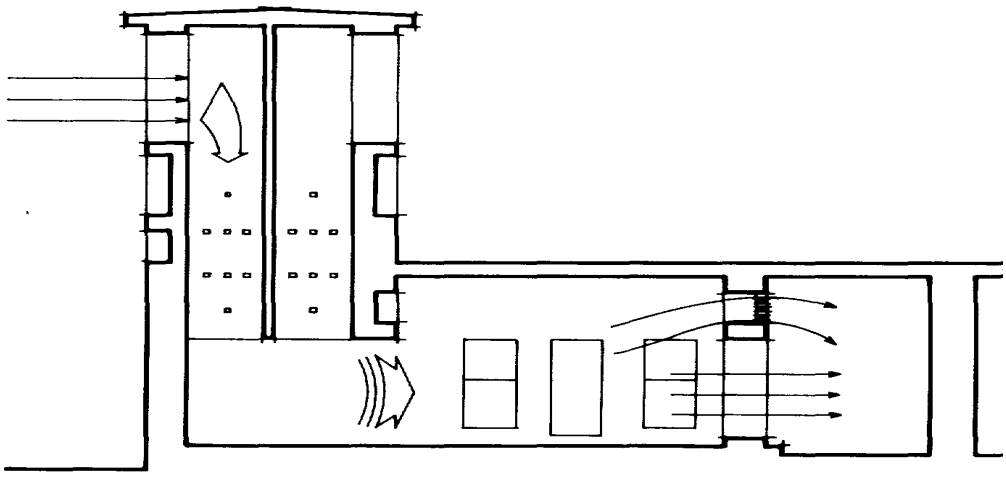

Fig. 12. Badgir section

Source. *United Nations University [http://archive.unu.edu/unupress/unupbooks/80a01e/80A01E0z.gif]*

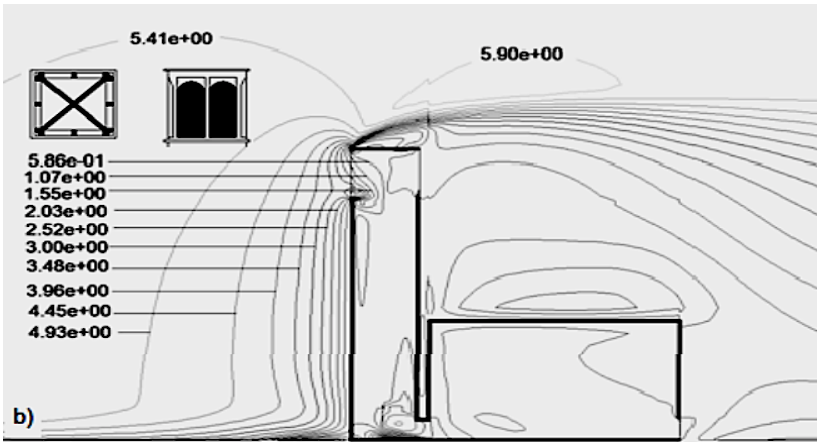

Fig. 13. Internal and external air velocity in typical badgir. Simulation with Computational Fluid Dynamics (CFD). Source. Ghadiri et al (2014: 15)

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Wind catchers' types: One way wind catcher, Two way wind catcher, Three way wind catcher, Four way wind catcher, Circular polygon wind catcher.

3.2 Neotropical region:

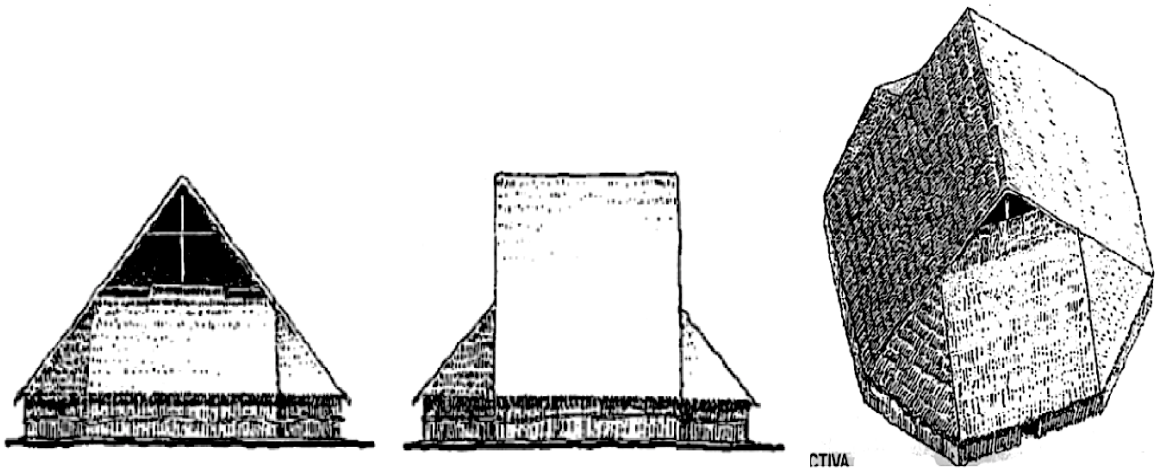

Fig. 14. Amazon Maloca. Surce. Marusi, F. (2004)

Maloca structure is wooden and the roof is made of palm.[2] Although these materials reflect solar radiation and do not allow heat build, which benefits the thermal comfort inside, the key bio-climatic element of this collective housing it is the cover design, which allows a huge Airflow. The large opening in the top of the roof generates a strong airflow, fostered the evacuation of hot air. "This construction plays an important role as a means of adaptation to the climate […] provide thermal comfort to the user; also, they are functional and eco-efficient" (Nort, 2012: 129).

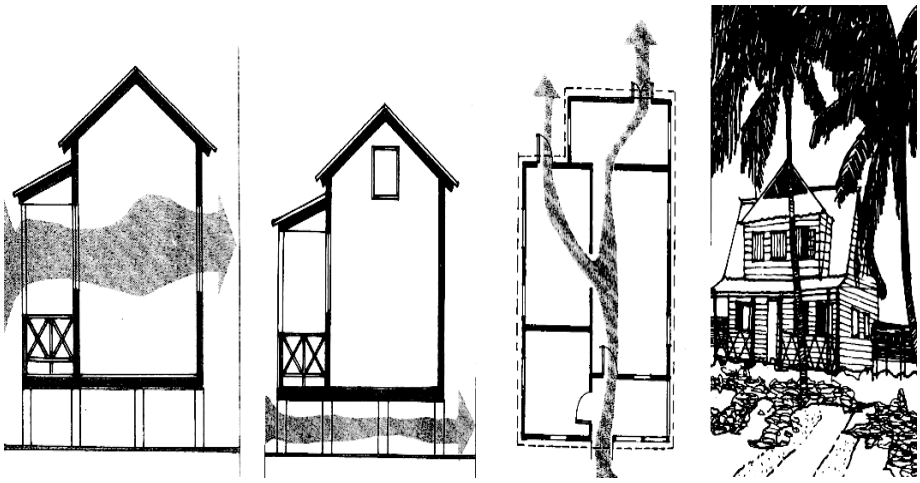

Fig. 15. Ventilation system in traditional house in San Andres Island, Colombia

Source. *BCH (1987)*

The climate comfort inside houses of Caribbean area is achieved through cross-ventilation, and also through elevation of the building on stilts, allowing wind circulation under the houses. The exterior walls of the houses had openings or openwork in top of windows and doors that allow free circulation of air within the house, made with careful and ornamental design, which also contributed distinctive elements of great aesthetic value. The lintels and arches upon windows and doors of these houses are very particular and so similar in all Antilles (Nuñez, 2011). The stilts system that keeps high the house allows a landscape better visual and refreshes the housing bottom. In the top of the house also there openwork that enabling the exit of hot air (Samudio, 2001).

[2] Several species of palm are used in Maloca construction, between them: *Lepidocaryum tenue, Attalea racemosa, Chelyocarpus ulei, Geonoma camana, Geomona maxima, Phytelephas macrocarpa*, and others.

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4. A SHORT REVIVAL OF VERNACULAR DESIGNS IN MODERN ARCHITECTURE

Natural ventilation in the architecture had a boom near Mid-twentieth century. In Saudi Arabia are emblematic the designs of the architect Hassan Fathy, especially his Nassif house in Jeddah, where used the cultural heritage of the Moorish architecture of Cairo, retaking the malqaf design that are in Qa'a of Muhib Ad-Dmin Ash-Shãf'i Al-Muwaqqi, built in 1350.

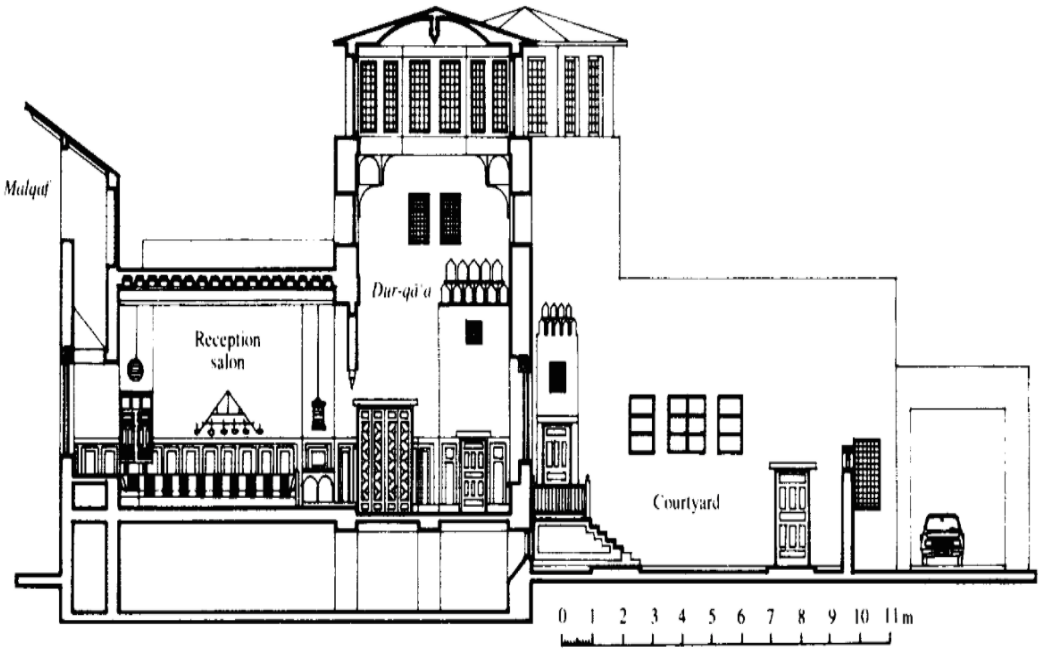

Fig. 16. Nassif House, in Jeddah, Saudi Arabia. Design Hassan Fathy, 1974

Source. *Fhaty, 1986 [On line: New Zealand Digital Library]*

But not only in Saudi Arabia are vernacular designs taken up again. In Africa, specifically in the School of Engineering, University of Science and Technology in Kumasi, Ghana, architect James Cubit retook the wind catcher design (double), through a system of Y-beams.

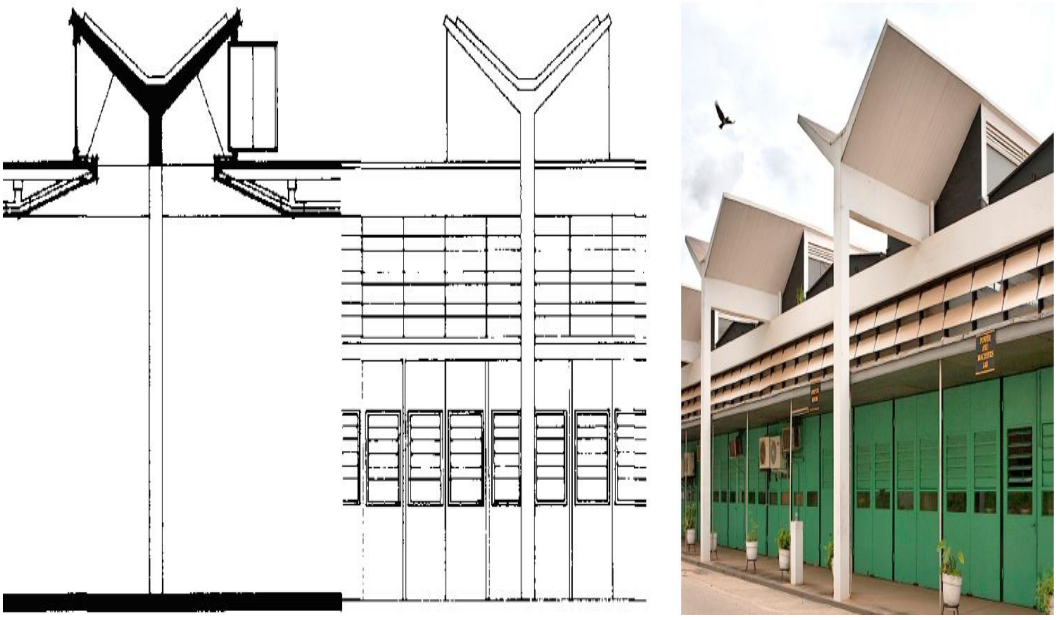

Fig. 17. Engineer School of University of Science and Technology, Kumasi, Ghana. Design James Cubit, 1956

Source. *Left: Fhaty, 1986 [On line: New Zealand Digital Library] Right: www.archdaily.mx Image cortesy Alexia Webster.*

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Around the same time the expert in bioclimatic architecture, Victor Olgyay, worked at the *Universidad del Valle* in Colombia. Olgyay conducted an investigation in three different climates of Colombian geography: cold, warm and humid warm, and published the resulting from their research in the book *Clima y Arquitectura en Colombia* (Olgyay, 1968). We emphasize that Olgyay designs, set for small town of Guapi, in the Colombian Pacific coast, retake the traditional vernacular architecture designs of communities of African descent. Unfortunately, this boom was abandoned, and had to spend almost fifty years for architects to revise the vernacular designs and use anew in their projects.

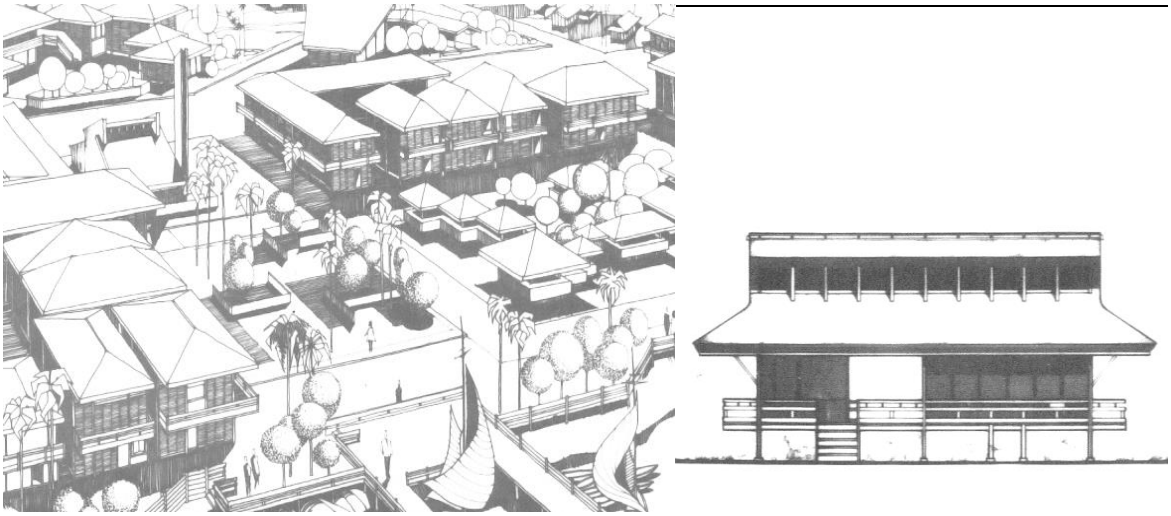

Fig. 18, 18a. Designs to Guapi, Colombia, by Victor Olgyay, 1968

Source. *Olgyay, (1968: 216-217).*

5. NEW ADAPTATION OF VERNACULAR TECHNOLOGIES IN CONTEMPORARY ARCHITECTURE

In the 21st century the architecture need sustainability. The contemporary designs cannot be dependents of energies external and its thermal comfort no can be dependent of air conditioning. Therefore, many contemporary architects retook old design of vernacular heritage.

In Middle East there many examples: The University of Qarar, in Doha; the wind towers in Masdar City, in Abu Dhabi;……

In the Neotropical area the most of the proposals are academic kind so far…

Until here I revised

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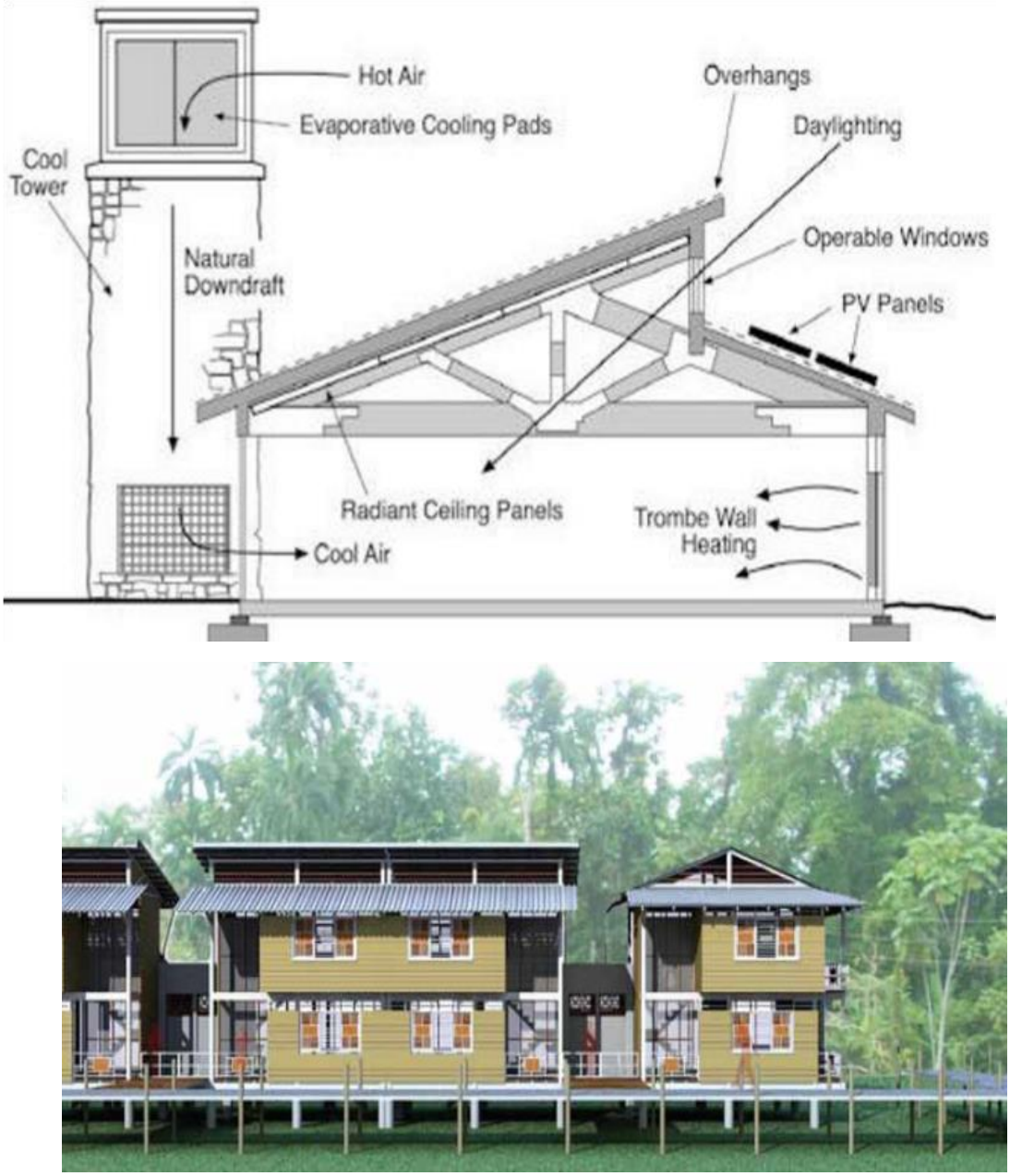

Fig. 9. Architecture Thesis, National University of Colombia, Design Landázuri y Rodríguez (2007-2008)

Sourse: *Mosquera (2009: 179).*

6. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Before the industrial revolution of the eighteenth century, the buildings were constructed according to the climate of the site. Since Then They Have built and used machines to heat, cool and ventilate indoor spaces, decoupling each time more the building of the climate.

There are several aspects that affect the form of windcatcher, modernization. High tech. and the change of climate now play an important role for give us many solution for windcatcher.

Economic, environmental social and cultural benefits of reusing local and global heritage in the architecture contemporary.

The wind catcher is an intelligent exploitation of wind energy which makes possible thermal comfort in hot region. The major advantage of the wind towers is that they are passive systems, requiring no energy for their operation.

Wind mechanism is based primarily on the basis of wind blowing to draw fresh air into the building , and the reaction force of the hot air is used to drive the suction. Since wind contacts with a barrier or wind catcher inner wall so it descends. The other openings of the wind catcher locating against wind direction flow hot air upstream and work as wind ventilators and suction devices.As before mentioned due to installation of basins that wind catchers are located over them the pleasant air is circulated and the interiors are cooled. Wind catchers circulate cool air into the room and move the hot air out. Other use of wind catchers is something like modern refrigerators. On the way to the basement there are closets (niche) embedded in a timber. In winter, the closet is closed to relationship between interior and exterior rooms to be discontinued. Inside the closet, the food is maintained. So, cold wind is favorable in the canal that prevents spoil of food.Researches show that history of wind catchers in the world dates back to BC, but it is difficult to quantify who have invented it for the first time. According to Papyrus dates back 1500 BC and researches conducted in Mesveda and Tapeh Chakhmaq in north of Shahroud construction of wind catchers dates back 4,000 years before Christ. This could be the reason for the Iranians claim to have invented the world's wind catchers because no record does not exist in Middle East (8)But the Iranians used the wind catchers before the Arabs and certainly it can be emphasized and this claim is sufficient for two reasons: first, application of Persian word for these structures, how to make it across the "Persian Gulf" can be mentioned. Today Bajir is defined as an abbreviation of Badgir. Second, the wind catchers of Emirates in the area of Bastak are predominantly Iranian that Iranians were the first inhabitants (9).Points discussed in this paper indicate that the Persians used the wind catchers before the Arabs in "Persian Gulf" region as a sign of creativity and innovation of Iranian architects. It can be said that other architects have inspired by Iranian architects in designing of wind catchers.

REFERENCES

[1] Aflaki, A.; Mahyuddin, N.; Mahmoud, Z. A. C. & Baharum, M. R. (2015). A review on natural ventilation applications through building façade components and ventilation openings in tropical climates. *Energy and Buildings*, vol. 101: 153-162.

[2] Aguilera, M. (2010). *Geografía económica del archipiélago de San Andrés, Providencia y Santa Catalina*. Cartagena: Banco de la República.

[3] Attia, Sh. & De Hierde, A. (2009). *Designing the Malqaf for Summer Cooling in Low-Rise Housing, an Experimental Study*. PLEA2009 - 26th Conference on Passive and Low Energy Architecture, Quebec City, Canada, 22-24 June 2009.

[4] Ávila Arias, Serge Edwin and Toro Cárdenas, Juan Carlos (2003). *Entre lo vernáculo y lo contemporáneo reinterpretación de la vivienda palafítica en Buenaventura*. Pregrado thesis, Universidad Nacional de Colombia. [www.bdigital.unal.edu.co/1604/]

[5] Bahramzadeh, M.; Sadeghi, B. and Rou, S. (2013). A Comparative Study to Compare the Wind Catcher Types in the Architecture of Islamic Countries. *Journal of Basic and Applied Scientific Research*, 3(2s): 312-316.

[6] Banco Central Hipotecario-BCH (1987). *Islanders Traditional House: Saint Andrew, Old Providence, Saint Catalina. Short Letter of Construction*. Bogotá: BCH

[7] Brañas, J. M. (2015). *Los techos de hoja de palmera en la vivienda tradicional amazónica*. Iquitos: Instituto de Investigaciones de la Amazonía Peruana.

[8] Dominguez, M. (2011). New directions of Caribbean architecture. *Arquitectura y Urbanismo*, Nº 6: 4-29.

[9] Duran Aybar, M. (2013). *Adecuacion bioclimatica a viviendas en el tropico caribeño. El caso de la Republica Dominicana*. Tesis de maestria: Universidad Politécnica de Valencia.

[10] El-Shorbagy, A. (2010). Design with Nature: Windcatcher as a Paradigm of Natural Ventilation *Device in Buildings. International Journal of Civil & Environmental Engineering IJCEE-IJENS*, vol. 10, Issue 03: 21-26.

[11] Fathy, H. (1986). *Natural Energy and Vernacular Architecture: Principles and Examples with Reference to hot Arid Climates*. Chicago: University Of Chicago Press.

[12] Ghadiri, M.H.; Lukman, N. and Mohamed, M. F. (2014). Performance Evaluation of Four-Sided Square Wind Catchers with Different Geometries by Numerical Method. *Engineering Journal*, vol. 17, Issue 4: 10-17.

[13] Gil Crespo, I.G. (2014). El lenguaje vernáculo de las ventanas tradicionales canarias: antecedentes, tipología y funcionamiento bioclimático. *Anuario de Estudios Atlánticos*, Nº 60: 817-858.

[14] Goldman, I. (1979). *The Cubeo Indians of the Northwest Amazon. Illinois*: University of Illinois Press.

[15] Harris, C. (2003). *Dictionary of Architecture and Construction*. New York: McGraw-Hill.

[16] Hufford, M. (1994). *Conserving Culture: A New Discourse on Heritage*. Illinois: University of Illinois Press.

[17] IDEAM Instituto Colombiano de Hidrología, Meteorología y Estudios Ambientales (2005). *Atlas climatológico de Colombia*. Bogotá: IDEAM.

[18] Koboldt, C. (1995). *Optimising the Use of Cultural Heritage*. Paper presented at the Conference "Economic Perspectives of Cultural Heritage", Cannizzaro, 16-19 November 1995.

[19] Komijani, Z.; Gharachorlou, A.; Zargarian Ahari, F.; Batoomi Abadi, M.; Nahidi Azar, F. & Hassnpour Gozali, A. (2014). Wind Catcher History and Performance in Iran as Iranian Ancient Architectural Heritage. *Switzerland Research Park Journal*, vol. 103, Nº 2: 1343-1350.

[20] Marussi, Ferruccio (2004). *Arquitectura Vernacular Amazónica: La maloca, vivienda colectiva de los boras*. Lima: Universidad Ricardo Palma.

[21] Miranda North, R. (2012). The Maloca: sustainable Amazonian vernacular architecture. *Consensus*, vol. 17, Nº 1: 129-142.

[22] Mohamed, M. (2010). Traditional Ways of Dealing with Climate in Egypt. *The Seventh International Conference of Sustainable Architecture and Urban Development (SAUD 2010)*. S. Lehmann, S.; Waer, H.A. and Al-Qawasmi, J. (Editors). Amman: The Center for the Study of Architecture in Arab Region (CSAAR Press): 247-266.

[23] North, R.M. (2012). The maloca: sustainable Amazonian vernacular Architecture. *Consensus*, vol. 17, Nº 1: 129-142.

[24] Nuñez, M. (2011). *Arquitectura vernacular y colonial dominicana*. Barcelona: Universitat Politècnica de Catalunya.

[25] Peralta González, C.M. (2014). Vernacular architecture in the lower Guayas River Basin: Urban and rural housing. *Arquitectura del Sur*, vol. 32, Nº 46: 42-53.

[26] Pirhayati, M.; Ainechi, S.; Torkjazi, M. and Ashrafi, E. (2013). Ancient Iran, the Origin Land of Wind Catcher in the World. *Research Journal of Environmental and Earth Sciences*, 5 (8): 433-439.

[27] Roaf, S. (1982). "Wind-Catchers" In: Beazley, E. and Harverson, M. *Living With the Desert*, pp. 57-72. London: Aris & Phillips.

[28] Saadatian, O; Haw, L.Ch. Sopian, K & Sulaiman, M.Y. (2012). Review of windcatcher technologies. *Renewable and Sustainable Energy Reviews*, vol. 16, Issue 3: 1477-1495.

[29] Samudio, A. (2001). La arquitectura vernacular del Caribe. *Revista La Tadeo*, Nº 66: 33-39.

[30] Segre, R. (2003). *Arquitectura antillana del siglo XX*. Bogotá: Universidad Nacional de Colombia.

[31] Tunbridge J.E. (1984). Whose heritage to conserve? Cross-cultural reflections on political dominance and urban heritage conservation. *The Canadian Geographer / Le Géographe canadien*, vol. 28, Issue 2: 171–180.

[32] Vélez White M. L. (2006). *Una mirada a la arquitectura en San Andrés, Providencia y Santa Catalina*. San Andrés: Universidad Nacional de Colombia.

[33] Miles Danby, Privacy as a Culturally Related factor in built Form, in farmer, 1983.

[34] Gut Paul and Ackerknecht Dieter. Climate Responsive Building. SKAT, 1993