Executive summary

VULNERABILITY OF BAMBOO HOUSING TO CLIMATE CHANGE in the Coast of Ecuador

The onset of climate change and its consequences demands that governments, institutions, and all types of bodies formulate a set of objectives, strategies, and mechanisms to establish plans and programs which improve adaptation to climate change, as well as mitigate its effects.

Existing bamboo housing in the world, most of which is inhabited by low-income families, is not immune to the threat of climate change, which presents a high level of risk to the material itself and to the well-being and livelihood of its occupants.

Bamboo housing present common deficiencies and risks, so this document strives to make it possible to define the problems related to this kind of housing and their effects, in order to provide effective solutions to the process of adaptation to climate change and to reduce or eliminate traumatic effects for users.

This document, which is the result of specific observations and proven technical methods, is aimed at offering solutions regarding potential sources of harm which could arise from different causes.

The Eloy Alfaro de Manta University published an “Analysis of the Main Natural Phenomena Recorded in the Province of Manabí”, which contains information about the causes and effects related to different El Niño phenomena, and which, together with the study "Second National Report on Climate Change", from the GEF/UNDP/Ministry of the Environment Project (2011), were the studies which addressed the natural and human causes which affect the vulnerability of buildings.

Water, in the form of intense rainfall, is the origin of disasters such as landslides, flooding, and so on, which result in loss of life, crops and animals, and the destruction of homes, bridges, and roads. These problems contribute to the damage caused to housing as does the wind and other lesser phenomena.

The purpose of this document is to be not just a manual, but an instrument of discussion, where the proposed solutions are enriched by the experiences and know-how of the rural and suburban communities of Ecuador and other countries.

CONTEXT

Upon observation of the results of the analysis, first by classifying the regions and their provinces and then by the capitals of each province with the highest number of bamboo homes, the following is noted:

- Regarding the percentage of bamboo houses in the censuses of 2001 and 2010: In the coastal provinces, the increase in bamboo houses goes from 87.04% to 93.16%, whereas in the mountain provinces, the percentage of bamboo houses went down from 11.25% to 5.6 %.

- Regarding the number of bamboo houses in Guayaquil and Portoviejo, cities which in both censuses showed the highest number of bamboo houses: Guayaquil saw a percentage increase from 39.8% to 60.2%, that is a total increase of 20.4%. Whereas Portoviejo saw a decrease from 52.6% to 43.4%, which is a reduction of 9.2%.

- The city which has the highest number of bamboo houses is Guayaquil, with 60,521 houses, which means that around 302,605 people not only live in poverty, but at risk, due to the fact that most of these houses are dangerous independent constructions.

- The province with the highest number of bamboo houses is the Province of Manabi, which according to the census of 2001 had 93,550 houses, which went down to 88,744 in 2010. During the same period, the Province of Guayas had 87,945 houses in 2001, which went up to 135,087; i.e. there has been a significant increase in the number of bamboo houses in the Province of Guayas.

- In terms of the total number of bamboo houses in all the provinces of Ecuador, the last census revealed that the country had 329,416 bamboo houses, which meant that around 1,647,080 Ecuadorians lived in this kind of house. However, two years after the last census we can use mathematical extrapolation (taking into account population growth rates), and assume that, as of the date of this study, there are around 378,828 bamboo houses, which means approximately 1,894,140 people live in them, most of whom are at risk, due to persistent threats and vulnerability.

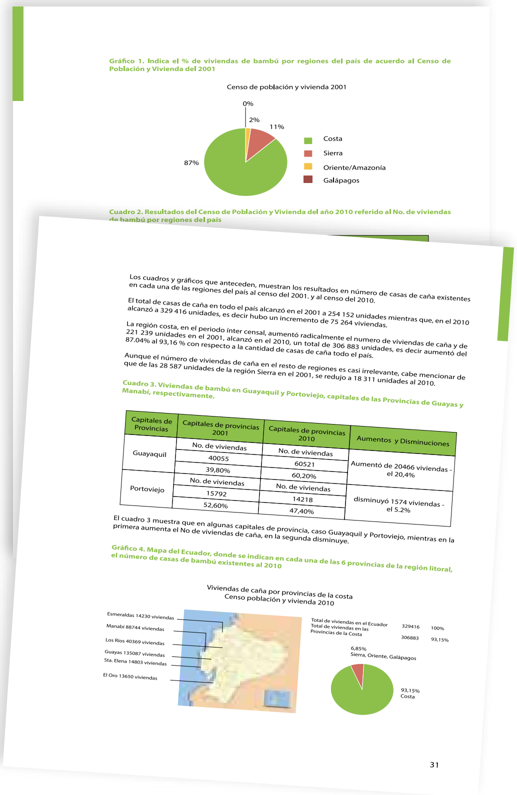


Gráfico 1. Indica el % de viviendas de bambú por regiones del país de acuerdo al Censo de Población y Vivienda del 2001

Censo de población y vivienda 2001

0%
2%
11%
87%
Costa
Sierra
Oriente/Amazonía
Galápagos

Cuadro 2. Resultados del Censo de Población y Vivienda del año 2010 referido al No. de viviendas de bambú por regiones del país

Los cuadros y gráficos que anteceden, muestran los resultados en número de casas de caña existentes en cada una de las regiones del país al censo del 2001. y al censo del 2010.

El total de casas de caña en todo el país alcanzó en el 2001 a 254 152 unidades mientras que, en el 2010 alcanzó a 329 416 unidades, es decir hubo un incremento de 75 264 viviendas.

La región costa, en el periodo ínter censal, aumentó radicalmente el numero de viviendas de caña y de 221 239 unidades en el 2001, alcanzó en el 2010, un total de 306 883 unidades, es decir aumentó del 87.04% al 93,16 % con respecto a la cantidad de casas de caña todo el país.

Aunque el número de viviendas de caña en el resto de regiones es casi irrelevante, cabe mencionar de que de las 28 587 unidades de la región Sierra en el 2001, se redujo a 18 311 unidades al 2010.

Cuadro 3. Viviendas de bambú en Guayaquil y Portoviejo, capitales de las Provincias de Guayas y Manabí, respectivamente.

Capitales de Provincias	Capitales de provincias 2001	Capitales de provincias 2010	Aumentos y Disminuciones
Guayaquil	No. de viviendas	No. de viviendas	Aumentó de 20466 viviendas - el 20,4%
	40055	60521	
	39,80%	60,20%	
Portoviejo	No. de viviendas	No. de viviendas	disminuyó 1574 viviendas - el 5.2%
	15792	14218	
	52,60%	47,40%	

El cuadro 3 muestra que en algunas capitales de provincia, caso Guayaquil y Portoviejo, mientras en la primera aumenta el No de viviendas de caña, en la segunda disminuye.

Gráfico 4. Mapa del Ecuador, donde se indican en cada una de las 6 provincias de la región litoral, el número de casas de bambú existentes al 2010

Viviendas de caña por provincias de la costa
Censo población y vivienda 2010

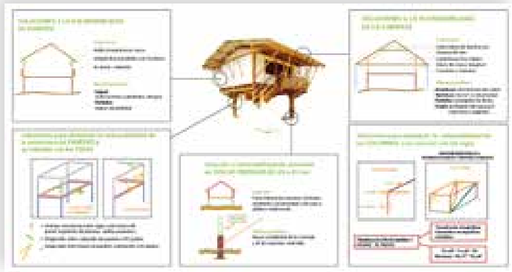
Esmeraldas 14230 viviendas
Manabí 88744 viviendas
Los Ríos 40369 viviendas
Guayas 135087 viviendas
Sta. Elena 14803 viviendas
El Oro 13650 viviendas

Total de viviendas en el Ecuador 329416 100%
Total de viviendas en las Provincias de la Costa 306883 93,15%

6,85%
Sierra, Oriente, Galápagos
93,15%
Costa

31

Soluciones



VULNERABILITY OF ROOFS

SOLUTION 1.

REDUCTION OF THERMAL CONDUCTIVITY:
Attach a suspended ceiling to the roof structure, formed by a layer of bamboo shavings, such that a 5 to 10 cm wide space is formed between the roof and bamboo shavings, called an air cushion.

SOLUTION 2.

NOISE REDUCTION (acoustic problems): In light of strong and intense rain, and to avoid the noise it causes on metal roofs, the proposals will look to reduce the noise made by the rain.

SOLUTION 3.

USE ROOVES WITH EXTENDED EAVES ON ALL FOUR SIDES: It is important to build with eaves which are at least between 1 m and 1.2 m long. Extending the eaves will stop water falling from the roof to affect the walls, and they will also provide shade to protect the house from the sun.

SOLUTION 4.

USE GUTTERS AND DOWNPIPES: The use of water collectors along the lower edges of the roof and installing downpipes for rainwater will counteract the negative effects of the water.

SOLUTION 5.

PROPER FASTENING OF THE ROOF: In order to avoid zinc roofs becoming fully or partially detached, three things need to be done:

a) Fasten the zinc panels to each other, using wire fasteners that tie the four corners of each panel to neighbouring panels.

b) Use hooks or zinc nails to fasten each of the panels to wooden strips or belts that are part of the roof support structure.

c) Fasten the ends of the roof to the supporting structure of the house using steel rods. This type of arrangement can also be used if there are structural elements such as beams or columns under the roof.

The increase in range will result in water being drained faster and it will fall to the ground at a higher speed, causing indentations and puddles in the ground. In all cases it is important for the angle of the roof to also have a water collection gutter and corresponding downpipes.

The type of plate or zinc should be based on which has the deepest grooves

Orientation of the rooves: larger rooves should be oriented from east to west to reduce the amount of time exposed to the sun.

The roof should be kept clear of dust, and be shiny or white. This will reflect the sun more without absorbing too much heat.

SOLUTION 7.

PHYSICAL PRINCIPLES FOR IMPROVING INTERIOR TEMPERATURE: Passive solar design principles with simple application of the thermosyphon effect will allow hot air to be displaced and cold air to enter, creating a constant breeze inside the house.

VULNERABILITY OF WALLS

Bamboo walls, and in particular outer or edge walls, are the ones most affected by the rain and damp in the winter, and by the dust during summer or drought periods.

SOLUTION 1.

PROTECTION OF WALLS AGAINST THE IMPACT OF RAIN: The most vulnerable parts of the walls in the event of rain are the lowest parts of the wall; that is, from floor level up to 1.2 m.

In the aforementioned areas and around the whole outer perimeter of the wall, it is important to apply a 1 cm layer of a sand-cement mortar. This layer should be applied on a wire mesh attached to the bamboo wall with wire ties.

SOLUTION 2.

PROTECTION OF WALLS AGAINST VECTORS: The remaining outer walls, from 1.2 m up to the roof, should be lined on the inside with a mosquito-resistant mesh. Ensuring that:

- Mobile wood or bamboo frames are placed around the windows, protected by the same nets.
- Interior walls or divisions should have an opening at the top for two reasons: use electric light for two rooms and allow air to circulate.
- Walls with air cushions avoid thermal transfer caused by the sun's rays.

VULNERABILITY OF FLOORS

Floors in bamboo houses are generally made from soft woods (also called formwork wood), given the impossibility of using hard woods due to their costs and dwindling availability.

SOLUTION 1.

FLOOR WITH BAMBOO STRUCTURE: This alternative comprises the following elements:

a) Round bamboo elements which form part of the structure as strings or supportive floor beams (fig. 1).
b) Two layers of bamboo shavings, secured by bamboo joists which work as the floor (fig. 2). Alternatively, the bamboo shavings can be used to make a mat.
c) Sand-cement mortar covering over the metal mesh which works as an extra floor layer. (fig. 3).

The bamboo joists or ties are 0.35 m apart between axes.

The bamboo shavings, in two layers arranged at right angles, are attached to the bamboo.

The top floor layer consists of a sand-cement mortar placed over a metal mesh. The bamboo sections and shavings should be dry and preserved. The thickness of the sand-cement mortar should not be more than 2.5 cm.

VULNERABILITY OF THE SUPPORT STRUCTURE

SOLUTION 1:

USE OF COLUMN FOUNDATIONS: It is absolutely necessary that all of the columns have a good foundation. This way, the loads of the building are arranged more evenly and the columns can interact mechanically with each other.

- The ground must first be prepared; to do this stones which are at least 15 cm in size will be introduced in the excavation, on top of which the well-compacted ballast should be placed.
- Seal the foundation level with a layer of sand-cement mortar, in the ratio of 3 measures of sand for every 1 of cement (in volume). This layer is called the "bed" and it should be at least 5 cm thick and levelled out.
- On top of the bed there should be a base or plate anchored to the base of the reinforced concrete column (the dimensions and design of the plate and column depend on the design load).
- The reinforced concrete column must rise above the flooding level by at least 30 to 40 cm.
- A fastening element will be used to anchor the bamboo that will form part of the floor support beams. Do not introduce the bamboo into the concrete column as this will destroy the bamboo.
- The lower section of each column will be fastened to the bases of the other columns using joists, which will contribute to improved stability for the building.

SOLUTION 2:

STABILITY OF THE STRUCTURAL SYSTEM OF PILLARS ANDBEAMS:

- Beams and diagonal elements to aid equilibrium between vertical and horizontal elements. It is important to add the rigidity of the components of the set by forming triangles with bamboo or wood elements, both in the pillar and beam places. Example: A to B, just like for the ends or vertices of the opposite planes, for example from C to B.
- In the upper vertices between pillars and beams, or between concurrent beams, it is possible to install small elements that add rigidity such as the D bars.

- When the structure is treated this way, it leads to isostatic equilibrium, which allows it to resist lateral forces from earthquakes or landslides from flooding.

SOLUTION 3: THE VULNERABILITY OF WALLS AND THEIR RELATIONSHIP WITH BEAMS:

- Join the panel structure to the floor and beams using metal elements such as steel rods.
- Place diagonal wood sections across the top of the corner panels, in order to fasten them to each other. A small bracket or diagonal steel plate that can secure the two panels will aid stability.
- Place diagonal elements in each panel, to fasten them to other panels as well as the vertical structure and the floor of the house.

VULNERABILITY OF THE LAND

SOLUTION 1.

LAND PRONE TO FLOODING: The most vulnerable points in this type of housing situated in land prone to flooding for short periods and shallow depths are the vertical structural supports. The solution is to replace said supports or columns with damp-resistant supports.

Materials which are resistant to damp and are durable include concrete and hardened plastic. If sized correctly, these kinds of supports could be buried and surpass the flood level.

On top of said supports, it is feasible to build with bamboo, as long as continuity and a strong joint between the two materials can be guaranteed.

Concrete has the following disadvantages: the cost, manufacture, installation, and weight; whereas the only drawback for plastic supports is the cost.

SOLUTION 2.

LAND AT AN ANGLE: Possible solutions to this particular problem include:

- Longer eaves
- Water collectors or drains, situated on the lowest part of the rooves, to collect rain water.
- Water-gathering channels on the steepest incline and on the lowest one.

These channels made from blocks or soil-concrete, will allow water to be collected from the pipes which bring the water down from the roof and from the upper parts of the incline, which will help to redirect the water sideways towards larger water collectors or gutters and drains in the street. This solution requires commitment and people to work as a community.

SOLUTION 3.

IN PERMANENTLY FLOODED LAND: The technical solutions range from hydraulic filling to housing designs on HA platforms, but which require the installation of services including water, power, communication, and drainage. Both solutions are technically feasible.

The first costs less that the second, however, considering the economy in these countries, it would be better to relocate the population to less vulnerable and therefore more suitable locations.

MEASURES FOR ADAPTING TO CLIMATE CHANGE

Incorporation of design elements and improved construction techniques adapted to the context of the houses.
Name of the measure: Improvement of wood and bamboo low-cost housing in the coast of Ecuador and Peru.
Purpose of the measure and main actions involved: Increase the resiliency of families who live in areas with a high risk of flooding and landslides in the coast of Ecuador and Peru.

- Action 1. Construction of prototypes of improved housing in rural and suburban areas.
- Action 2. Incorporate improved construction designs and techniques in the institutional approach of construction companies or initiatives which promote social housing.
- Action 3. Improve the level of expertise in the local construction sector (qualified labourers) in order to improve the construction techniques for wood and bamboo houses in the coast of Ecuador and Peru.
- Action 4. Creation and presentation of an improved construction standard for housing using wood and bamboo which has been adapted to climate change. This standard has been presented to the national committee which is responsible for writing the construction regulations in Ecuador. In the case of Peru the standard was approved and has been published in the official registry.

INBAR
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This executive abstract is a summary of the Study of Vulnerability of Bamboo Housing to Climate Change in the Coast of Ecuador.

Created by architect Jorge Morán Ubidia as part of the Project "Optimisation of Low-Cost Bamboo Housing to Adapt to Climate Change in the coastal regions of Ecuador and Peru" with financing from the European Commission.

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Quito, November 2014