Social aspects of Green Technology - Bamboo construction cases.

Paula Regina da Cruz Noia\textsuperscript{a}\textsuperscript{*}.

\textsuperscript{a}Faculdade de Arquitetura e Urbanismo da Universidade de São Paulo- FAU USP, Brazil; paula.noia@usp.br

*Corresponding member

ABSTRACT

Over the last years, a great variety of construction materials, systems and technologies have been developed over the world and the preoccupation about sustainability issues related to the field have become compulsory. Research had been developed concerning innovation assuming environmentally friendly characteristics of those materials, systems and technologies; however, few had been discussed about the social issues of sustainability. It must be taken into account that sustainability includes not only environmental, but also economic and social aspects, and the latter has direct implications on the well being of society. The actions aiming this goal should be based on historical and cultural values and in the relationship between citizens and nature. In the case of this research, we will analyze on the social perspective, the benefits that an unconventional material like bamboo can bring to specific contexts where it is implemented, through the study of selected cases. The buildings, based especially on local production process, in areas where this constructive culture is consecrated, and with regional manpower can be identified as a large contribution initiative from the social development perspective, in addition to the clear environmental and economic benefits. Thus, the research aims to elucidate the importance that this process in the production autonomy, representing a great user domain and an important vehicle of engagement of social inclusion projects and manpower training.

KEYWORDS: bamboo, social sustainability, sustainable construction, bamboo housing.

1. Sustainability and Green Technology

The definition of sustainability has a multidimensional character, in which economic, environmental and social issues should be worked out to ensure a better context understanding. Such status brings to the term the challenge of complexity in the development and follow-up evaluation systems. Overall, most of the researches conducted on the subject refer only to two dimensions: economic and environmental, neglecting social issues inherent of the issue [1].

In the green technology context, a broad view of the concept is needed, which includes definitions of consumption and production chain, with its contextual causes and consequences. The term sustainability tends to highlight a strong environmental concept, advocating the preservation of the
current development. In general, the perspective of the production chain in this view is a one-way flow system, where material support on a one-way movement, through consumption to disposal [2].

The systemic view of sustainability seeks a cyclical concept, questioning the concept of "cradle-to-grave" and suggesting the use of the term "cradle-to-cradle" according to theorists like Edwards and Bennett (2003) Henn and Fava (1994), Kibert (2003) and McDonough Braungart (2003) [1].

There are also the need to consider the existing variables in different contexts, as the developed and developing countries. Indexes, goals and sustainability requirements are distinct, as placed here:

"[...] The production and consumption patterns of the 'North' countries is perceived as being the desirable ideal for all human life on Earth. We are not all the same, [...] We do not have the same base material. [...] We are therefore potentially different in our needs, dreams and desires. All this, however, is denied by those interested in keeping us deluded" [3].

Sustainability can be seen as a balance point, and sustainable development is the way for its achievement. In this logic, sustainable or green construction can be defined as a holistic process that seeks to restore and maintain harmony between the natural and the built environments and create settlements that affirm human dignity and encourages economic equality [4].

Thus, green or sustainable building seeks the balance between the three concepts mentioned in order to maximize the beneficial social and economic effects while minimizing negative environmental impacts. Concepts such as "environmental protection", "economic efficiency" and "social equity" are increasingly consolidated, with numerous consequent implications.

Fig 1 – Diagram of economic, social and environmental demands. [5]
2. Social aspects of green technology

Technology can be defined as the set of the technical terms of an art or a science or as the science of processes transformation by man's work [6]. From the industrial revolution, the technology becomes the only progress indicator of a society, so that technological determinism defines and associates that social development emerges spontaneously from technological development. However, many neo-Marxist thinkers criticize this theory, claiming that technology and social models support each other materially and ideologically. Thus, the nature of technology developed by a society is made through their relationship with production models. Therefore, technology can contribute both to develop and to stagnation and decay of a society [7].

In the specific case of construction technology, this is not just a technology created in response to a society demand, but also has the potential to define a future society. In any environment, culture and work related to construction reflects not only the local development strategy, but also local characteristics, aesthetic preferences, climate, technical, financial, cultural, historical, and other settings [8].

Technology development is identified as an opportunity to generate employment, income and improvements in living conditions of the population, contributing to their social development. Usually this kind of work establishes dynamic organization and involvement in the process. The recognition of political leadership, support for small entrepreneurs are important local autonomy mechanisms [9].

"(...) Issues as employment generation, justice in the workplace, health and safety are discussed, as well as greater participation of workers in decision-making. All this tends to be seen increasingly as an opportunity for training and achievement." [1]

Thus, the development of building technologies are increasingly related to social aspects. The main challenges, actions and strategies for the development of building technologies for social development, are:

• maintaining decent work;
• the establishment of health care, safety and good working conditions;
• commitment to improving environmental quality;
• promoting environmental education;
• promoting sustainable development in the construction industry;
• the participation of government social projects;
• encouraging "socially inclusive" motions;
• producing maintenance manuals for buildings and systems users;

In such a way, industry outlines major opportunities in organization process, with the establishment of strategies that generate new products focused on the optimization of human and material resources. The mobilization of these resources to support research and feasibility studies of new technologies undergoes major coordination problems. Contrary to what is widespread, most limiting factor generally
is about the lack of management of these factors, and not the lack of financial resources. The presences of private and academic sphere are important so that these resources can be harnessed and directed to initiatives in the construction sector. Funding of research and development activities can be shared by all spheres as well as the development time of technical issues can be reduced if there is intersectoral this building [4].

A successful example that includes the characteristics described above is the Ibero-American Program of Science and Technology for Development (CYTED). It is an international and multilateral program of scientific and technological cooperation that facilitates technology development and innovation through the coordination and cooperation of institutions like the University, research and development centers and innovative businesses. The program contained an initiative of a subprogram called HABYTED, which specifically dealt with the social housing in Latin American countries. Applied research to innovative materials and techniques has also extended to the social policies of the participating countries.

A new development concept emerges in developing countries, which focuses on meeting basic human needs and well-being as a way for achieving socio-economic organization. For such a effective development concept, it is necessary that decisions taken represent the real aspirations of the population and not the interests of a production based on capitalist structure of private benefit.

In developed countries, goods production is based on the consumption stimulus and circulation of goods in short time. Though the basic demands are already covered, the consumer society moves the search for innovations. However, in developing countries the process is slightly more complex. In such case, the society is divided between a small wealthy layer and a large layer working sector, producing raw material of much lower wages, of which the upper layer is dependent. Similarly, the technology is also divided: a part that is mainly used by rich layer, imported from industrialized countries and traditional technology produced empirically by less favored class and passed orally through the generations. This disparity further accentuates the duality between rich and poor.

The creation of a specific methodology for the development of technologies that benefit the local development should identify among the needy population existing social needs improvement, checking the existing traditional solutions and ways of improving it by modern science.

Industry, on the other hand has a important socio-economic role, once it can in all its facets, enhance social sustainability. Construction process, especially because of its labor-intensive nature of its activities, is a opportunity for poverty alleviation.

"The construction industry (in its narrow definition) is the largest industrial employer in the world with 111 million employees worldwide. Of these, 74% are in the low-income countries. Since low-income countries produce only 23% of the global construction output, it is clear that the "employment intensity" of construction activities is much higher in low-income countries than in the high-income ones." [4]

In this sense, the impact on local communities can be quite significant, and the major social impact is undoubtedly on the workforce. The construction industry offers much needed employment for a large
number of the world’s poorest people. In developing countries construction work provides a traditional point of entry to the labor market for migrant workers from the countryside [10].

According to Wells [10], and socially speaking, economic activities have impacts in society in three important ways:

- who is involved: workforce;
- where it takes place: local community;
- what is involved: wider global community.

Architecture, engineering and construction community can do much to promote these principles in the developing world. For working in those countries it is necessary to commit themselves to socially responsible business. In this context, responsibility seems to make more sense in this context than sustainability. Many companies started adopting the principles of Corporate Social Responsibility (CSR), even if there is still little agreement as to what this actually means in practice. It is important to assume that, social responsibility is about minimizing the negative and maximizing the positive effects economic activity has on people and society.

It is important to mention that those practices are not costless. Many of the practices promoting worker's rights and protection have a high cost involved, but these are intended to be recouped in longer term through productivity gains. Governments and international financing institutions plays a major responsibility in this task, encouraging socially responsible business practices that promote and protect workers rights in accordance with the ILO Declaration on Fundamental Principles and Rights at Work [10].

Sustainable bookmarks plays important role in the evaluation of construction practices. According to Häkkinen [11], their purpose are:

- to define sustainability criteria precisely;
- to measure construction industry and built environment performance;
- to enable decision makers to evaluate economically and technically feasible strategies to improve quality of life;
- to enable actors in the construction and development process using tools and guides based on indicators to improve practice and the quality of construction.

To investigate all these methods is important for a multidimensional view of the concept since there is a clear emphasis on environmental issues on the theme. Strand and Fossdal [12], when analyzing the laws, regulations and standards on sustainable buildings, note that the development of indicators deals only with certain aspects: "The socio-economic in particular receive any attention". Although one of the sustainability features, discussion of multidimensionality is still segregated to a conceptual approach, and rarely addressed in the strategies, the most general to the specific. Even if today there is a greater understanding in conceptual level about the need to integrate policies for development and the environment, there is still a large gap between rhetoric and practice.
Technology development, even when applied in a specific context, is not enough for a considerable sustainability change in the industry scenario. It must be seen as an opportunity of qualification and achievement. For that, it is necessary involving the actors in participation policies. The context complexity demands a real multi-dimensional approach, enabling greater transparency in the decision-making process and the expression of system operation. Sustainability is inherent to the place because the data used are specific to a place, and also because the perception of "gain" or "loss" can be interpreted in different ways other contexts. Technology isolated does not present great opportunity to practice sustainability, but it does when related to other stages of the process.

User participation is an important work to reduce prejudice and rejection of native techniques, that symbolizes primitivism, underdevelopment and poverty [4]. The origin of this behavior is associated with the colonial period, with the imposition of building codes and planning concepts of the colonizing countries. It is necessary a balance in the use of global building materials (cement, steel, aluminum, glass) and local ones (brick, cement ground, local wood, bamboo and other renewable products).

Green products are usually made from environmentally friendly raw materials that reduce environmental impacts during construction, renovation or demolition and reduce also the environmental impacts of the use of the building, contributing to healthy environment. Besides that, some of those are also socially sustainable as bamboo.

3. Bamboo construction

The great production capacity of bamboo add to its easy cultivation, producing, harvesting, transporting and handling makes the bamboo an interesting material for the construction sector. Its ancient use and popular character make it present in most constructive cultures of the world, especially in Eastern countries such as Indonesia, India, China and Japan. In the Americas, during discovery period, Spanish labeled the presence of vast forests of giant bamboo. Most of these forests were then distributed over southern Mexico, Central America, South America and northern Argentina, indicating the existence of settlements exploring the use of bamboo in all its vastness. The set of descriptions indicates the regions of Central America, Colombia and Ecuador as the regions where bamboo culture in construction is still manifested in America, making them today reference countries in bamboo technology.

While crop, the bamboo culture has significant advantages. It is a perennial and highly renewable tropical plant well adapted to most developing countries. Its production has an important role as environmental protector, alleviating timber exploitation, recovering forests, containing soils and preventing erosion. According to Pereira and Beraldo [13], bamboo is a renewable material with low production cost, time low of renovation and major annual yield per unit area.

As production process, the material allows the user easy process domination. All steps are enforceable by user in a relatively simple way, from cultivation to handling. Thus, bamboo is seen as a consolidated raw material for engaging social inclusion projects and manpower qualification. Finally, such constructive culture can represent an important mean of social training, requalifying the population that already disintegrated the know-how of the way of life they used to own.
Villegas [15] says that in a universe where the species grows naturally, the cost for building with bamboo represents values up to 45% lower than those of conventional construction, representing an interesting alternative to the serious housing shortage problems affecting most countries in Latin America. Therefore, it is necessary to develop bamboo construction technologies and to disseminate appropriate technologies, training and enabling building manpower and organizing community production systems. Simplifying and universalizing the use of bamboo materials as a quality construction element, natural, renewable and rapid growth, it can be consolidated as an important alternative to the multiple demands of the construction, including housing public policies. Bamboo building systems can undergo a prefabrication process, optimizing the construction. The stems can be pre-sized and cut according to the planned project; however, it should have some flexibility to make adjustments when assembling, since by being a natural raw component it generally has dimension variability. Bamboo prefabrication can offer considerable opportunities for poor communities to increase economic independence and self-sufficiency. Bamboo can be grown in small scales; preservation can be made in small factories that do not require large initial investment and the construction can easily be developed based on mutual support, using simple equipment.

In this context, housing prefabrication can attend productive and quantitative issues and must always be linked to users' decisions. According to Sánchez e Tole [16], prefabrication is a concept associated with the optimization of the construction process, taking the prefabricated element as a construction material itself. Thus, the prefabrication of housing in Bamboo is an interesting alternative for a fast and low cost production, with low initial investment and good quality. If properly conducted, this alternative may even be object of community organizing practices for self-construction.
Given the existing housing shortage in major Latin American cities and considering housing as a priority human need, it is constant the research for low-cost materials, usually linked to the rationalization and prefabrication. Thus, developing constructive systems in bamboo becomes an increasing option for social housing in Latin American countries context.

The case study of two examples of such programs/projects developed in Latin American countries seek to analyze how social issues described above were incorporated in such initiatives. It focuses on issues such as participatory processes, technology transfer, training processes of local population, with greater or lesser relevance in the country housing scene.

4. Study cases
Founded in 1973 in Guayaquil, Ecuador, the program Viviendas Hogar de Cristo (VHC) is led by a non-governmental catholic organization and aims to produce low-cost emergency housing with prefabrication composed of constructive elements in bamboo, sold to families with cost price [19].

The project has been responsible for building more than 60,000 homes, due to the evolutionary process of rationalization and efficiency in prefabricated building elements production. In addition to providing housing, the project aims to strengthen family cohesion, defending the premise that when creating a shelter already is promoting the start of the economic and social development of a family. The program
encourages the making improvements in housing by families, and considers the housing unit in bamboo the starting point for this.

The VHC atelier that produces such low-cost housing is responsible for great activity on the local economic sector as it ensures the creation of jobs for processing, assembly and transport of building kits. One single factory is responsible for manufacturing 50 housing units daily and needs of the workforce of 150 people [20]. The bamboo Guadua used is extracted from forests and directly processed with small hand tools such as hatchets and axes [19].

On a journey of eight hours of work a worker is capable of producing 18 panels, enough for 3 homes per day. In general, a full house is manufactured every 2.5 hours, resulting in the aforementioned daily production of 50 houses mentioned [21]. At the end of prefabrication of the kit components is carried and mounted in place through a manual. According Vries [21], the house can be assembled by the beneficiaries themselves.

Another program conceived in 1986 in Costa Rica, the Proyecto Nacional del Bambú (PNB) owned as main objective to meet the demands generated by the housing crisis in the country, especially in rural areas with low incomes. In addition to providing affordable housing for this population, the project aimed to stimulate the generation of jobs based on local resources without degradation of the environment, preserving the local forest resources and involving the use of bamboo to the promotion of social and economic development. The organization of the project was an initiative of the Government of Costa Rica through the Ministerio de Vivienda y Asentamientos Humanos (MIVAH) in San Jose, administered by the United Nations Development Programme (UNDP) and funded by the Dutch Government and the Central American Bank for Integration economic (BCID).

According Vries [21], the project had three main objectives: the construction of 760 housing units in bamboo model in 38 rural communities of the country, an aid program for the construction of 7500 homes a year in rural areas; the cultivation 700 acres of Guadua bamboo to ensure material for the future of the program and training more than 1,000 professionals, technicians and householders to the methods of cultivation, production and preservation of bamboo for use in construction.
The project was developed in three phases. First, a preparatory stage for the presentation of a constructive culture to the population that unknown such practice. In the following stages, the implementation in rural areas was carried out with technical training activities, massive bamboo cultivation, organization of work and environmental assessments of technology and furniture production. Thus, the project achieved important goals, such as the development of a construction technology that allowed cater to the most needy sectors of the country and the development of a factory of bamboo panels that allow mass production, cheapening and optimizing production.

According to Janssen [23], the execution of the houses was made by the residents themselves through technical training based on building methods with mutual aid. Thus, the project developed a training process with families not only focused on technical and construction issues but also on the benefits of community organization. The involvement of families exceeded the limits of housing construction itself, stimulating and motivating stakeholders to engage in neighborhood improvement actions such as the improvement of public infrastructure networks.

For technical training, both the material and the constructive bamboo culture represented a new vocabulary for Costa Rica people. At the end in 1991, 400 families and 60 technicians were trained on the topics: growing, planting, processing and drying of the material and construction of furniture and houses, as well as concepts of community organization and management of small farms. Alongside the production, a research and development center was created to ensure the improvement of techniques such as drying and immunization through the boucherie method and practice of quality control measures.

The work required in the production of PNB units has low constructive complexity according to primary requirement: the self-construction. The equipment used in the construction process were mainly hand tools. However, some tasks of the process were more complicated and required a particular skill, such as the nesting blocks, and finishing facilities.
5. Conclusions

Both projects, VHC and PNB, can be considered successful once they correspond to a constructive answer to very latent housing demand in the Latin American context. Among its main positive points related to every aspect, we can list the production ones:

• creating employment opportunities for people in production and manufacturing of bamboo;

• simplicity of equipment in production process and small initial investment;

• rationalization of production by prefabrication and little waste;

• simplicity of production can be operated by small factory.

They have a great attribute in its integrated and complete approach. They encompassed issues such as technology transfer, community organization, protection of the local natural environment and the formation of manpower and a productive activity on site. In the case of PNB, the project was cataloged as one of the 100 best practices in the Habitat II conference in Istanbul in 1996, and in 1998 Costa Rica hosted the V International Bamboo Congress, first held outside the Asian continent.

Overall, both were successful processes, with relatively low cost that resolved many of housing deficit issues in developing countries. Thus, the projects attracted many interested in the process, with international repercussions, especially among Latin American countries, due to socioeconomic similarity that unites them. It can be concluded that green technology can introduce important social aspects that must be considered when regarding the sustainability issues. In this field, bamboo can represent an unconventional technology with a large contribution initiative from the social development perspective.

References


[17] Information on http://bambus.rwth-aachen.de/

[18] Information on http://www.todoarquitectura.com


