

# DESIGNING SUSTAINABLE AND HEALTHY HOMES

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## **Abstract:**

Recent research in the field of architecture and building systems is focused on providing solutions that decrease energy consumption whilst producing less CO<sub>2</sub> emissions and providing users' comfort. These solutions include: utilising less building materials that come from sustainable and local sources, specifying more efficient lighting and home appliances, maximising the use of natural ventilation and daylight, integrating renewable energy technology and efficient heating, ventilation and air conditioning systems. However, few researchers and designers have concentrated their efforts on providing healthy and affordable built environments. The main aim of this research is to design a sustainable home with passive and active systems that could improve the health of the inhabitants of a poor Mexican town called Azumiatla (latitude: 19° N, altitude: 2,100 m, temperate climate). This community lacks of regular access to drinking water, sewage connection, toilets and rubbish collection service. A previous study have shown that houses have no daylight access or views, have minimum natural ventilation, and are built with poor thermal and acoustic materials such as cardboard sheets, steel sheets and concrete block (Mundo et al, 2010). Architectural proposals developed for Azumiatla include: local materials, walls and roof materials with good thermal and acoustics properties, "dry" toilets, green roof, vegetable garden, daylight access, natural ventilation, and energy efficient oven and lamps. Solar energy systems are considered. These proposals have taken into consideration the lifestyle and characteristics of the families in Azumiatla; and the methodology used has included the views and needs of the population.

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**Keywords:** Sustainable housing, healthy homes, low energy consumption, passive design

## Introduction

There is an evident relationship between the environment and human health due to our constant interaction with our surrounding atmosphere. It is crucial to secure a sustainable development of our natural and built environment in order to secure our wellbeing. Rubio González (2008) has stated the main factors of the environment that determine the public health of an urban population: natural characteristics and climatic conditions of the area, soil and waste impact, air pollution, water quality, acoustics, contamination by electromagnetism and smells. The same author (2008, p. 25) has grouped together all the elements that interrelate determining the health and wellbeing of a family or neighbourhood, this is shown in a figure called *Arco iris* (Rainbow) (Figure 1).

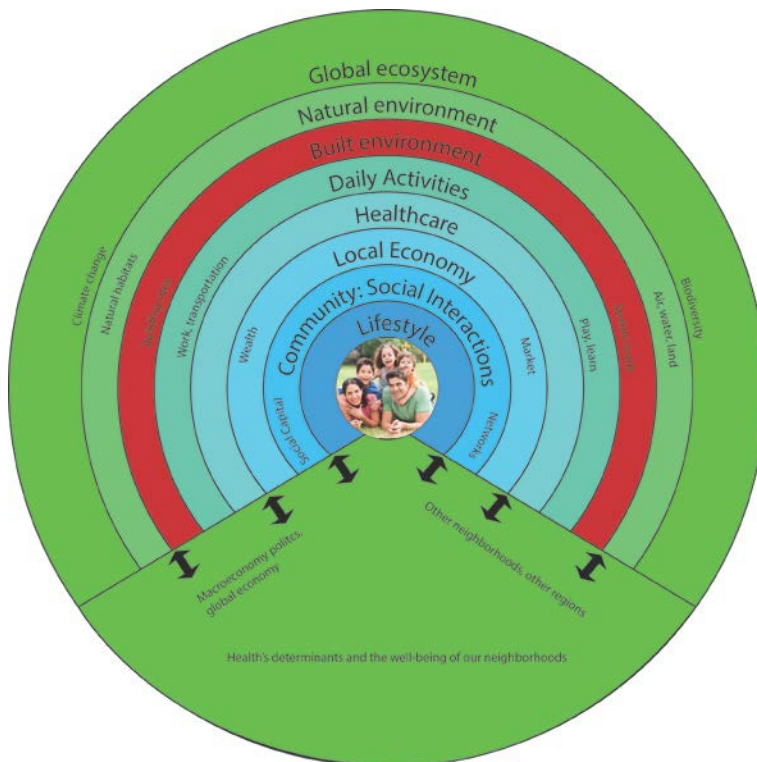


Fig. 1 Factors influencing people’s health and wellbeing in a neighbourhood (adapted from Rubio González, 2008).

The World Health Organization (WHO) has defined health as a “state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity”. And the term environmental health “addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviours. It encompasses the assessment and control of those environmental factors that can potentially

affect health” (WHO). Although the definition given by the WHO excludes behaviour not related to the environment, as well as behaviour related to the social and cultural environment, the research presented here considers all those factors and are grouped under the name Life Style.

According to Prüss-Üstun (2006) an estimated 24% of the global disease burden and 23% of all deaths (premature mortality) is caused by modifiable environmental factors. This burden is much higher in developing countries than in the developed world. Among diseases with the largest absolute burden attributable to modifiable environmental factors are: diarrhoea, respiratory infections, malaria, road traffic injuries and chronic obstructive pulmonary disease (COPD) from exposure to dust and chemicals, indoor air pollution from household solid fuel use, traffic emitted gasses and tobacco smoke (Prüss-Üstun, 2006, p. 10). Air pollution from household solid fuel use together with poor ventilation is a major problem in the community where this research is carried out. The approach followed in this study takes into account the influence on people’s health and wellbeing of behavioural, biological, social and environmental factors.

The house and neighbourhood are spaces where individuals are more influenced by environmental conditions. We spend around 90% of our time in enclosed spaces, such as: office buildings, schools, shopping centres, houses; and among those buildings, our home has the highest effects on our health, security and wellbeing, because people spend in their house around 16 hours per day (Keall, Baker, Howden-Chapman, Cunningham & Ormandy, 2010).

The World Health Organisation has stated that there are four interrelated dimensions that need to be considered when carrying out a housing analysis (WHO Europe, 2011). First, the home including psychosocial, economic and cultural aspects produced by the occupants; second, the dwelling in terms of its construction, materials and interior quality; third, the immediate built environment including infrastructure and transportation; and finally, the community which relates to the social environment, characteristics of the residents and local community services (Figure 2).

Furthermore, inadequate dwelling contributes to accidents, falls, electrocutions, fires, CO and tobacco smoke poisoning. Other relevant possible health threats to be found in dwellings are: overcrowding, indoor air quality, noise, humidity and mould growth, indoor temperatures, exposure to asbestos, lead, radon, volatile organic compounds (VOC), lack of hygiene and sanitation equipment, lack of daylight and appropriate electric lighting (Bonnefoy, 2007).

According to Bonnefoy (2007, p. 412) people “who have the least resources at their disposal suffer the worst housing conditions”. Therefore,

poverty is an important aspect to be considered when designing housing policies and programmes.

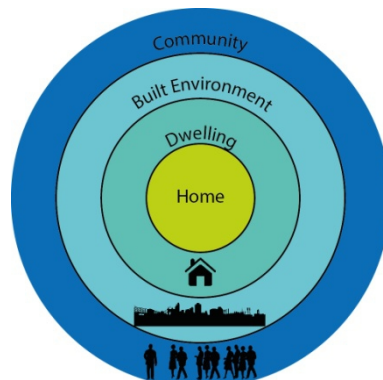


Fig. 2 The four dimensions of housing (WHO Europe, 2011).

### Case study: San Andrés Azumiatla, Puebla, Mexico

San Andrés Azumiatla (SAA) is a town located 27 Km away from Puebla’s city center. This community is part of a classification called “*Polígonos Hábitat*”<sup>82</sup>, which means that it is a town with low housing quality, lack of drinking water and drainage, and very low people’s income (less than \$55 MX pesos/day = 3.10 Euros per day)<sup>83</sup>. In Azumiatla live 8,509 people, from which 4,173 are men and 4,305 are women<sup>84</sup>. Their main economic activity is construction (46%), followed by agriculture (20%) (CECACVI, 2009). The latter explains the fact that all the houses in Azumiatla are self-built.

According to some Mexican Institutions, Azumiatla has a high degree of marginalisation evident by the following data (CONEVAL, 2010, SEDESOL, 2011, INEGI, 2010, CONAPO, 2010): Illiterate population older than 15 years old: 38%; Population with no access to public health care services: 98%; Houses with no flooring material: 34%; Houses with no toilet: 76%; number of houses without water supply: 13%; Houses with no sewage system: 84%; Houses without electricity supply: 2%; Houses without

<sup>82</sup> *Polígono Hábitat* is a territorial classification made to identify poverty according to inhabitants’ income, housing, clothing and transport characteristics for each member of a family (CONEVAL, Mexico, 2010).

<sup>83</sup> Ministry for Social Development, *Polígonos Hábitat*. Plan Municipal de Desarrollo 2008-2011, Ayuntamiento de Puebla, Available at: <http://www.pueblacapital.gob.mx/joomla/images/contraloria/pdf/Final.pdf> (last visit: 22.11.13). p. 2:6. Currency conversion. Banco de México. Available at: [http://www.banxico.org.mx/portal-mercado-cambiario/index.html?utm\\_source=feedburner&utm\\_medium=feed&utm\\_campaign=Feed%3A+BancoDeMexicoTipoDeCambioEnDlaresDeLosEeuuafix+%28Banco+de+M%C3%A9xico%2C+Tipo+de+cambio+en+d%C3%B3lares+de+los+EE.UU.A.+%28FIX%29%29](http://www.banxico.org.mx/portal-mercado-cambiario/index.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+BancoDeMexicoTipoDeCambioEnDlaresDeLosEeuuafix+%28Banco+de+M%C3%A9xico%2C+Tipo+de+cambio+en+d%C3%B3lares+de+los+EE.UU.A.+%28FIX%29%29). (last visit: 24.06.14).

<sup>84</sup> Inegi. Censo de población y vivienda 2010. Puebla Gobierno Municipal. Available at: [www.inegi.org.mx](http://www.inegi.org.mx) (last visit: 13.05.14).

washing machine: 93%. Other problems found in Azumiatla´s dwellings are: lack of natural ventilation, lack of daylight access and views, lack of sewage and toilets, construction materials with low thermal and acoustic properties (Figure 3), waste management, there is usually only one room for families of 5 and 6 people, and in exterior areas there is a mix of uses including space for domestic animals, playing area for children, laundry and rubbish collection (Figure 4) (CECACVI-FEBUAP, 2009. *Instrumento de valoración comunitaria con enfoque de sistemas*; Mundo-Hernández, Valerdi, Hernández, Sosa & Rugerio, 2010).



Fig. 3 House in Azumiatla built with cardboard, it has no windows.



Fig. 4 Exterior areas of a house in Azumiatla.

## I

The methodology developed for this study is intended to be applied in future studies. It contains a social approach with a significant consideration of health issues. This study has been designed under the premise of the influence of the built environment on our health and mood. Several studies have raised the importance of the Sick Building Syndrome

considering it as a cause of people discomfort, illness and work absenteeism (Rubio-González, 2008; Silvestre & Bueno, 2009; Bueno, 2009).

The figure below shows the different phases of the research and design process of the homes proposals developed in this study. The last two stages have not been carried out yet.



Fig. 5 Methodology developed for this research.

Five different house proposals were developed. Each of them were intended to fulfil the following design objectives:

1. Use of local construction materials
2. Reduce the environmental impact of the building
3. Take advantage of the climate characteristics
4. Maximum use of daylight, but preserving the use of small windows for privacy
5. Use of native and adaptive vegetation
6. Consider users lifestyle and traditions
7. Collection and use of rainwater
8. Low maintenance house
9. Use of renewable energy
10. Users must be able to build the house by themselves.

The selected home proposal included these characteristics:

1. Use of Tecno-adobe material for walls (manufactured locally with zero CO<sub>2</sub> emissions; good thermal and acoustics properties, no need of finished material);
2. Use of “dry” toilets which use zero water;
3. Treatment of grey water for irrigation;
4. Separate rooms for parents and children;
5. Bathroom integrated into the house;
6. Living area and bedrooms are oriented due S and SE for more thermal comfort specially during winter;
7. All rooms have windows for direct daylight access and views. Indirect lighting from upper windows lit the main interior corridor;
8. Cross and one sided ventilation is used in every room. Stack effect is used for ventilating the living-dining area;
9. Vegetables garden;
10. Green roof for thermal and acoustic control;
11. Special areas are included in the design that comply with people’s life style and traditions: praying altar, corn storage, pigs and goats area;
12. Rubbish separation area;
13. Rainwater collection from the roof to use it for irrigation;
14. Integration of solar and PV panels for water heating and electricity production (not visible in the image).

The house project was presented to some people from Azumiatla and to one family that was selected based on their current home location, which is within the area studied in this project and it is close to the main road for easy access of construction materials, and also because of the family size and characteristics: seven people living in one room. The family agreed to participate in the study and let the research team to measure their land and their current home, which will be included in the project. Part of the sustainable approach of this project is to use existing built infrastructure and buildings.

Images below show the first proposals developed (Figures 6-9) and the final proposal (Figures 10-12).



Fig. 6 Home proposal no. 1: small windows for privacy, green roof, exterior areas, stack effect for natural ventilation.





Fig. 7 Exterior and interior view of proposal no. 2: use of adobe, circular plan, big windows.



Fig. 8 Views of proposal no. 3: big windows, more modern design, use of adobe, ventilation trough roof opening in corridor.

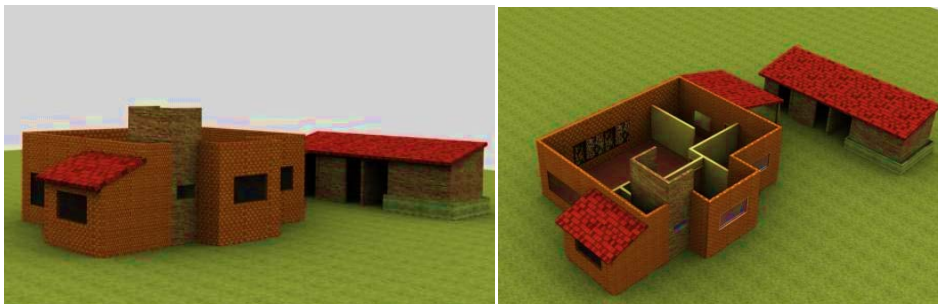


Fig. 9 Views of proposal no. 4: use of recycled pet bottles in some walls, use of adobe and stone, and tiles on roof.



Fig. 10 Exterior and interior views of the final proposal.



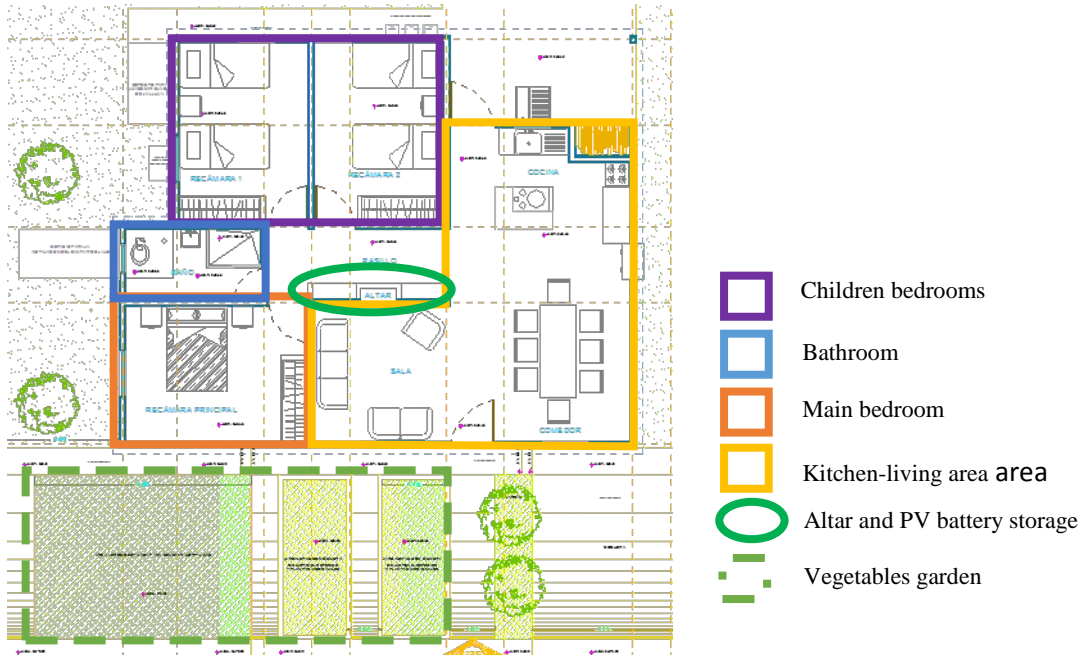


Fig. 11 Plan of Azumiatla’s Home Project.

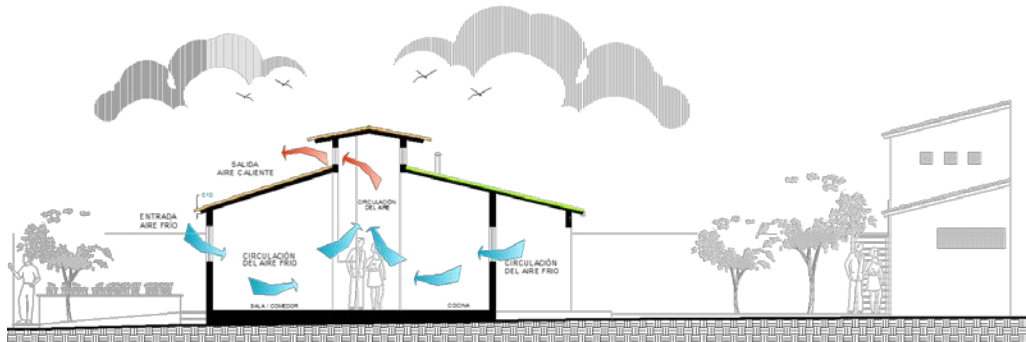


Fig. 12 Section showing natural ventilation strategy.

The final house model is intended to be built by the people from SAA, since their majority are construction workers. In addition, people from Azumiatla own large land areas, which is usually divided among their children once they get married. Therefore, the budget calculated for the construction of this house excludes construction labour and land cost. This house could be built with \$145,000 Mexican pesos, approximately 8,170 Euros<sup>85</sup>. This represents an affordable house solution, even for people with

<sup>85</sup> Currency conversion: 17.74 Euros per one Mexican peso. Banco de México. Available at: [http://www.banxico.org.mx/portal-mercado-cambiario/index.html?utm\\_source=feedburner&utm\\_medium=feed&utm\\_campaign=Feed%3A+BancoDeMxicoTipoDeCambioEnDlarsDeLosEeuuafix+%28Banco+de+M%C3%A9xico%29](http://www.banxico.org.mx/portal-mercado-cambiario/index.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+BancoDeMxicoTipoDeCambioEnDlarsDeLosEeuuafix+%28Banco+de+M%C3%A9xico%29)

low income. In addition, currently there are some government programs that provide economic support to people from non-developed communities, to help them build their home or to improve their existing house or community infrastructure<sup>86</sup>.

Designing and building “healthy homes” involves more than only an adequate and comfortable physical dwelling, it also involves other factors such as creating an adequate housing environment where the occupants feel protected and able to develop social integration activities. Furthermore, the home and dwelling must be analysed within their context, where the residential setting should cover all minimum habitability standards and shall fulfil all the residents’ expectations (Bonney, 2007). Hence, the proposals presented here represent only one section of the whole environment that influences the health and wellbeing of an individual or family. Future work includes a study of current infrastructure, and the condition of the built and natural environments of SAA; this in order to recommend actions to improve infrastructure and community services.

## Conclusion

Current architectural design must include concepts that were put aside during the past century but were widely used before, especially in vernacular architecture. Those concepts such as natural ventilation, the use of daylight, thermal mass, solar protection, evaporation, insulation, climate characteristics, etc., all form what we call now a passive house or in general bioclimatic architecture. Designing and building this kind of architecture is now compulsory for all building professionals, and it soon would be required by all clients. Green building rating systems, such as LEED, are playing an important role in the construction industry. Buildings reaching a LEED certification become a sustainability reference among the industry, and also among their own commercial colleagues or competitors and public in general. Moreover, housing design should focus on producing healthy homes and communities, together with education and environmental programs that promote healthy lifestyles (Hernández-Alvarez, 2012).

The United Nations Member States have defined housing as *adequate shelter* involving: adequate privacy, adequate space, physical accessibility, adequate security, security of tenure, structural stability and durability,

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<sup>86</sup> The Mexican Ministry for Social Development (SEDESOL) has implemented programs such as *Habitat* and *The Program for the Development of Priority Regions*. Available at: [http://www.2006-2012.sedesol.gob.mx/es/SEDESOL/Programa\\_para\\_el\\_Desarrollo\\_de\\_Zonas\\_Prioritarias\\_PDZP](http://www.2006-2012.sedesol.gob.mx/es/SEDESOL/Programa_para_el_Desarrollo_de_Zonas_Prioritarias_PDZP) (last visit: 26.06.14).

sufficient lighting, heating and ventilation, access to water supply, sanitation and waste management facilities, suitable environmental quality, and accessible location with regard to work and basic facilities. All of them should be available at an affordable cost and must take into consideration local cultural, social, environmental, economic and gender or age-specific factors (Bonney, 2007, p. 413).

Developing countries with low quality housing stock should seek for solutions that are environmentally friendly but also user friendly. The latter includes designing comfortable and affordable houses that respond to people's needs, beliefs and traditions. Therefore, home design must be flexible enough to adapt to families' changes and characteristics, as well as to climate conditions. In addition, housing design must consider users' views and ideally, future occupants should be involved during the design, construction and operation processes. This also applies for building contractors and building services engineers.

In temperate climates, such as Central Mexico's, passive homes with integrated renewable energy systems are today's solution for achieving low energy consumption houses, and more comfortable and healthy home environments. Despite Mexico's high solar radiation availability, solar energy is far from being harvested to its full potential. Government policies are changing towards achieving a better use of our solar potential, but unfortunately this is happening very slowly.

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