Bringing Quality of Life to Residents of Ica

Prototype of a Basic House Applying Passive Architecture

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Abstract

"Low-quality housing has long plagued the low-income communities in Ica, Peru. However, there may be solutions to this housing crisis in the local vernacular architecture" (Maiztegui, 2021). This case study focuses on the housing needs of citizens of Ica to improve their quality of life. It does so by explaining cross-ventilation and comparing it to other ventilation sources to address the problems Ica faces. As a result, I created a prototype house for the lower-income residents in Ica, utilizing cross-ventilation designs from traditional homes in the area, which is the most effective way to provide comfort to the user inside the house. Cross-ventilation expel the hot air inside the house, bringing fresh air from the outside. It costs $0 and wastes 0% of energy. This prototype house provides most of their basic needs without removing the vernacular architecture. Adopting these design standards could help remedy the housing crisis in Ica, Peru.

***Key Word*: architecture, passive design, cross-ventilation, Ica, Peru, houses**

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Introduction

Cross-ventilation offers a realistic option for cost-effective structures that provide high comfort levels while taking advantage of the climate. In the face of rapidly increasing energy prices, natural cross-ventilation is an economically attractive option. It is also a chance for homeowners and residents to gain independence from volatile energy markets. The energy needs of a Passive House building are so low that they can easily be met with active solar gains or other renewable sources located either on-site or nearby (Feist. 2014).

In Ica, Peru, the main problem is the lack of knowledge in using cross-ventilation and applying it in houses. The hot weather can explain part of the underutilization in Ica, which ranges from 18-33 °C (Senamhi, 2021), and the limited income of the citizens is another factor. However, Barahona & Ortiz (2019) highlight Ica, Peru, as the perfect place to apply sustainable housing design because the desert climate and high temperatures make cross-ventilation in residential architecture necessary and efficient.

The information leads us to think: how is cross-ventilation applied in residential homes? Moreover, how does a basic house that applies cross-ventilation look? The purpose of this study is to inform and create a prototype house that applies cross-ventilation and other passive strategies to provide options for a better quality of life to residents from Ica that adapt to their budget. The research is aimed at everyone interested in learning about cross-ventilation, how the techniques are applied in residential architecture, and how a prototype house that applies cross-ventilation can look.

Methodology

Study Area

The study area for this project is in Ica, Peru (Figure 1). Ica is located in a valley surrounded by deserts. Ica is a good place for a house prototype with cross-ventilation because these methods can help low-income residents save money.

Figure 1:Map of the study area, Ica, Peru (Wikipedia)

Research Design

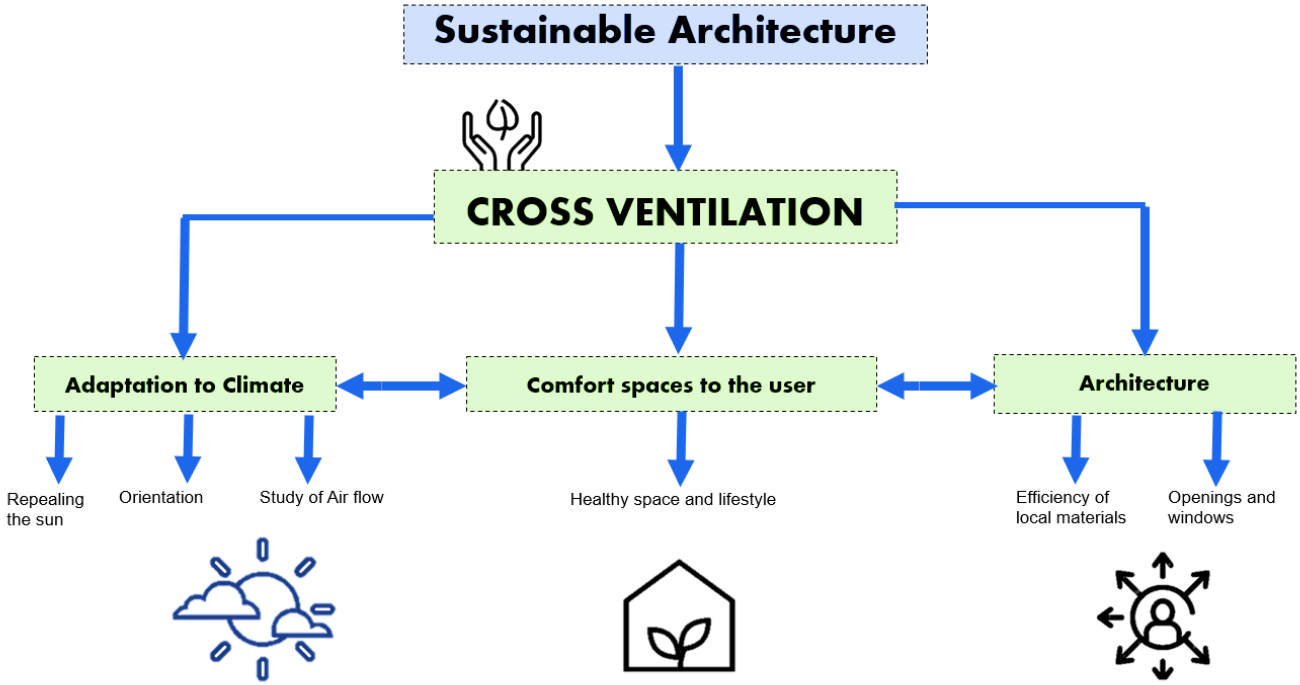


Figure 2: Conceptual Framework for research design Source: Made by Joaquin Chocano Blest

Figure 2 describes how cross-ventilation is part of sustainable architecture by adapting to the climate and creating comfortable spaces through the architecture.

The study aims to identify how to apply cross-ventilation and create a prototype of a basic house for residents in Ica with low incomes. The data collection methods will be case studies, books, news, and data from government places such as MINAM Ministerio del Ambiente, INEI Instituto Nacional de Estadistica Informatica, and the municipality of Ica that will help us to determine the area's history, needs, and other climate and building information.

Data and Measures

I use averages in the weather of Ica for a basic quantitative analysis. Also, I use government data about the houses in Ica, Peru, by the INEI "Instituto Nacional de Estadistica

e Informatica," which are surveys done to understand the status of the houses and the demand for them.

Literature Review

Houses in Ica: Supply

The housing deficit in Peru is significant. Ica is one of ten cities with Peru's most significant housing deficits. (Image 3). Around 67,000 citizens look for houses. This deficit makes it challenging to accomplish the sustainability goals set in Agenda 2030, such as reducing poverty (Goal #1).

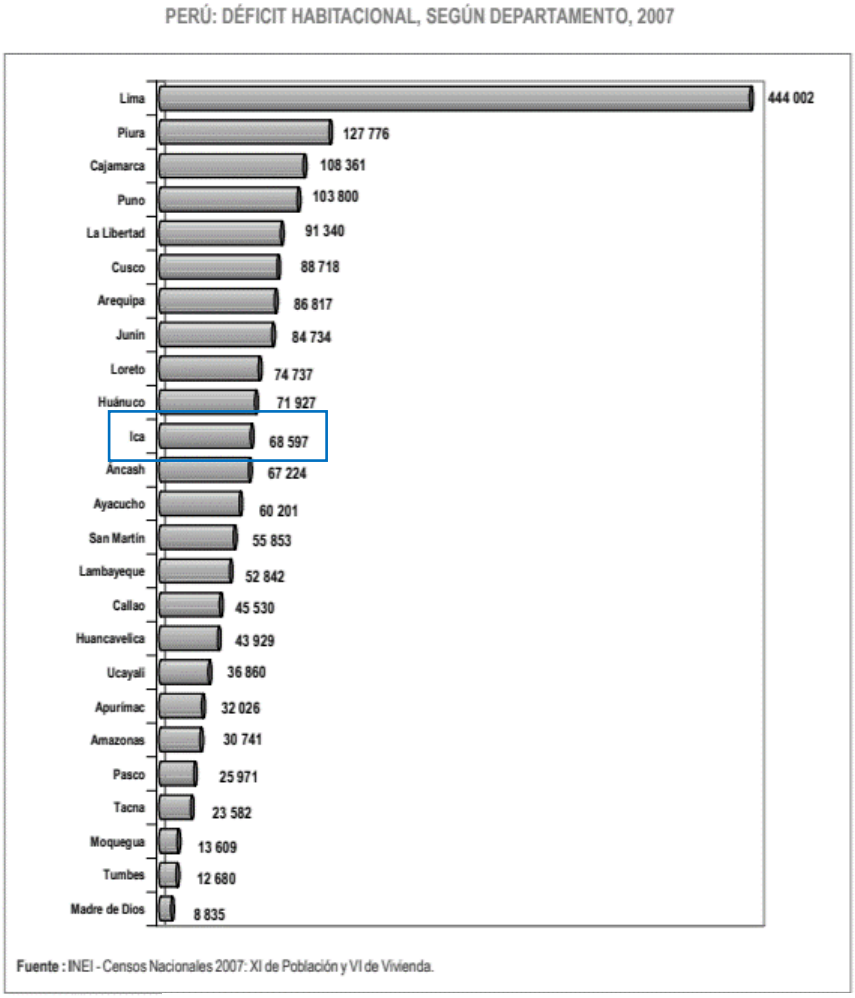


Figure 3: Housing deficit in Peru. Source INEI

Houses in Ica: Demand

According to the INEI "Instituto Nacional de Estadistica e Inteligencia," Ica is one of the fastest-growing places in Peru in terms of the demand for houses (Figure 4). The housing

demand growth is due to more population, but most families have a limited budget with a monthly income of around 1552 soles (RPP, 2020), which means 375 dollars monthly.

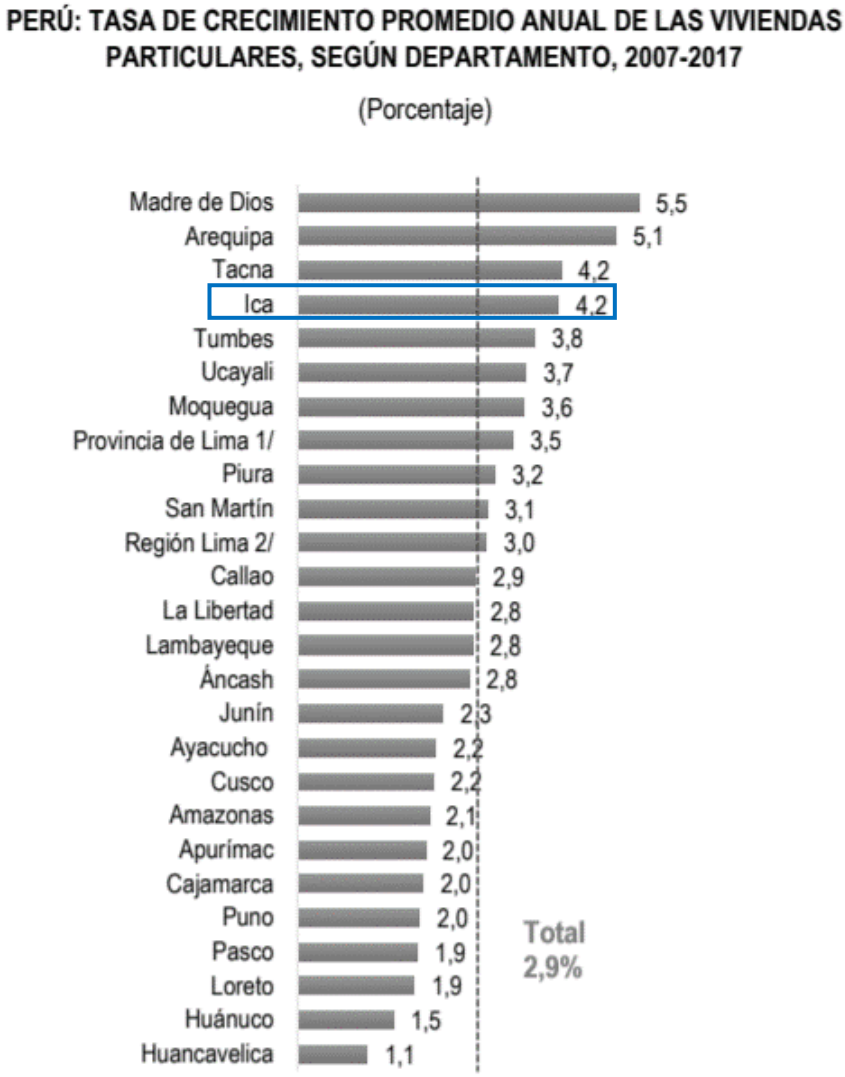


Figure 4 Graphic showing the growth of houses in Peru. It shows Ica as one of the most cities with more growth of houses but still not sufficient for the population demand. Source: INEI

Therefore, the houses they can afford are typically not sustainable, poorly built, and lack technology and facilities. Because of the hot weather and desert climate, the city of Ica can apply passive design strategies to give a better quality of life for the citizens. This improved design is urgently necessary, and, according to the INEI, Ica could have up to a million people in 2020.

The typical House of Ica

History

Ica is where many ancient cultures have settled, like Paracas, Nazca, and Chincha, due to the vegetation and the sea (Gobierno del Peru, 2018). When the Spanish people came to Peru, the indigenous people of Ica were enslaved by wealthy farm owners. In 1821, Peru gained independence, but it was not until 1854 that slavery ended. The population grew as time passed and the city evolved, but some traditions remained, such as using mud and adobe for home construction (Gobierno del Peru, 2018).

Construction materials

Materials most applied

According to INEI "Instituto Nacional de Estadística e Informática" (the National Institute of Statistics and Informatics). The material used most for building houses in Ica is adobe, concrete, and bricks (Figure 5).

PROVINCIA	TOTAL VIVIENDAS	MATERIAL PREDOMINANTE EN LAS PAREDES							
		LADRILLO BLOQ.DE CEMENTO	PIEDRA O SILLAR	ADOBE O TAPIA	QUINCHA	PIEDRA CON BARRO	MADERA	ESTERA	OTRO MATE-RIAL
TOTAL	100,0 (113395)	30,2 (34280)	0,5 (515)	59,7 (67705)	5,0 (5656)	0,7 (742)	0,5 (594)	2,8 (3198)	0,6 (705)
ICA	48254	35,8	0,4	55,5	6,4	0,4	0,1	1,2	0,2
CHINCHA	30674	17,8	0,5	73,6	2,5	1,0	0,3	4,0	0,3
NAZCA	11461	26,5	0,7	61,3	3,6	0,6	2,5	1,8	3,0
PALPA	3148	9,6	0,3	59,5	17,9	2,7	0,4	8,9	0,7
PISCO	19858	41,3	0,5	47,7	4,1	0,5	0,7	4,5	0,7

Figure 5 Chart showing materials for building houses in Ica. Source INEI

The problem with some materials is the lack of earthquake resistance, which is a hazardous problem. In 2007, one earthquake hit Ica, leaving 500 people dead because of unsuitable

construction (RPP, 2019). To make materials earthquake-resistant, there are some things to consider such as the dimension of columns, girders, and others.

Adobe

Adobe (Figure 6) is one of the most used materials in Ica, and it has been used for many years, including by some ancient cultures. What makes this material so attractive to residents in Ica is that the cost of these bricks is very cheap and has good thermal properties. According to Planos y Casas, for making it earthquake resistant, it is important to:

- Use mud of good quality, not too much sand, not too many minerals.
- Use the exact amount of water to mix it with the mud.
- Use straw before making the brick which adds consistency to the brick.
- Make a test of the adobe to see the resistance.

Figure 6 "Construction of adobes" source: Planos y Casas

Before placing the adobes, it is important to use cane sticks and set a suitable concrete base so the adobe walls can resist earthquakes (Figure 7).

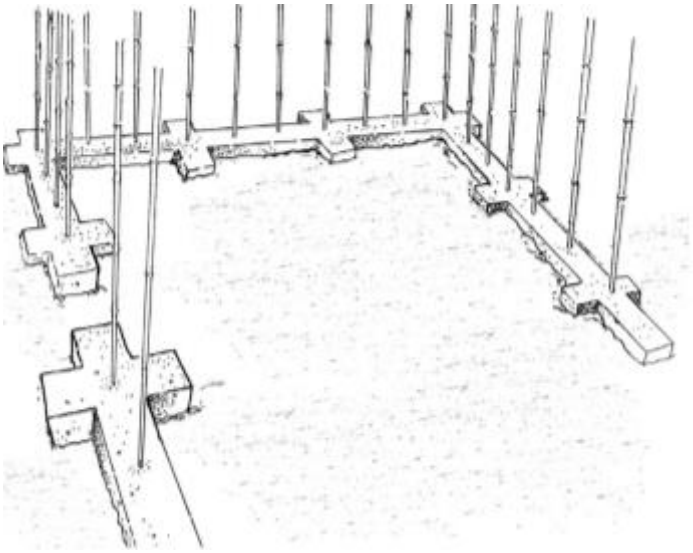


Figure 7 "base of concrete and cane sticks set" Source: Manual Popular Adobe

After setting the base, it is important to "overlap" the adobes (Figure 8). For the construction method is important to take into consideration:

- The mix of the cement and the water.
- Colocation of the bricks should be overlapping each other.

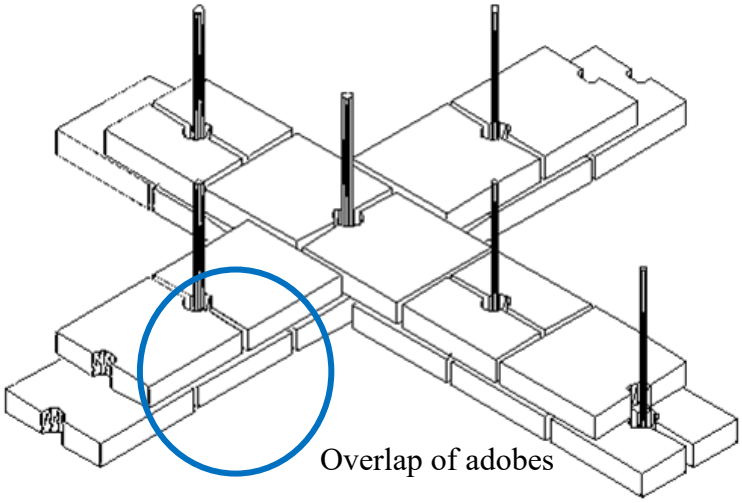


Figure 8 Overlap of Adobes. Made by: Joaquin Chocano

Bricks and concrete

Bricks and concrete are very earthquake-resistant construction method. Both need treatments to be earthquake resistant. Adobes need straws, and bricks need steel rods because they are heavier. The problem with this method is that the cost is too high for residents (Figure 9). Most of the use comes from the middle class.

Figure 9 "House in Ica not finished because of a limited budget." Source: Google Earth.

Basic prototype house in Ica

The houses in Ica Peru for the low-income class are very poor and do not meet the necessary spaces to give good quality of life for the residents (Figure 10).

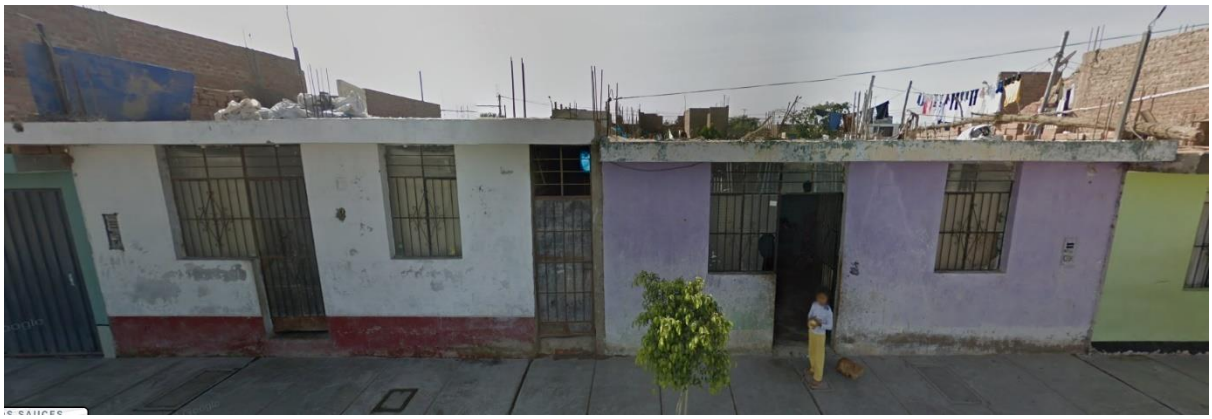


Figure 10 "Typical House in Ica for low-income class" Source:Google Maps

The typical house usually has two spaces plus a bathroom. The first space serves as a dining room, living room, kitchen, and bedroom for children's and the second space serves as the master bedroom. (Figure 11).

Figure 11 "Inside spaces in a low-income house" Source: En el radar

The government's solutions for low-income residents are prefabricated houses and apartments promoted by the government (Figure 12). However, these houses do not consider

the typical house of Ica and the typical materials. The spaces are very small, around 550 square feet for the entire house, including 3-2 bedrooms and 2 baths, which leaves the spaces uncomfortable (Figure 13).

Figure 12 "Residential buildings made by the government" Source: Adondevivir

Figure 13 "3D of the apartments made by the government" Source: Adondevivir

Climate analysis

Temperature

Ica has a climate between 27-18 ºC which is considered between hot and mild weather. The strategic location of Ica being in a valley with hot and mild weather makes Ica an attractive place for farmers and people that want to cultivate food.

Sandstorms and dust

Because deserts surround Ica, sandstorms are inevitable, but they do not occur often. According to IGP (Instituto Geofisico del Peru), sandstorms in Ica called “Vientos Paracas” only occur between two months of the year, August and September. Mostly, they do not hit the city of Ica. Even though the air still brings sand, the amount is reduced thanks to the valley and green areas.

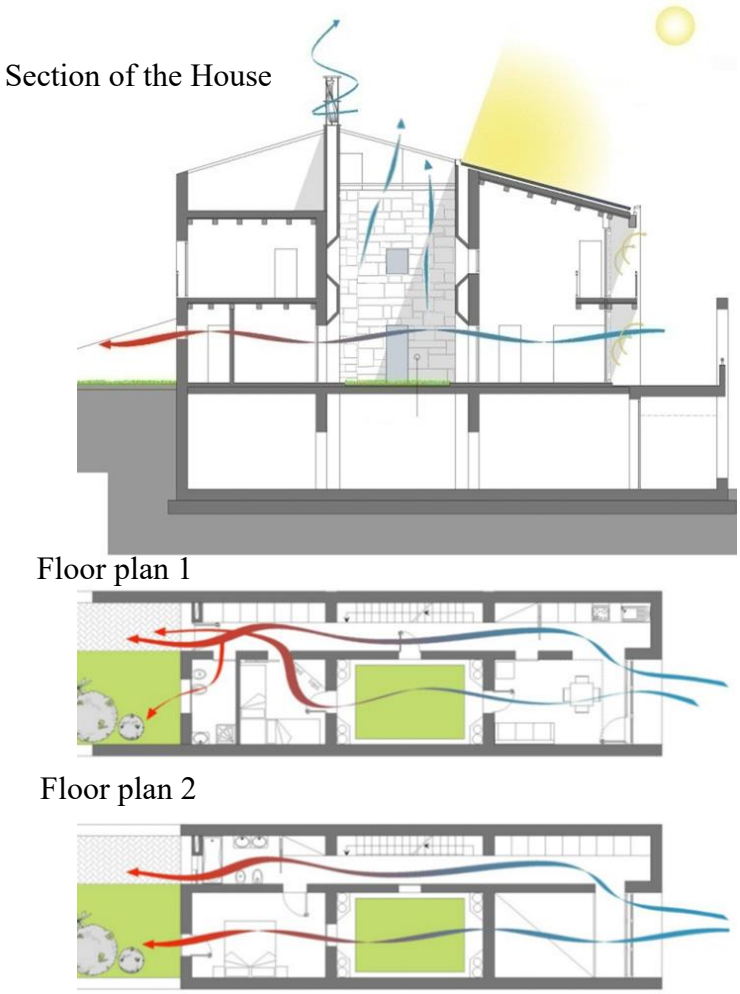
It is easy to avoid issues from sandstorms because they rarely occur in Ica. Closing the windows every time will avoid the dust entering the house. It is common to see dust in Ica because of the surroundings, but dust is easy to avoid. HGTV highlights that plants can help keep dust outside the home, and it helps to purify the air.

Cross-ventilation

How is cross-ventilation applied?

Natural cross-ventilation is where openings in a specific environment or construction are arranged on opposite or adjacent walls, allowing air to enter and exit (Figure 14). Recommended for buildings in climatic zones with higher temperatures, the system allows for air changes inside the building, renewing it and considerably reducing the internal temperature (Archidaily, 2018). When applying cross-ventilation, such as the orientation and windows, there are some things to consider, but its benefits will be reflected in the lower

energy consumption. This method is very effective in constructions located in places with



high temperatures.

Figure 14 Explanation of cross-ventilation, one way of passive ways. By Annarita Ferrate Retrieved from https://www.researchgate.net/figure/Cross-ventilation-and-vertical-air-extraction-at-the-buildings-scale_fig3_254218274 (accessed on March 2021)

Effectiveness of cross-ventilation

In Ica, Peru, ventilation is necessary, like other places with hot weather and high temperatures. Therefore, most houses apply air conditioning as the easiest way of bringing comfort to the space. What is unknown by most people is that air conditioning consumes **around 7% of the energy in the monthly energy consumption bill** (Peru retail, 2019). It is classified as one of the machines that consume more energy in a home because of the large spaces it cools. Figure 15 shows how energy consumption is distributed in a house where the air conditioning does not go, such as the patio, garage, laundry, and others.

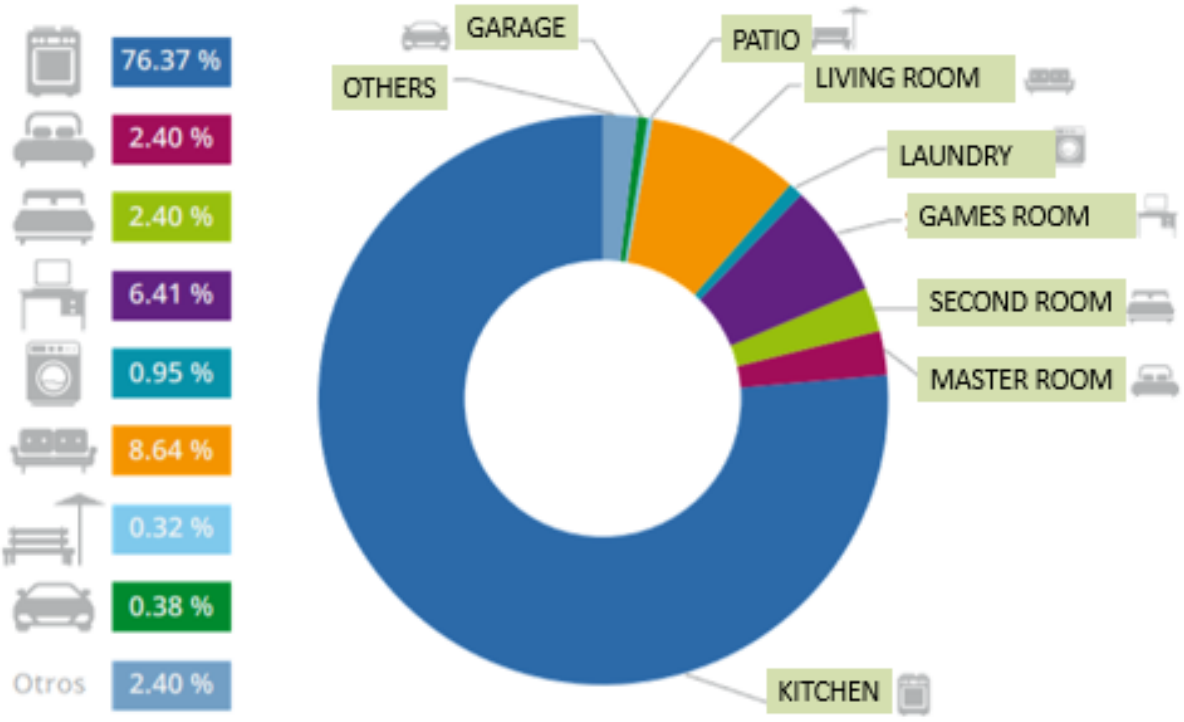


Figure 15 Use of electrical energy in non-passive house. Retrieved from MINAM

Even though the possibility of applying air conditioning is a valid and easy way of giving comfort in the space due to the hot weather, in reality, it can be a challenge in Ica. Because of its centralization in Lima, the technology in Ica is very limited. Apart from the amount of energy consumption and the maintenance it requires, air conditioning is a luxury machine to have in most houses. So, most of the citizens in Ica ended up living in an uncomfortable space or having fans all over the place. One fan costs 9.5 soles monthly (Mapfre, 2019), which is an extra cost for the house.

However, a house that applies cross-ventilation can consume less energy with the same comfort level as a house with air conditioning. It is also better than fans that recirculate the same warm air inside the space; cross-ventilation creates better comfort because it is constantly circulating air from the exterior.

Example

La Piedad House is a good example of a house that applies cross-ventilation. The house is divided by a central patio that allows the hot air to exit the principal façade and ventilation to the back part (Figure 16).

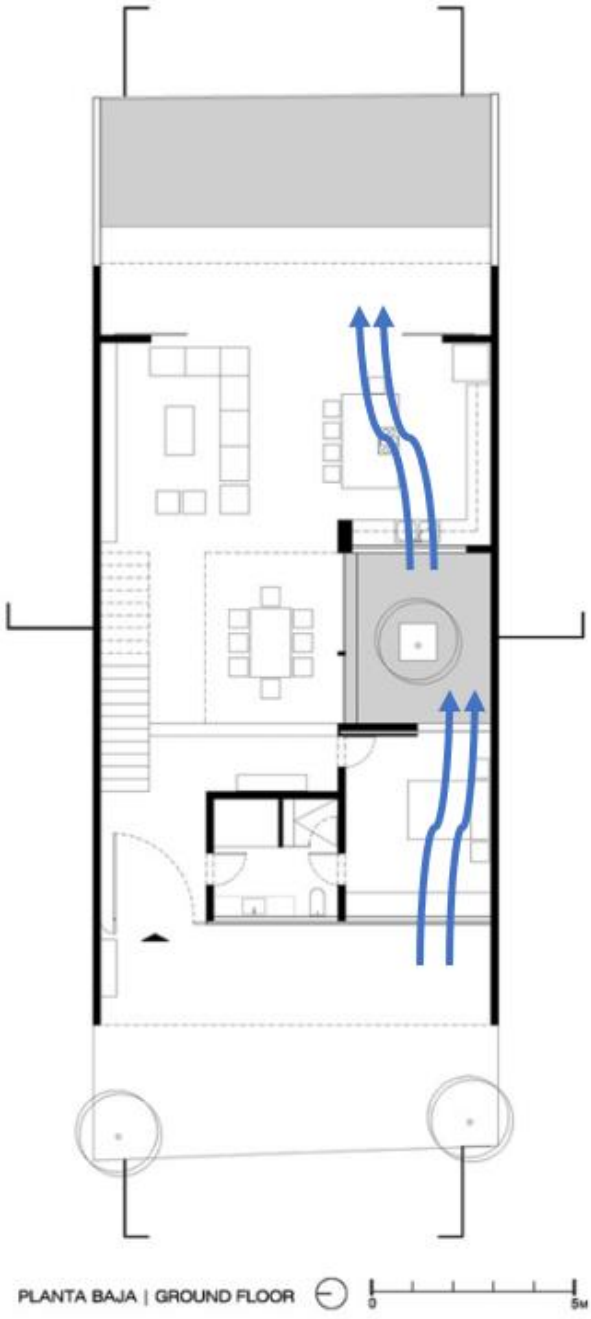


Figure 16 "Description of cross-ventilation on the first floor". Retrieved from: archdaily

Results

Applying cross-ventilation

Because of the need for cool housing in Ica and the tight budget of the citizens, it is essential to apply cross-ventilation to give comfort in spaces and give a better quality of life to families in Ica. Some design aspects to take into consideration these homes need is to:

- Consider the importance of orientation and collocation of windows.
- Keep traditional use of adobe construction.
- Follow the manual of adobe construction.
- Satisfy the needs of the family in terms of space so they have a better quality of life.
- Set aside a place for cars; although families are low-income, they may own a vehicle in the future.

Design

The prototype of the house will have three bedrooms, two bathrooms. The house will keep the traditional architecture and materials against the houses made by the government to keep the tradition and make residents feel comfortable with their lifestyle. So, the house must be made of adobe and will show the correct position of the adobes based on the rules to build adobe houses (Figure 17). All the spaces will have cross-ventilation to provide a high-quality living arrangement. Rooms will apply cross ventilation using light wells (Figure 18). The Orientation of the house will depend on the airflow. In the case of Ica, the airflow goes from southwest to northeast so windows and openings must face the southwest.

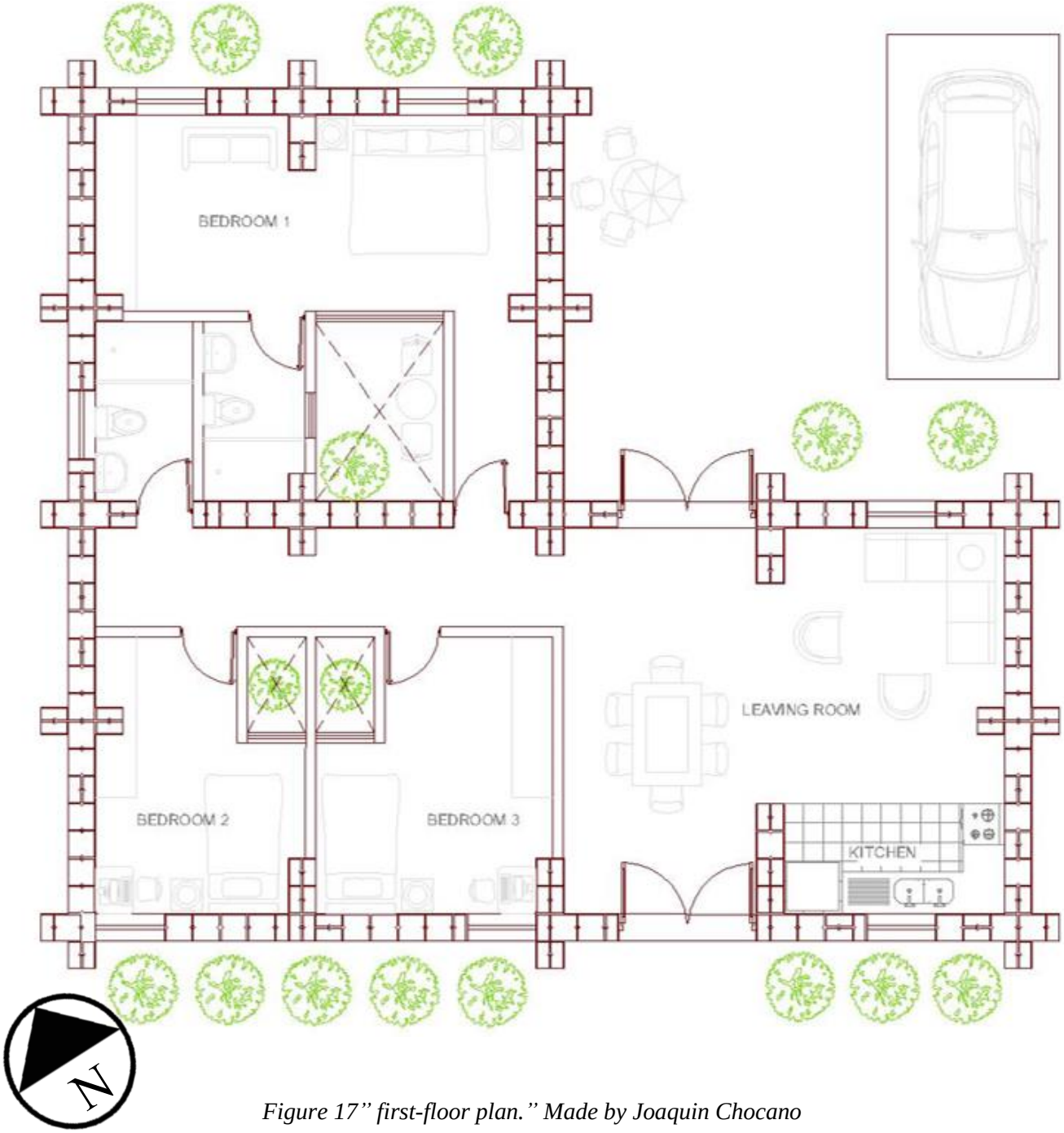


Figure 17" first-floor plan." Made by Joaquin Chocano

This figure is a description of the floor plan distribution and shows how adobes and canes sticks must be placed to make it earthquake resistant. In this floor plan, the colocation of plants is in front of the windows will block most of the dust from the outside.

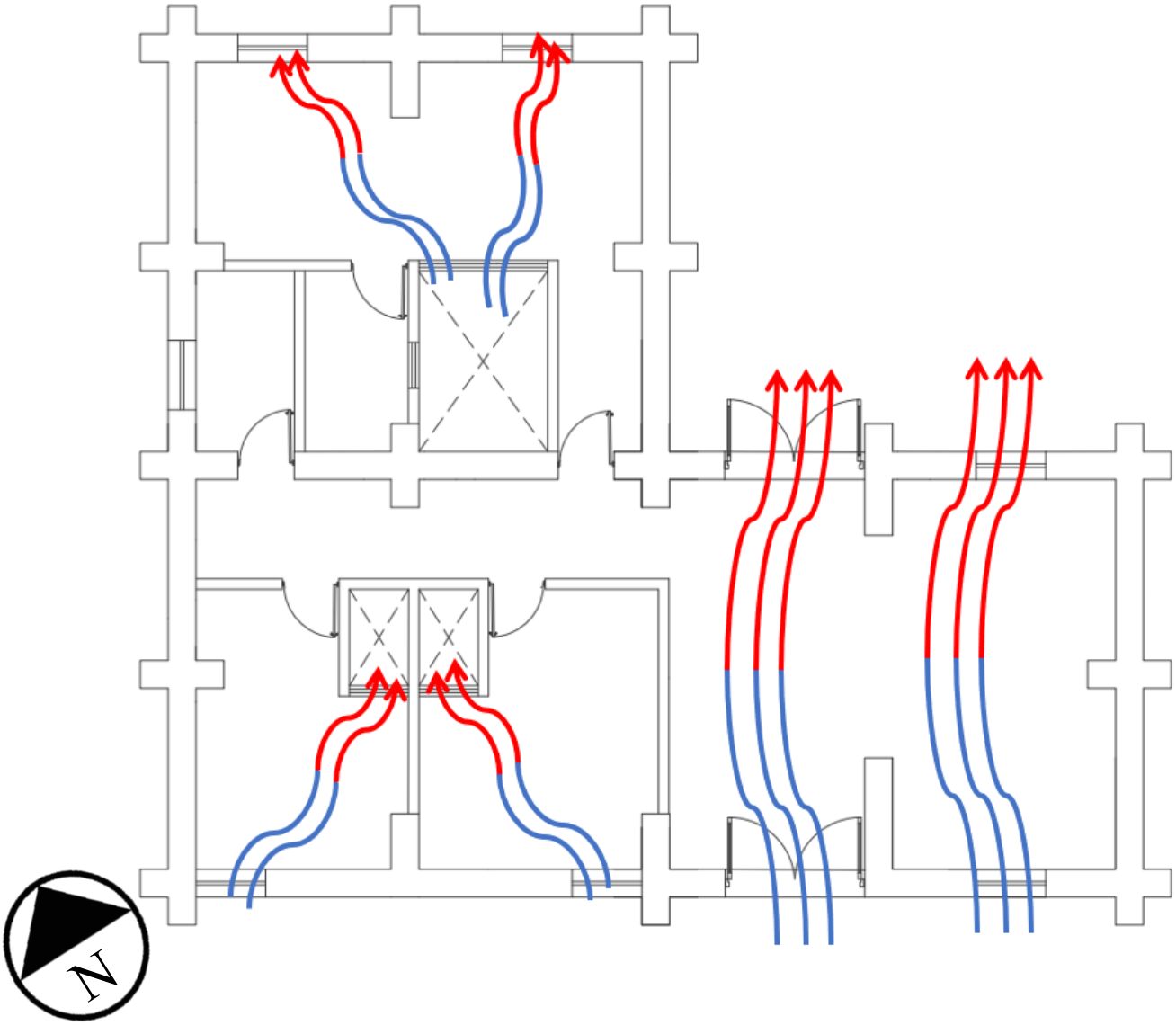


Figure 18 Description of cross-ventilation on the first floor. Made by Joaquin Chocano

This figure shows the cross-ventilation and how the air flows from southwest to northeast, bringing fresh air from the southwest and expelling the hot air from inside the house by the northeast. Each room applies cross ventilation. To make the bedrooms cross-ventilation work, the design applies small patios to let the air be expelled or get inside.

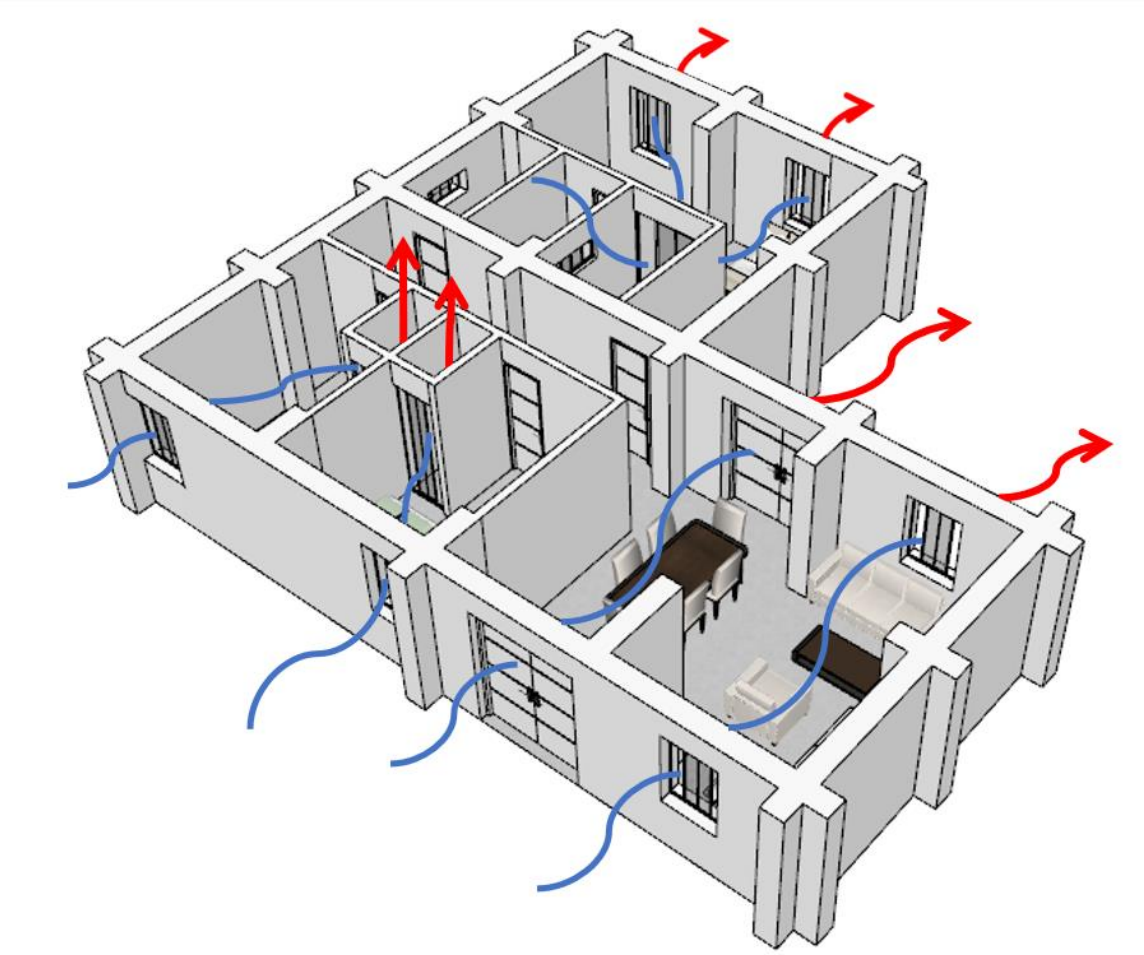


Figure 19 3D of the house describing cross ventilation. Made by Joaquin Chocano

This figure shows the cross-ventilation in a 3D model of the house prototype. In the picture it is clearer to see how cross-ventilation is applied in the rooms by creating small patios for the air to enter (in the main room) and leave (in the secondary bedrooms)

Figure 20 3D of the house. Made by Joaquin Chocano

Final 3D of the housing prototype with final details

Recommendations

All spaces must have two openings, one in front of the other, so that the cross ventilation can be effective. This brings problems with rooms in front of each other. The solution proposed for these problems was to create small terraces so the air could exit or enter by that opening. Some recommendations for the design are to consider the airflow, always have one opening for the air to enter and one for the air to exit. Cross ventilation must be applied in critical spaces, such as the bedroom, living room, and dining room, to give comfort throughout the house. For avoiding dust, it is essential to leave a space for plants in front of the window or opening.

Conclusion

The study area in Ica, Peru, presents good conditions to apply cross ventilation and is the best way to give comfort to the user. Even though there are other possibilities for ventilation such as air conditioning, fans, and others, they cost money which means an extra income to the house. On the other side, cross ventilation costs $0 and wastes 0% of energy in the house. The reality that Ica Peru faces with a lack of technology to apply air conditioning leaves the houses as uncomfortable spaces. Because of the climate of Ica with hot weather, cross ventilation is the best way possible to create better houses with comfortable spaces.

Cross ventilation works with openings in a specific environment or when the construction allows the air to enter and exit freely. Cross ventilation is recommended for buildings in climatic zones with higher temperatures. The system allows for air changes inside the building, renewing it and considerably reducing the internal temperature.
For applying cross-ventilation in residential homes, there are some criteria to follow:

- Consider the orientation and airflow
- There must be one opening for air to enter and one opening for air to exit
- To give comfort in throughout the house, cross-ventilation should be applied in critical rooms, such as the bedroom, living room, and dining room.
- To avoid dust from outside its important to leave a space for plants in front of the window.

The limitations found in the study were that the design must consider how all spaces have two openings, one in front of the other. This can create an issue for interior rooms. However, creating small terraces so the air could exit or enter by that opening is a potential solution.

If following these criteria, a house that applies cross-ventilation will look like a comfortable house that brings fresh air inside and always creates a cooling airflow, bringing a

better quality of life for the residents. Cross ventilation can be adopted as part of the policy in sustainable houses. The “Bono Verde” program from the country gives incentives to sustainable houses, helping builders construct the house. Utilizing the proposed design in this capstone could dramatically improve the quality of life for residents without increasing costs.

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