B

Bio-construction Potential for Sustainability in São Paulo, Brazil

Caio Cesar Makalski Carvalho,
Micheli Kowalczuk Machado and
Estevão Brasil Ruas Vernalha
Núcleo de Estudos em Sustentabilidade e Cultura – NESC/CEPE, Centro Universitário UNIFAAT, Atibaia, São Paulo, Brazil

Definition

Bio-construction seeks to build based on solutions with greater integration with the environment and with minimal environmental impact. This process prioritizes the use of natural and local materials, uniting ecology, architecture and urbanism (Amaro 2017). Thus, this proposal can meet principles of sustainability not only during the construction period, but also post-construction, seeking to bring about social, economic and environmental benefits.

Introduction

The construction industry is causing significant impacts on the environment. In the construction of buildings for various purposes, as well as infrastructure projects in general, there is the power consumption from the extraction materials phase to demolition. Moreover, it is also great given the impact of nonrenewable resources use. In this context, it is important to emphasize that such impacts are not restricted to the natural environment. The construction industry uses a vast range of materials, many of which contain chemicals whose action on human health is still unknown, exposing to risks both users of the buildings, such as those who participate in their production and employment (Sattler 2002).

Colombo et al. (2006) mention that if society consider the purely technological development, the future of construction will follow the path of execution with the use of pre-made materials that result in an increasingly faster execution as in the case of allocation with equipment precast elements and even the substantially complete building. However, this model has proven to be destructive for the key elements of a good quality of individual and collective life and therefore needs to be associated with or even replaced by a more organic model, resulting in the construction of environments that allow the continuation of a life in harmony with the environment.

Thus, the construction sector has to be necessarily approached from the point of view of sustainability. In this perspective, we can consider the past of construction and aggregate the present knowledge, showing, this way, an alternative to a future for the construction and future of life on the planet. The future of construction, then, may be related to bio-construction models that combine the present technologies with the previous

W. Leal Filho (ed.), *Encyclopedia of Sustainability in Higher Education*,
https://doi.org/10.1007/978-3-319-63951-2_502-1

models, generating a model to be done on a smaller scale and with no or little industrial materials. So, it becomes more organic because it follows the model of nature without causing impacts just like the current buildings cause (Colombo et al. 2006).

Bio-construction unites ecology, architecture, and town planning, prioritizing the use of natural materials (earth, wood, bamboo, stones) and the region, "aimed at building solutions with minimal environmental impact and greater integration with nature, identifying the building as a living organism, with its lifetime, transformations and needs" (Amaro 2017, pp. 45–46).

This view meets the principles of sustainability, which increasingly need to guide the construction, given that it is considered one of the sectors that cause severe impacts on the environment due to the high consumption of materials and energy and to the high waste generation. According to Cantarino (2006), companies have invested in environmental responsibility, and many of them are specializing in bio-construction that combines ancient and innovative technologies to ensure sustainability not only in the construction process but also in the post-occupancy houses and apartments period.

One may consider:

> Use of raw materials, recycled or natural, available on-site; management and water saving such as reuse or use of rainwater; alternative energy sources such as solar heating and wind energy; selective collection and recycling; construction techniques based on the use of clay, straw or bamboo. The bio-construction covers a range of technologies and the ecological, economic and social viability of their application mainly depends on the assessment of the job site. (Cantarino 2006, p. 46)

Proposals such as bio-construction can collaborate directly with Agenda 2030, which is a plan of action for sustainable development. Among other important issues, the document seeks to promote the protection of the planet from degradation, considering both sustainable consumption and production, sustainable management of its natural resources, and urgent action to combat climate change, so one can meet the needs of present and future generations (United Nations 2015).

Thus, this article aims to present a reflection on the role of bio-construction as an instrument that can contribute in promoting sustainability in construction sector, considering the social, economic, and biophysical dimensions that are present in the current discussions on the social and environmental problems.

Bio-construction and Sustainability

According to the Institute of Permaculture (IPOEMA), bio-construction involves several vernacular architecture techniques, some of them with hundreds of years of history and experience, presenting a characteristic preference for local materials, which allows, among other factors, the reduction in spending with manufacturing and transportation and the construction of housing with reduced cost and offers excellent thermal comfort. This practice includes aspects such as creativity, personal will, and ecological solutions adapted to each case and that considers local characteristics. It should be noted that bio-construction techniques search the maximum use of available resources with minimal impact at the stages of planning, execution, and use of the construction project (IPOEMA 2017).

It is important to mention that bio-construction is related to the concept of vernacular architecture that differs from primitive architecture, given that its main characteristic is harmony with the environment, not only from a material point of view but also folkloric and cultural (Teixeira 2008). For the author, in general, the original term is related to something that has little research or technological development, unlike the vernacular architecture that uses professionals to its construction and takes into account the place and the microclimate, respect with other people and their houses, and the natural and built environment. So, there is a utility and sense of community, searching simplicity in construction solutions, being able to use techniques and materials belonging even to a pre-industrial era (Teixeira 2008).

In addition to its relationship with the concept of vernacular architecture, according to IPOEMA (2017), bio-constructions are important elements

of permaculture, seeking the integration of units built with their environment. For Mollison (1999), permaculture promotes energy, human food, and housing balanced with the environment, from the design, implementation, and maintenance of productive ecosystems that maintain diversity, stability, and resilience of natural ecosystems. According to Soares (1998, p. 4), a permaculture project "results in seamless integration between people and the landscape, providing food, energy and housing, among other material needs and non – materials in a sustainable manner." Complementing the above concepts, it is worth mentioning Mantovanelli (2012, p. 1), to whom "permaculture proposes systemic thinking and the conception of ecological principles so that the planning, management and improvement of the efforts made by individuals and communities can guide a viable future."

Jacintho (2007) explains that permaculture is the planning and implementation of sustainable human occupations, combining traditional practices with modern knowledge of the areas, especially in agricultural sciences, engineering, architecture, and social sciences, all addressed from the perspective of ecology. According to the author, for this process it is necessary to consider the permaculture design established in the area which there is a plan that involves, in addition to the technical aspects of the necessary actions, temporal and economic suitability of implementation and a willingness to adapt to environmental conditions where applicable (farms, rural settlements, villages, urban areas, residential lots, etc.). Local environmental condition is the biggest difference between permaculture design and other modes of occupation, planning, and land use. In general, traditional enterprises start from the premise of changing the physical and environmental reality in favor of a certain goal, "while planning to use permaculture methodology will try to fit the desired objectives for the environment, respecting its ecological dynamics and taking advantage of local resources positively" (Jacintho 2007, p. 39).

Considering the concepts and proposals of vernacular architecture, permaculture, and permaculture design, presented above, it is noted that bio-construction is a key component to the interaction of construction processes with the conservation of the environment, thus providing more sustainable actions.

According to the Ministry of Environment (ME), bio-construction is "building sustainable environments through the use of low environmental impact materials, with suitability of local climate architecture and waste" (ME 2008, p. 9). In this process, the building systems are environmentally friendly during the design phase and construction (in the choice of materials and suitable building techniques) and along the building use (energy efficiency and treatment of waste) (ME 2008). Camillis (2017) points out that bio-construction techniques vary from place to place, since the materials available are different depending on geography and location. Bee (2015) reinforces this view by mentioning that building with natural materials or the ones available locally requires research on what works best in each region.

The bio-construction incorporates in its proposal factors such as considering waste as resources, using local materials, valuing traditional architecture, building considering the weather, and enjoying the natural energies, as shown in Table 1.

In addition to these factors, there are many techniques that fit the profile of bio-construction, and practically every region of the world had at the beginning of its construction a more natural and organic model. It's worth remembering that the term bio-construction is much more recent than the used techniques, since the term was developed in the 1970s, while some techniques are thousands of years dated (Colombo et al. 2006).

According to Keeler and Burke (2010, p. 130), "alternative building techniques reflect the hands that mold, and, therefore, are often seen as rudimentary structures built by the need to use locally available materials." However, even though this fact is generally true, now these techniques have gained increasing credibility due to modern interpretation.

Camillis (2017) also explains that the different techniques of bio-construction permit addressing the discussion about the possibility of making

Bio-construction Potential for Sustainability in São Paulo, Brazil, Table 1 Factors to be considered in bio-construction

Consider waste as a resource	In bio-construction, building a house or planning a community must take into account the treatment of different waste. Furthermore, it is essential to reduce the amount of waste generated
Using local materials	Whenever possible, it is necessary to opt for conscious and sustainable use of local materials such as earth, stone, straw, wood, etc.
Valuing traditional architecture	Since the progress of industrialization in the nineteenth century, traditional building techniques have been abandoned. People with few financial resources have less access to industrial goods and follow making the use of ancient techniques such as adobe, the stick-and-daub, and mud mortar. These techniques are associated with low-income population, which creates prejudice that remains to this day. On the other hand, society has experienced a time of breaking of this prejudice. This is due both to the recovery of original materials of historical monuments and to a growing concern for the environment. It is known that the construction industry is one of the activities that consume more energy and natural resources of the planet. Increasingly, organizations around the world seek a bailout from the traditional way of building, incorporating new technologies to optimize the construction processes
Build considering the weather and enjoy the natural energies	In bio-construction are used the most of natural energies, like the sun and the wind. When building a house, for example, one must take into account the local climate. It is also important to consider the rainy season and the wind regime in the region

Source: The authors based on Ministry of Environment (2008)

different efforts and from the cooperation demarcating collective wills – both from individual and society. "The bio-constructor makes the clay and the clay does bio-constructor; this 'do' is only possible in cooperation – the relationship" (Camillis 2017, p. 37).

To Sattler (2002), to search for a form of sustainable construction transcends the simple production of a built environment, because it must be sustainable also in social and economic terms. Thus, bio-construction goes beyond the use of environmentally friendly materials and involves cultural, economic, social, political, and philosophical to promote a sustainable environment.

According to the Ministério do Meio Ambiente (Ministry of Environment 2008, p. 9), a sustainable environment is one that "meets the housing needs, food and energy ensuring that future generations will have to meet the same needs." Thus, it is necessary to think about sustainability at the local level (beware of the earth, sustainable management of forests, conscious extraction of resources) and globally. To contribute to building a more sustainable world is necessary, for example, consume carefully, giving preference to products from the region, and choose to use renewable energy.

It should be emphasized that building a sustainable environment provides autonomy to the communities and the field of construction techniques and the upgrading of traditional techniques are a step closer to that autonomy. In this perspective, the communities do not have to depend on external resources to the environment where they live. Therefore, if there is conservation of the environment, society will have the resources necessary for their survival and future generations as well (MMA 2008).

Considering the bio-construction characteristics and its importance for sustainability, the following item presents an analysis of construction techniques aimed at greater integration with the environment, environmental conservation and promotion of a sustainable environment.

Case Study: Espaço Maitá, Bragança Paulista, SP, Brazil

The bio-construction, as mentioned above, involves several techniques that have been perfected over time and is characterized by the

preference for local materials, reducing expenses with manufacturing and transport, and allowing to build with low energy demand, appropriate to the weather and local landscape (Colombo et al. 2006).

With the passage of time and constant improvements in used construction techniques and technologies, humans started to look for a single model of construction, reducing the variety of materials and ignoring local needs. Searching for this model, the environments are becoming increasingly sterile and isolated from nature and consume more and more nonrenewable materials, and we do not care about environmental responsibility.

This type of construction has the need to create a standard way of construction, tending to be a constructive method much faster and not caring about different environmental conditions, which ends up creating spaces that consume more and more energy, often needing ventilation, air conditioning, and artificial lighting (Pinha et al. 2015).

Seeing the need for more sustainable bio-construction proposals has proven to be a more viable alternative to the present building system. According to Soares (1998), it is known that the construction industry is the human activity that consumes natural resources and energy at the most, and so it is necessary to minimize the impacts from this activity, with the goal of better use of resources, recycling of materials, development of new technologies, and reducing energy consumption during construction, operation, and maintenance. For always thinking of a better relationship with the environment, bio-construction should employ techniques and materials that are best suited to each mode of construction and climate, minimizing environmental impacts by using renewable resources and integrating the building to the environment and society.

In this perspective, from the studies carried out in a research project developed in center of study and research of Atibaia College (CEPE/FAAT), this work demonstrates some techniques related to bio-construction used in Espaço Maitá, located in Bragança Paulista, São Paulo, Brazil.

The Espaço Maitá (Fig. 1) is an institution devoted to the promotion of experiences with social and environmental focus, which include, for example, several courses related to

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 1 Espaço Maitá. (Source: The authors 2017)

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 2 Mud wall. (Source: The authors 2017)

environmental education, medicinal plants, agroforestry, and bio-construction, among others. It has become a model in the region and uses and teaches various construction techniques to reduce environmental impacts (Espaço Maitá 2017).

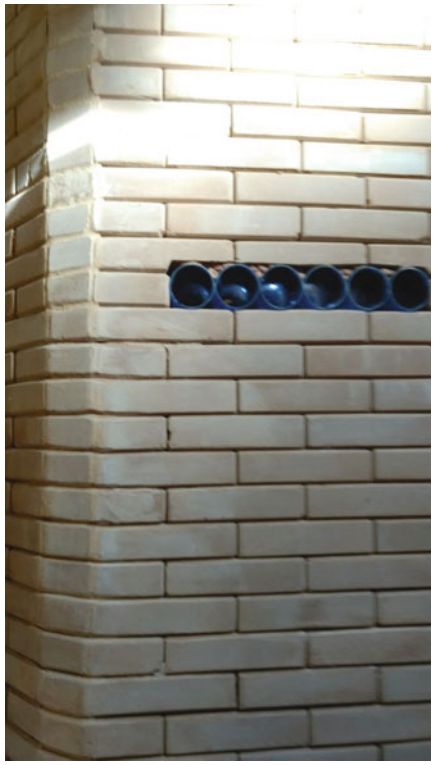
The building in question is located in an area of 9 ha and was built from the perspective of bio-construction with materials found in the region, many of them taken from the property. The proposal merges more traditional techniques, such as mud walls, and more current, such as the use of soil-cement brick. As a basic concept, everything has been designed to generate minimal impact, and, during the construction process, a number of techniques that allow to re-evaluate the way the building is seen today were used. It is a building designed to integrate function, environment, and society.

One of the techniques used in Espaço Maitá is the *mud wall* (Fig. 2), which uses as starting material earth, straw, and bamboo. This technique has low production cost and generates passive thermal comfort (Lengen 2014; MMA 2008; Keller and Burke 2010). The walls were built strategically to protect the construction from strong winds, and elsewhere the ambiances do not have walls, in order to integrate the interior with the exterior of the building. The land is used as the main material for building this construction.

The choice of this material was made due to its abundance at the site and because it causes low environmental impact, since it does not need much processing and, moreover, does not require transport, which minimizes the CO_2 emissions. The process of construction of the entire project involved collaborative efforts with participation of several people from the local community, in which the techniques taught were put into practice. This form of work develops a new environmental relationship between the building environment and society.

In addition, *soil-cement bricks* were used (Fig. 3), made from ground raw material and concrete. This technique creates blocks with this mixture, which are stacked to form a wall. These blocks are easy to construct and facilitate the passage of plumbing and electrical ducts and, being rapidly built, generate large passive thermal comfort, and the mud walls has low cost of production and offers other aesthetic standard to the construction. In manufacturing, burning is not required, and the bricks can be manufactured on site, because it is a simple mixing process. Another advantage of using this material is that none of it is wasted, as the broken bricks can be grounded and reused (Motta et al. 2014; Tajiri et al. 2011).

In order to use natural light, the technique of *zenithal opening* was used (Fig. 4), consisting of a



Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 3 Wall made with soil-cement bricks. (Source: The authors 2017)

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 4 Zenithal opening. (Source: The authors 2017)

window in the roof using natural light and avoiding the need for artificial light. It reduces energy consumption in illumination during the day and may be a complement to lighting already generated by the windows. This window was also used to generate a greater comfort to the environment users where it was installed (Lengen 2014; MMA 2008; Tajiri et al. 2011).

Regarding the wastewaters, the Espaço Maitá captures rainwater (Fig. 5) that is stored in tanks. This technique allows rainwater reuse and more consciously use of drinking water provided by the municipal water network and provides savings on consumption and also promotes security of supply. The water collected is not for consumption, but is used in various activities such as washing internal and external areas, irrigation, and toilet use (Lengen 2014; MMA 2008; Tajiri et al. 2011).

Still in relation to management of water, *the evapotranspiration system* (Fig. 6) in this location collects and treats the black water. The wastewater is decomposed into the system, which avoids the pollution of soil, surface water, and groundwater. In this system, human waste is transformed into plant nutrients, and water by evaporation is the output, which is completely clean. It is important to emphasize that all treatment is biological, with no use of chemicals (Galbiati 2009; Solomon et al. 1998).

Finally, the *green roof* (Fig. 7) present in Espaço Maitá replaces the traditional cover tiles for plants, which, in addition to providing thermal insulation, has the function of creating a microbiome. This technique allows a temperature drop inside the building in hot weather, and, in cold days, the thermal blanket reverses this effect, causing the heat to stay inside the house, barring the low temperature. It also features easier maintenance than common tiles, but one should take some precautions, like watering in times of drought, because, as it has little soil, the roots tend to dry out easily (Lengen 2014; MMA 2008; Tajiri et al. 2011).

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 5 Rainwater capture. (Source: The authors 2017)

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 6 Evapotranspiration system. (Source: The authors 2017)

To conclude the presentation of the case study in Espaço Maitá, it is worth mentioning that in the local are held several training practices, which use bio-construction elements, such as the green roof and mud wall techniques and educational tools connected with the local environment. Thus, it is noted that, in addition to a set of techniques and methods, bio-construction is an important instrument for the promotion of actions aimed at sustainability, as well as education of individuals, an essential factor for ensuring the conservation and quality of life on the planet.

Final Considerations

The construction industry, besides being highly impactful, dictates constructive standards and processes and reduces people's autonomy and diversity of constructive solutions. Thinking about the large existing bioclimatic differences in locations, and the great diversity of materials that can be used in construction, the standardization of materials and construction techniques is inadequate.

In this sense, it is critical to reflect on bio-construction, especially those aspects related to sustainability, durability, and comfort. Sustainable

Bio-construction Potential for Sustainability in São Paulo, Brazil, Fig. 7 Green roof. (Source: The authors 2017)

buildings can be very comfortable, efficient, non-toxic, and durable, with high aesthetic and environmentally friendly standards.

In addition, the development of this work showed that the adoption of this practice goes far beyond the choice of techniques and environmentally friendly materials. It is a collaborative process, educator and transformer, to the extent that bio-constructors may have a deeper contact with the environment in which they live, share, and receive knowledge, besides contributing to environmental conservation and improving the quality of life.

References

Amaro EKP (2017) Vivências de bioconstrução: um caminho para a leitura da paisagem. Dissertação, Universidade Estadual Paulista

Bee B (2015) O manual dos construtores de cob. Deriva, Porto Alegre

Camillis PKD (2017) Bioconstrução: a cooperação como prática In: Anais do VI Colóquio internacional de epistemologia e Sociologia da ciência da administração, Universidade Federal de Santa Catarina, Florianópolis, 26–28 April 2017

Cantarino C (2006) Bioconstrução combina técnicas milenares com inovações tecnológicas. Inovação Uniemp 2(5):46–47

Colombo CR, Sattler MA, Almeida MJ (2006) Bioconstrução: construção do passado ou do futuro? In: Anais do XI encontro nacional de tecnologia no ambiente construído, Associação Nacional de Tecnologia no Ambiente Construído, Florianópolis, 12–14 November 2006

Espaço Maitá (2017) Quem somos. http://espacomaita.com.br. Accessed 23 Feb 2017

Galbiati AF (2009) Tratamento domiciliar de águas negras através de tanque de evapotranspiração. Dissertação. Universidade Federal do Mato Grosso do Sul

Instituto de Permacultura (2017) O que é permacultura. http://ipoema.org.br/. Accessed 20 Feb 2017

Jacintho CRS (2007) A agroecologia, a permacultura e o paradigma ecológico na extensão rural: uma experiência no assentamento colônia. Disssertação, Universidade de Brasília

Keller M, Burke B (2010) Fundamentos de projeto de edificações sustentáveis. Bookman, Porto Alegre

Lengen JV (2014) Manual do Arquiteto Descalço. Livraria do Arquiteto, Porto Alegre

Mantovanelli DF (2012) Quintais agroecológicos: sala de aula informal para capacitação formal: as experiências do assentamento rural Araras. Dissertação, Universidade Federal de São Carlos

Mistério do Meio Ambiente (2008) Curso de bioconstrução. Secretaria de Extrativismo e Desenvolvimento Rural Sustentável, Brasília

Mollison N (1999) Permaculture: designers manual, 8th edn. Tagari Publication, Tyalgum

Motta JCSS, Morais PWP, Rocha GN et al (2014) Tijolo de solo-cimento: análise das características físicas e viabilidade econômica de técnicas construtivas sustentáveis. Exacta 7(1):13–26

Pinha PRS, Prompt CH, La Noce EM et al (2015) Bioconstrução na Reserva Biologica do Lago Piratuba: austentabilidade e tecnologias apropriadas. Biodiversidade Bras 5(1):74–93

Sattler MA (2002) Edificações e comunidades sustentáveis: atividades em desenvolvimento no NORIE/UFRGS. In: Anais do IV Seminário Ibero-Americano da Rede Capacitação e Transferência de Tecnologia para Habitação de Interesse Social, Instituto

de Pesquisas Tecnológicas, São Paulo, 11–-13 September 2014

Soares ALJ (1998) Conceitos básicos sobre permacultura. Ministério do Meio Ambiente, Brasília

Solomon C, Casey P, Makne C, Lake A (1998) Evapotranspiration Systems. U.S. Environmental Protection Agency under Assistance Agreement. http://www.nesc.wvu.edu/pdf/WW/publications/eti/ET_tech.pdf. Accessed 07 May 2018

Tajiri CAH, Cavalcanti DC, Potenza JL (2011) Habitação Sustentável, Secretaria do Meio Ambiente Coordenadoria de Planejamento. Ambiental, São Paulo

Teixeira CM (2008) Arquitetura vernacular. Cad Arquitetura Urban 15(17):29–45

United Nations (2015) The 2030 agenda for sustainable development. https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf. Accessed 20 Jan 2017