

# Sustainability of Vernacular Architecture as a Basis for New Popular Housing Projects in Arequipa, Peru

Marco Antonio Vilca Mamani<sup>1</sup> and Leopoldo Eurico Gonçalves Bastos<sup>1,2</sup>

1. Programa de Pós-Graduação em Arquitetura—PROARQ, Faculdade de Arquitetura e Urbanismo—FAU, Universidade Federal do Rio de Janeiro—UFRJ, Rio de Janeiro, 21941-901, Brazil;

2. Mestrado em Arquitetura e Cidade—Universidade Vila Velha, Vitória-ES, 29102-920, Brazil

**Abstract:** The aim of this work is to present an analysis about three vernacular houses (Churajón, Moral, and Chicha) from remarkable architectonic periods of the Arequipa city in Peru: Pre-Spanish, Colonial, and Republican. Some historic facts related with the region are presented in order to furnish a general panorama. This city is an oasis on the border of the Atacama Desert, and aside there are three volcanoes. Also, at the last 40th years, this region has suffered eight earthquakes. The bio-environmental equilibrium is fragile. Nowadays, due to the urban spread and the increase of the land price, the poor people go to live in the city periphery inside uncomfortable and fragile houses. Also, it is observed an intense occupation of the meadow areas which are crucial to maintain the regional climate, food production, and the ecosystem. Fundamentals of social sustainability and bioclimatic architectures are employed in the analysis in order to create conditions to empower poor people and an environment protection.

**Key words:** Vernacular architecture, social sustainability, bioclimatic approach, Arequipa.

## 1. Introduction

Nowadays, around the world, the integration of the sustainability in the cities is a permanent challenge. In this way, Bui [1] lists some subjects to be considered by developing countries as: urban demography growth, non-equilibrium urban-rural, land access, spontaneous housing, urban transport, environmental quality, healthy, education, people equity, cultural value and patrimony conservation. The authors [2] emphasize social aspect of sustainability and say: “we have highlighted the necessity of working through underlying conflicts and equitable and meaningful solutions to the problems confronting us”. Some housing problems in Peru are indicated by Mora and Calvo [3] as: (13.7%) dwellings built using precarious or non-desirable materials, (32.29%) dwellings not offering minimum living standards (electricity, sewage system, running water).

Nowadays, Arequipa, the second Peruvian city, has been engaged to develop some sustainable politics and strategies to deal with actual problems as: the conceptual divorce treatment for urban land, territory and environment; pressure on peasant lands; meadow reduction; air and water pollutions [4]. It is a fact that as time goes, peasant people came before to the city lost ancient techniques, know-how and the use of raw building materials. Thus, actually low-income houses built by them contribute to generate waste and environmental pollution, beside non-comfortable and fragile houses. Considering a methodological point of view, Rapoport [5] proposes for the vernacular architecture an approach considering process and product, and emphasizes to learn by analysis. Also, Almodóvar and Jiménez [6] and Almodóvar et al. [7] dealt with the urban layout of Arequipa and the accessibility to solar energy, and present indoor temperature measurements for a colonial house. The transformations of the Peruvian vernacular architecture as a result of the decolonization process and the recovery of original pre-Hispanic sources are

---

**Corresponding author:** Leopoldo Eurico Gonçalves Bastos, D.Sc., Mechanical Eng., professor; research fields: bioclimatic building design, and sustainable architecture. E-mail: leopoldobastos@gmail.com.

focused in Ref. [8].

The intention of this work is to redeem some lessons from the vernacular architecture of Arequipa along three historical periods to subsidy an analysis for the current relationship between the city and its low-income houses. Thus, in this sense is chosen a representative vernacular habitat from each of the three architectural periods in Arequipa: Pre-Hispanic, Colonial, and Republican.

### 2. The City of Arequipa

Arequipa is an oasis city located in the south of Peru: 16°24'10" S and 72° 32'10" W (Fig. 1). It has an altitude of 2,329 m from the sea level, 280,000 inhabitants and is crossed from north to south by the

river Chili [9]. It is sited near three volcanoes of the Andes Mountains, and near the Atacama Desert and the Pacific Ocean. Beside the volcanic activities and earthquakes, there is a potential danger of melting ice on the Andes due to the greenhouse effect, therefore the ecological and environmental balances are fragile, [10]. From Fig. 2 can be seen the yearly climate regularity of the region, the marked temperature differential between days and nights, and also the intense solar irradiation on a horizontal plane.

During the day, there are predominant cool winds (temperature 20-25 °C, relative humidity 25%-55%) coming from W and SW. At night, there are cold winds (5-10 °C, 15%-25% relative humidity) from NE (Fig. 3). Average wind velocity along the year is around 1.5 m/s



Fig. 1 Localization of Arequipa. Source: Ref. [9].

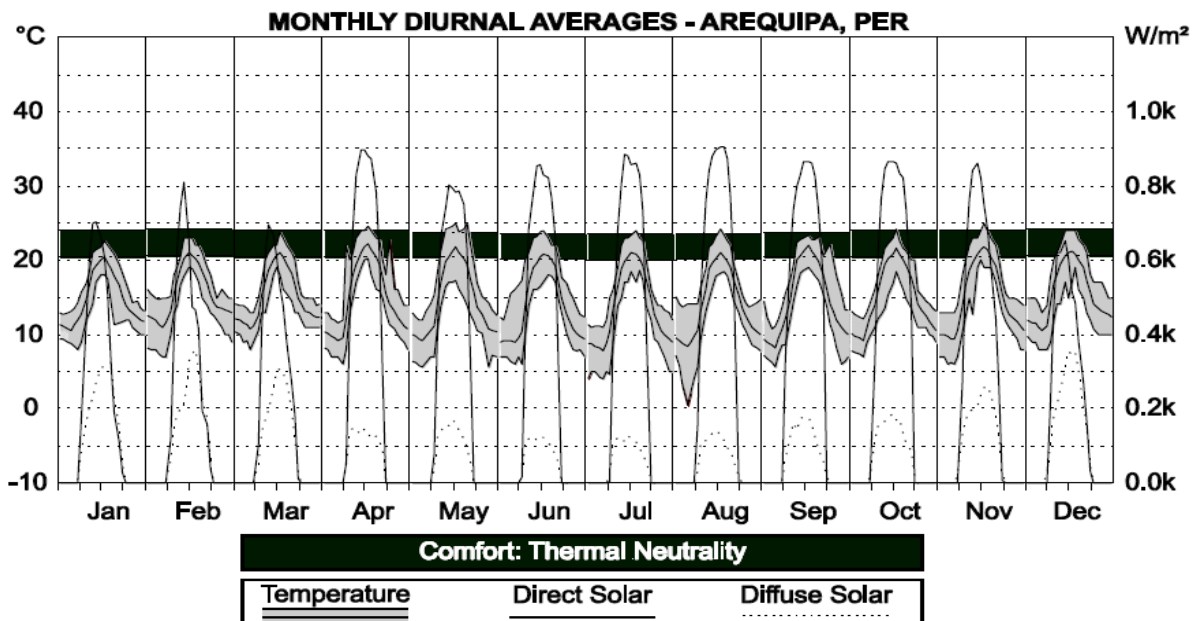
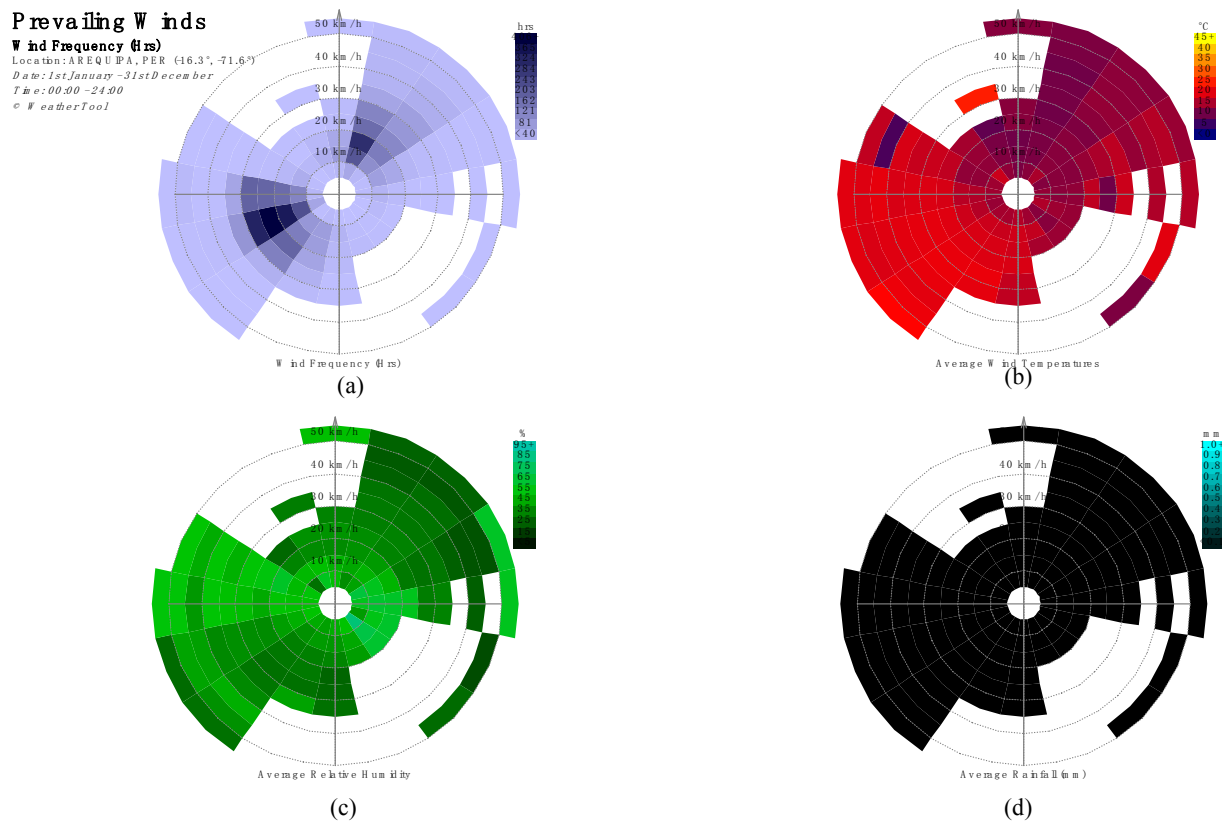


Fig. 2 Climatic context of Arequipa. Source: Ref. [7].



**Fig. 3** Yearly average: (a) wind frequency; (b) ambient temperature; (c) relative humidity; (d) rainfall. Source: data processed from Rodrigues Ballón airport by weather tool (2011).

to 2.5 m/s. According to the Givoni Bioclimatic Diagram (Fig. 4), some bioclimatic strategies required for indoor thermal comfort in Arequipa are: passive and active solar heating, thermal mass, natural ventilation, etc. [10]. Also, it can be seen from Fig. 5 a view of the meadow and andenerias of Arequipa.

### 2.1 Arequipa Pre-Hispanic Vernacular (300 BC to 1540)

Arequipa, from archaeological findings belonged to the Puquina (300 BC to 500) [11]. The economy was agrarian and pastoral. As time went on, there were a succession of ethnicities such as Tiahua-co-Huari (500-1000), Churajón (1000-1450) and Inca (1450-1540). Along this period, the habitat evolved from primitive subterranean shelters to houses of stone implanted with shape of a circle such as those found in archaeological sites of Churajón and Polobaya. Under the 90th years of Incas domination, the economy was based on agriculture, rebuilt and

expanded the build (introducing adobe and straw); built villages and improved waterworks.

The cultural process influenced the architecture, which evolved over time adapting and increasingly better to this geographical environment, through new techniques and local materials. The worldview of these cultures also restricted the use of stones from the volcanoes because they were considered deities (iconographies and mummies were found in the Pichu Pichu volcano). The Arequipa meadow and the terraces on the hills (andenerias), Fig. 5, are areas recovered from the desert by these Andean ancestors with works of hydraulic infrastructure and formation of the fertile ground for cultivation.

The vernacular habitat chosen as representative is the Churajón house (dated 1200). The house major axis is NE-SW (azimuth 45° from the north) contributing to maintain on the façade north a solar radiation almost constant along the year of 2.5 kWh/m<sup>2</sup>. Also, the location of the rooms is around

### Psychrometric Chart

Location: AREQUIPA, PER  
 Frequency: 1st January to 31st December  
 Weekday Times: 00:00-24:00 Hrs  
 Weekend Times: 00:00-24:00 Hrs  
 Barometric Pressure: 101.36 kPa  
 © A.J.M aish '00

**SELECTED DESIGN TECHNIQUES :**

1. passive solar heating
2. thermal mass effects
3. exposed mass + night purge ventilation
4. natural ventilation
5. direct evaporative cooling
6. indirect evaporative cooling

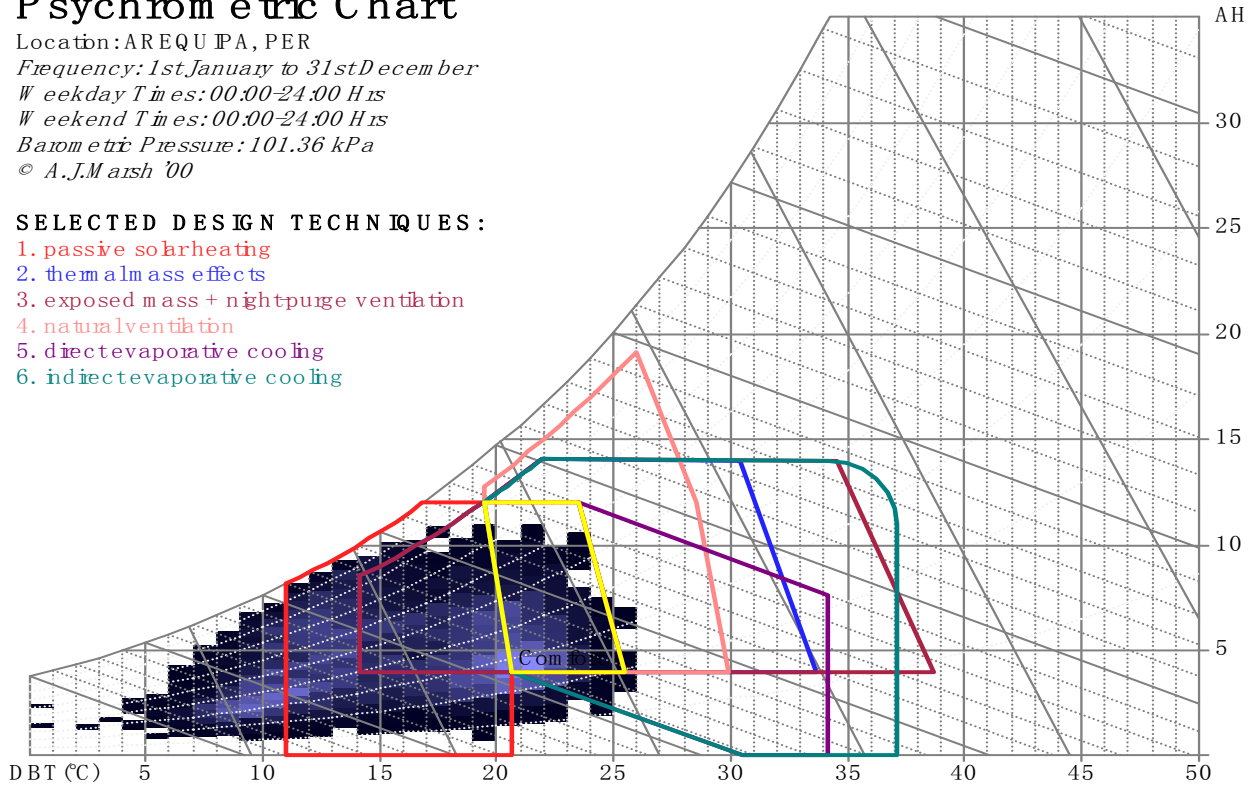


Fig. 4 The Givoni bioclimatic diagram for Arequipa.



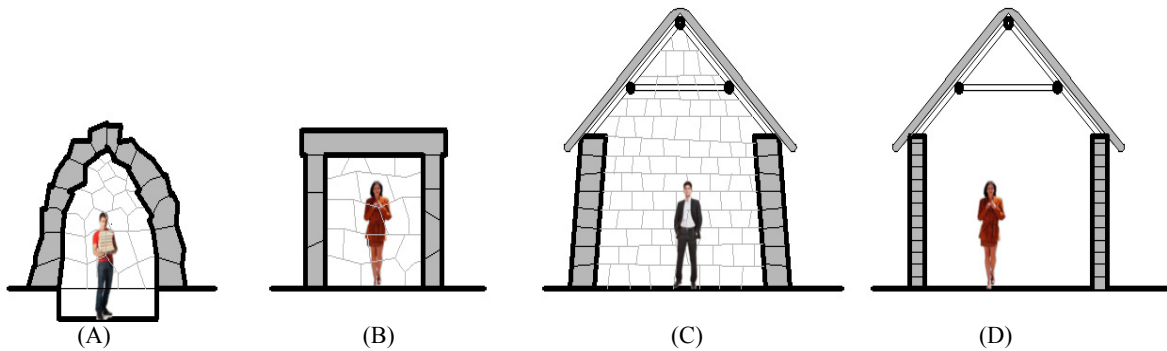
Fig. 5 Arequipa: (a) meadow; and (b) andenerias. Source: raptravel.org.

a courtyard allowing the sunshine in most of the facades, which stored energy by its mass, a convenience due to the temperature fall at nights. The plots follow an organic and irregular form adapting to the sloped terrain, and the mountain blocks the cold winds. The house walls were made with local stones as andesitic and granitic (30-40 cm thickness), a straw

pitched roof, and very small fenestrations (see Fig. 6) [12].

#### 2.2 Arequipa Colonial and Beginning of the Republic: Vernacular by Synthesis (1540 to 1945)

The Peruvian ancestors had a long architectural and urban tradition, thus under the Spanish domination,



**Fig. 6** Scheme of the vernacular construction processes in Arequipa: (a) primitive house from Puquina, Huactalacta ruins in Pochi; (b) Tiahuanaco and Huari houses; (c) Churajón house; (D) Inca house.

Source: adapted from Ref. [11].



**Fig. 7** Panorama of the colonial historic centre of Arequipa.

Source: skyscrapercity.com.



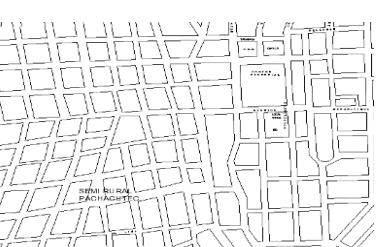
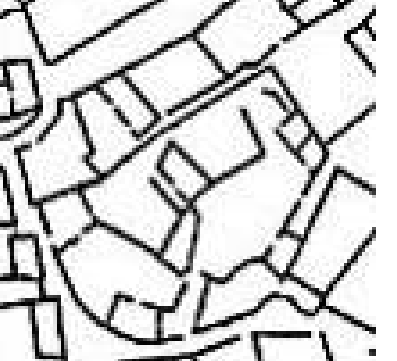

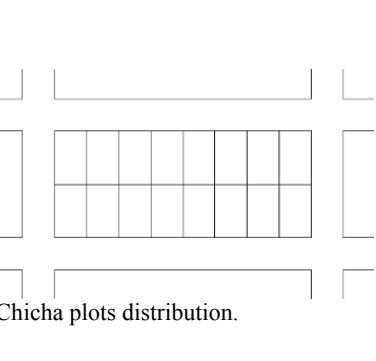
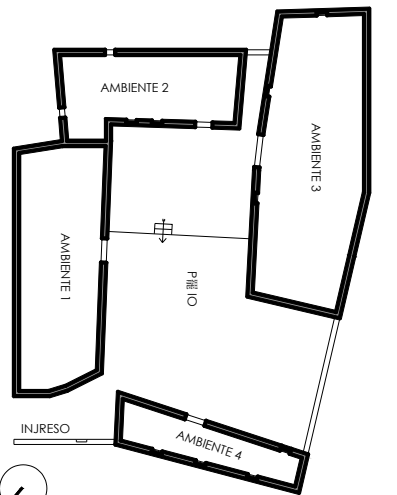
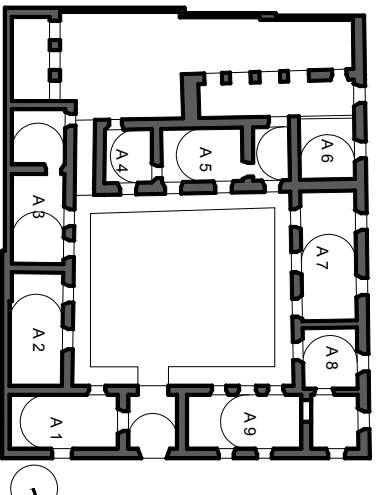
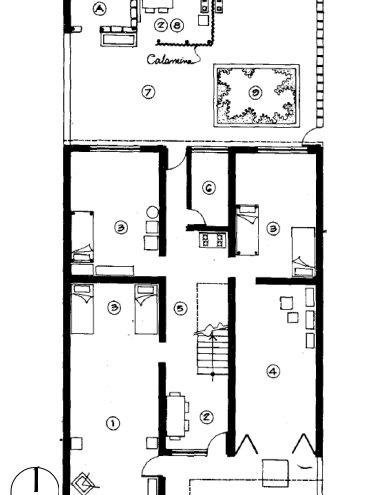
they contributed to a new expression of synthesis between the tradition and the coming Spanish models. This process occurred through an appropriation [13]. The sillar volcanic stone was used as a building material for the vaulted roofs and double walls favoring indoor thermal comfort and protection against earthquakes. All architectural expressions from this extended period are named vernacular by synthesis. Proto-Spanish (1540-1600): foundation of the city and social adaptation; earthquakes; agriculture and mining economy; incipient riverside houses; clay, trunks and straw; volcanic stone (sillar) in the portals of the churches. A view of the Arequipa colonial historic centre is shown in (Fig. 7). Baroque (1601-1700): earthquake; vice-reign; autochthonous labor building

process; century of religious buildings with sillar. Neoclassical (1700-1800): earthquakes; agriculture and mining; technology from religious buildings transferred to civil architecture; house layout changes; iconographic with religious content, but also with pre-Hispanic Andean motifs (baroque-mestizo); Del Moral house. Neo-Renaissance (1800-1900): earthquake; transition and independence of Peru (1821); exportations and textile industries, expansion of the urban fabric and people migration from neighboring cities. Mixture of styles (1900-1945): earthquake recovery; war with Chile; eclectic architecture, historicist, art decò, duke, neocolonial.

The Neoclassic Moral House (1750) is chosen as the vernacular representative of this period. The

Table 1 Urban and vernacular house typologies considered.

Source: the authors.

Ancient Vernacular (Pre-Spanic)	Vernacular by Synthesis (Colonial)	Modern Vernacular (Republican period)
 <p>Spatial network of the Churajón complex.</p>	 <p>Foundational tracing, Arequipa Historic Centre.</p>	 <p>An urban network: the "Cerro Colorado" neighborhood.</p>
 <p>Churajón plots distribution.</p>	 <p>Colonial plots arrangement.</p>	 <p>Chicha plots distribution.</p>
 <p>Ground floor orientation for the Churajón complex: the houses are sited around a square.</p>	 <p>"Del Moral house": ground floor orientation and distribution of rooms around a courtyard.</p>	 <p>"Chicha house": ground floor orientation and layout of rooms. The open space is placed in rear the house.</p>

orientation of the colonial urban plot follows an azimuth of  $20^\circ$  from north, parallel to the river Chili. This house has a central courtyard with a tree in the center, and is made of the white volcanic stone named sillar (walls and vault roof), and presents small windows. Nowadays, this building is a museum (Table 1). The NE-SW streets receive the cold night winds, and NW-SE streets the fresh daytime winds. The open inner courtyard provides ventilation during days and nights. The rooms mostly occupy the façade oriented to the daytime winds, and at night cold winds are incident on the service rooms. Also, at night, the bedroom doors were closed to conserve the ambient air heated and to reduce cold night air currents.

2.3 Arequipa Republican: Modern, Postmodern, Modern Vernacular (?) and Contemporary (1945-2015)

The period Modern (1945-1980): two earthquakes; informal economy; illegal work; public works for migrants; urban growth on the edge of the Misti volcano; higher incidence of migrant population due to industrialization; height growth of buildings; new avenues and popular urbanizations. Postmodern (1980-2000): high inflation; imports increase; informal markets; field-city migratory flow; search for cultural identity; trafficking and terrorism. Chicha Architecture. Contemporary (2000-2017): economic

growth through mining; mix of cultures and customs; definition of middle and poor classes; neighborhoods; blend of architectonic styles; majority of buildings of bricks, concrete and steel. During the 20th century and up to now, important buildings have been built following the international style, a tendency to be changed, facing the climate and environmental conditions.

A popular architecture named Chicha (1980-2017) is considered as representative of this period, because it was born under marginal circumstances, poverty; process of “andenizing” the city as an attempt of cultural decolonization from previous decades, a movement using native and mestizo symbols. Characteristics of low-income self-constructions, is a modern vernacular. Many authors like Lopes-Osorio et al. [8] deal with the vernacular phenomenon, the “Chicha architecture” (so named because of Incan ceremonial drink made with fermented corn). This architecture uses symbolic elements of rural buildings in urban constructions as a mere representation, Fig. 8. According to Burga [13], the Chicha architecture has a double code juxtaposing: rural and urban, vernacular and modern, ornamental and practical, historical and futuristic, provincial and metropolitan, traditional and current, artisanal and industrial. This building typology is erected by immigrants and summarizes a specific iconography with elements more characteristics

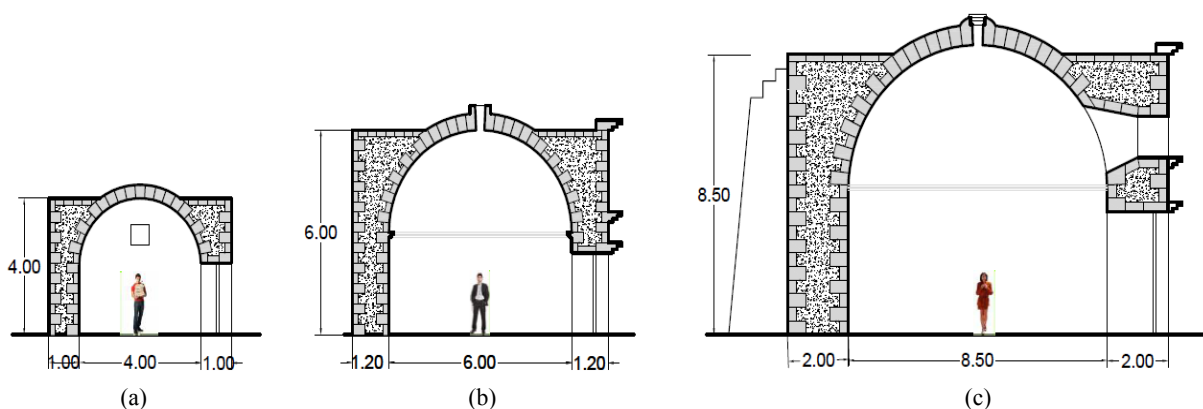


Fig. 8 The vernacular by synthesis, building escalate processes in Arequipa: (a) popular house; (b) high income house; (c) church.

Source: Ref. [15].



**Fig. 9** Picture of house façades from the Chicha architecture in Peru.

Source: Arq. Jorge Burg Bartra.

of an urban architecture, which will allow for him integration and adaptation more quickly to the city [13], see Fig. 9. The plots are rectangular and predominant North-South axis and then receive part of the cool winds during the day, and at night the cold winds. The house layout is compact and the courtyard is sited in the rear of the plot. The structure is of reinforced concrete, and brick walls [14].

Table 1 depicts the three considered vernacular architectures: Ancient (pre-Hispanic), Colonial (vernacular by synthesis), and Chicha (modern-vernacular) by means of the plots arrangement and houses orientation. According to the local climatic conditions are the tracing shown by the Ancient and Colonial plots and also its houses orientation.

### 3. Low-Income Housing and Sustainability

Currently, Peru is no exception among Latin American countries, while the conception of low-income housing is focused only on the economy, leaving aside the other dimensions of sustainability. The sustainable architecture conception requires a multicriteria approach at where architectonic criteria (spatiality, materiality, morphology, and implantation) are crossed to the conditions to be attended

(harmonious relationship with its environment, water and wastewater management, indoor comfort, etc.) [16].

It is estimated that 70% of houses are produced informally, which implies non-formal occupation of urban space, building without professional assistance, and the use of poor quality materials [17]. The social housing program “Mi Vivienda” promotes the access of houses to low-income families with financial credits. The construction of buildings is designated to private real estate. Most of them are simple housing modules that are repeated without considering the implantation, orientation, etc., the materials have not quality, location around the city periphery (low cost land). According to the national program, Arequipa currently has a deficit of 86,817 dwellings, generating problems such as the informality in the traffic of land, where groups of people gather to invade state or private lands as a response to a poor planning face to the urban sprawl.

### 4. Conclusions

The analysis performed reveals that the low-income housing in Arequipa is a problem evolving the sustainability in its broad sense. People and city are actors interfering on the fragile environmental



equilibrium of this region. Also, there are social problems as poverty, lack of housing and social segregation. Aside are the natural impacts from volcanoes and earthquakes. The ancient inhabitants create conditions to be well adapted through adequate shelters, agriculture, and grazing activities. The Churajón house is a vernacular good example: correct implantation, high wall thermal inertia, two ways cover, advantage from topography and the fresh daily winds, use of local materials. From the colonial period, the vernacular moral house is well adapted to the environment: good plot implantation, building with sillar, domed covers, new rooms layout, central courtyard, high wall thermal inertia, small windows. Concerning the vernacular modern Chicha, there is a setback due to the urban periphery occupation, face the urban swelling up and increasing land price, danger to meadow destruction, and pollution of the rivers. The sited plots and houses are not adequate to capture solar energy, the fresh daily winds, then are thermally uncomfortable. Also, there is a use of industrial materials, not suitable for indoor comfort, and producing too much material waste. Thus, it is time for the region of Arequipa to implement the local Agenda 21.

## References

- [1] Bui, T. U. 2012. "L'Intégration du Développement Durable dans les Projets de Quartiers: Le Cas de la Ville d'Hanoi." Thèse Doctorat, l'Université de Toulouse. (in French)
- [2] Vallance, S., Harvey, C., Perkins, H. C., and Dixon, J. E. 2011. "What Is Social Sustainability? A Clarification of Concepts." *Geoforum* 42: 342-8.
- [3] Mora, A. G., and Calvo, P. C. 2008. *House Finance Mechanisms in Peru*. Nairobi: UN Habitat. 50 pgs.
- [4] Encalada, S. 2009. "Estrategia Ambiental Urbana en Arequipa." Presented at SCP/LA21 en Perú. Serie Estrategias de Apoyo a la Gestión Urbano Ambiental, edited by Encalada, S., Zucchett, A., and Peralta, M. GEO Cities UN Habitat, 28p. (in Spanish)
- [5] Rapoport, A. 1990. "Defining Vernacular Design." In *Vernacular Architecture: Paradigms of Environmental Response*, edited by Mete, T. Aldershot, England: Green Publishing Company Limited, 67-101.
- [6] Almodóvar, J. M., and Jiménez, J. R. 2008. "Spanish-American Urbanism Based on the Laws of the Indies: A Comparative Solar Access Study of Eight Cities." In *Proceedings of the 25th Conference on Passive and Low Energy Architecture (PLEA)*, Dublin, Ireland.
- [7] Almodovar, J. M., La-Roche, P., Ramón-Jiménez, J., and Dominguez, I. 2012. "Learning from the Past: Environmental Aspects of the Traditional Architecture of Arequipa, Peru." In *PLEA2012—Proceedings of the 28th Conference, Opportunities, Limits & Needs towards an Environmentally Responsible Architecture*. Lima, Perú 7-9 November.
- [8] Lopes-OSorio, J. M., Vizcara, G. R., and Codes, U. M. 2015. "Architectures in Transformation in Peru: Tradition and Modernity." In *Vernacular Architecture: Towards a Sustainable Future*, edited by Mileto, V., Garcia, S., and Cristini, V., 443-8. New York: 2015 Taylor and Francis Group. ISBN: 978-1-138-02682.
- [9] Ramirez, C. 2002. *Equipo AQPLAN21. Plan Director de Arequipa Metropolitana 2002-2015*. Municipalidad Provincial de Arequipa.
- [10] Lihanque, J. 2003. *Effectos de la Contaminación Atmosférica en el Clima Urbano y Calidad Ambiental de Arequipa*. Arequipa: Universidad Nacional de San Agustín. (in Spanish)
- [11] Bernedo, M. L. 1949. *A Cultura Puquina*. Ministerio de Educación del Perú, 35-49.
- [12] Alvarez, P. 2002. *La Arquitectura y la Distribución Espacial del Poblado Prehispánico de Parasca (Polobaya) Arequipa*. Universidad Católica de Santa Maria. (in Spanish)
- [13] Burga, J. 2010. *Arquitectura Vernácula Peruana: Un Analisis Tipológico*. Lima: Colegio de Arquitectos del Perú. (in Spanish)
- [14] Chamfreau, M. 1988. *La Vivenda de los Pueblos Jóvenes de Arequipa y Trujillo*. Lima: Buletin Instituto Francés. IFEA. (in Spanish)
- [15] Bustamante, R. 2006. "Similarities and Differences in Barrel Vaults of Traditional and Stately Houses in the Historic Centre of Arequipa, Perú." In *Proceedings of The Second International Congress on Construction History*, Vol. I. Queen's Colleague, Cambridge University, 461-71.
- [16] Barroso, C. K., Bastos, L. E. G., Santos, C., Niemeyer, L., Salgado, M., and Zambrano, L. A. 2012. "Princípios de Alta Qualidade Ambiental Aplicados ao Processo de Seleção de Projetos de Arquitetura: O Laboratório Nutre." *Revista Gestão e Tecnologia de Projetos* 7 (1): 73-89. São Carlos, Brazil. (in Portuguese)
- [17] Arbulú, R. 2015. IEC *Informe Económico de la*

*Construcción*. Vol. Número 5. CAPECO. (in Spanish)

Arequipa-Perú: Universidad Nacional de San Agustín. (in

[18] Pastor, P. 2014. *Historia de la Arquitectura*. Vol. 6.

Spanish)