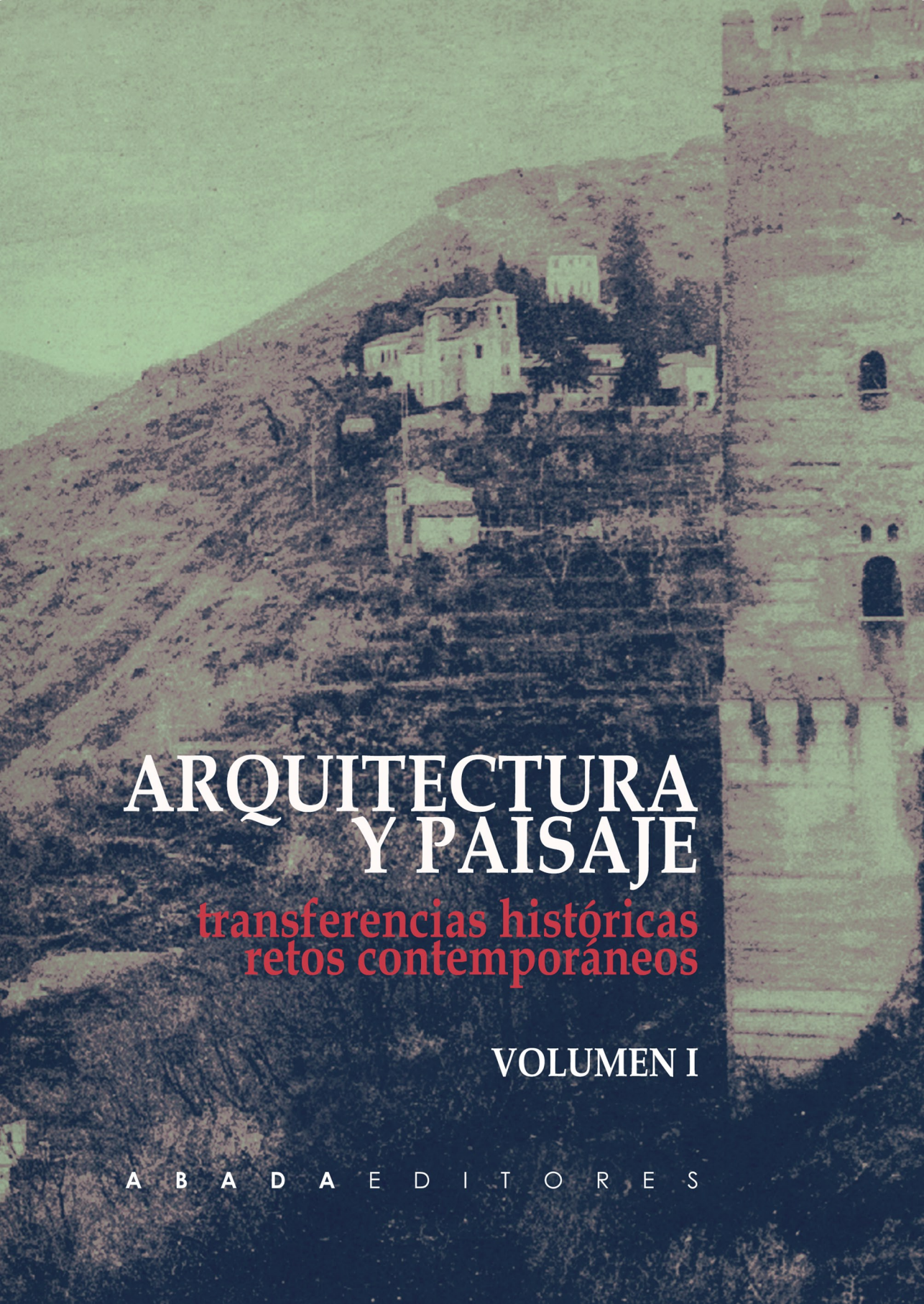

ARQUITECTURA Y PAISAJE

transferencias históricas retos contemporáneos

VOLUMEN I

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Challenging the Architectural Language: The Bamboo Case

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Abstract
La naturaleza intrínseca de la arquitectura se esconde en el estudio de la relación entre el hombre y la naturaleza, consciente de la fuerza de las construcciones naturales y de su lenguaje. La fuerte identidad de la arquitectura vernácula es un ejemplo que encarna bien la relación entre la naturaleza y la sociedad. Esta reflexión lleva a comprender la fuerza identitaria de los materiales y métodos de construcción que forman parte de la arquitectura vernácula: el bambú como material de construcción. La necesidad de una compatibilidad ambiental redescubierta es el resultado de un camino estilístico que, alcanzado su punto máximo en áreas desnaturalizadas, quiere volver a una dimensión más afín al paisaje. Por tanto, acercar el análisis arquitectónico a la sostenibilidad lleva a (re)descubrir materiales y métodos de construcción asociados hasta ahora con el paisaje no urbanizado o poco desarrollado, como en el caso de las estructuras de bambú.

The intrinsic nature of architecture hides in the study of the relationship between man and nature, aware of the strength of natural constructions and their language looking for territorial identity. In the contemporary society, the strong identity of the vernacular architecture is an example: a magnet of interest that well embodies the relationship between nature and society. This reflection leads to understand the identity strength of materials and construction methods that are part of the vernacular architecture: bamboo as a building material. The need for a rediscovered environmental compatibility is the result of a stylistic path that, reached its peak in denaturalized areas, wants to return to a dimension more akin to the landscape in which it fits. Therefore, the choice to approach the architectural analysis to sustainability leads to (re)discover materials and construction methods so far associated with the non-urbanized or poorly developed landscape, such as the bamboo structures.

Keywords
Bambú, arquitectura vernácula, ingeniería, sostenibilidad
Bamboo, vernacular architecture, engineering, sustainability

Introduction

The world we all are living in is facing an extremely challenging issue related to the massive use of non-renewable materials and the consequent huge amount of energy waste produced. Especially the building industry must deal with an urgent change of thinking that leads toward innovative and ecological technologies, using renewable and sustainable materials. Concrete and steel are too far from reaching the zero-waste goal asked nowadays; they don't fit with the Sustainable Development Goals of the 2030 Agenda because they are affected by polluting production and construction processes that use enormous amount of energy. Even timber materials are now considered as non-sustainable. In fact, even if the material per se is natural-based and compatible with the today ecological issues, the increasing demand for wood and wood-based products, facing the lack of availably, is generating a lot of concerns: the cost of the plantations, the slow growth and the uncontrolled management of the woody forests are now a real problem for the sustainability-based development. In this scenario, bamboo has stood out as an incredible and promising alternative, due to its characteristics.

Challenging the architectural language: The bamboo case

Bamboo is a member of the grass family, characterized by long stems of different diameters, and it is the fastest growing in the world; as a matter of fact, it can grow more than 1 m in 24 hours (world record: 1.20 meters in 24 hours in Japan). More than 1200 species of bamboo exist and most of them grow in tropical and sub-tropical regions of Asia, South America and Africa. Bamboo is known as one of the oldest building materials used since time began to satisfy the most basic needs for humankind: shelter, food, tools. The characteristics of bamboo make it a great ally not only due to its rapid growth but even to its easy availability and infesting spread, its simple management processes in harvesting, cutting and storing, its adaptability to different climate conditions, its low weight and its mechanical properties that allow to call bamboo as "the green steel of 21st century"[1] (fig. 1). For thousands of years, natives in Asia, South America and Africa have built their houses using bamboo poles, one of the most widespread and easy-to-find local materials, also combined with clay, to create shelters in harmony with the surroundings, by following the empiricism linked to the basics of vernacular architecture. For this reason and due to the fact that there wasn't any engineering fundamental ruling that kind of construction processes, bamboo has been thought as a poor and rough material for a long time, unsuitable for the modern building industry, defined "the poor man's timber"[2] and considered as part of an ancestral tradition no long worthy to be enhanced. This dualism is even more clear thinking about the social and economic development gaps typical of the different urban belts of an inhabited region; while the new-born cities grow being affected

[1] Von Trong Nghia Architects, "Bamboo: The 'Green Steel' of the 21st Century", in *Von Trong Nghia Architects* (*web page*), September 3, 2020, accessed April 20, 2021, https://www.vtnarchitects.net/post/bamboo-the-green-steel-of-the-21st-century.

[2] C. N. Hari Prasath, A. Balasubramanian, "Bamboo - The Poor Man's Timber", *Kissanworld, Journal of Argiculure and Rural Development* 44, no.11 (November 2017): 9-10.

by innovation and improved technologies, the rural and marginal areas remain necessarily faithful to that vernacular architecture that slowly becomes a synonym of tradition.
The vernacular architecture relates immediately to the strong cultural and social identity of a specific region, becoming a way for the people to express their own language. As a result of the 'non-experts' construction handicraft, the vernacular architecture links itself to the ethnic and regional dialects of a population, articulating the basic needs by using the local resources and possibilities, the empirical knowledge and the practical considerations due to the elapsing of the time. The concept of modern architecture has led to the conclusion that the vernacular buildings, son of necessity, practicality and functionality, responding to climate conditions and geographical location, were due to the non-professionalism. From this conceptualization, have born numerous antagonisms between what is considered archaic and stationary (the vernacular) and what is perceived the result of high performance (the modern): low culture vs high culture; tradition vs innovation; anonymous vs authored; spontaneous vs designed; layman vs professional. According to the theory of the 'primitive hut'[3] (the origin of the shelter, the archetype of the first man's house made by four poles, four beams and a roof), the self-preservation has encouraged humankind to satisfy its needs without any stylized preconceptions, by giving life to vernacular attempts of sheltering; these were the basis of the search for authenticity that architecture always strives for. In a romantic/picturesque vision, the value of the vernacular architecture lies exactly in the identity and relation between man and nature that it has been bringing on during time: the unintentional bond to the local resources (for example bamboo, clay, rattan, soil, wood, palm tree) has established an extraordinary precedent in the balance of the human life related to the environment. The vernacular architecture is clearly an example of how to merge the laws of nature with the man's needs, articulating a landscape identity that conjoins the cultural and social value of a territory and it makes it potentially durable over time.
Nevertheless, with the advent of new technologies, bamboo, as well as rattan or wicker, has been set aside and excluded from the building materials selection for construction; this has led to a lack of certified knowledge of the material itself and its properties and to a general disapproval on the potentialities of the natural-based raw materials. For years, plant-based matters (as well as wood) have not been studied, classified or just taken into consideration as a valid option for the architecture of the future, a more sustainable and ecological one. Moreover, this feeling of mistrust has been amplified by the emergence and the establishment of brick, steel and concrete as solid and safe matters, supported by numerous researches and studies that guarantee their characteristics and that set up and standardize the engineered processes for a correct use in the construction field. During the time, the building industry has raised more and more awareness in using those engineered products (brick, steel and concrete), unwittingly contributing to enlarge the gap between the urbanized areas, connotated as modern and innovative, and the rural areas, pictured as traditional and ancestral. For this reason, the consequent results lead to change the general vision about the 'vernacular architecture' that became 'traditional architecture', ostracizing all the elements linked to it; in fact, even if the term 'vernacular' is associable to "a local

[3] First articulated in *Essai sur l'architecture* by abbé Marc-Antoine Laugier in 1753.

style in which ordinary houses are built"[4], the technologies evolution has meant that the intuition to use the local materials, such as bamboo, to build shelters and general furniture, supplying to the basics longings, was confused with an ancestral heritage son of the lack of education and to remember and mention as part of the tradition of a specific region.

Figure 1: Fabian Matthias Hutter, *Building Trust International, Bamboo Landmark Design Challenge*, 2017 (Building Trust International).

The increasing alarmism raised from the latest environmental issues is becoming more and more demanding and it is affecting all fields, from food to construction industry; the tendency to build sustainable constructions, the environmental restrictions and the increased cost of woody materials (due to the scarcity and the lack of reforestation) are letting bamboo coming out of the corner and showing its great characteristics. As said before, bamboo is a fastest-growing plant, simple to find and eco-friendly; moreover, it is cost effective and very easy to work; its excellent elasticity makes it a viable alternative to steel in building in high earthquakes risk areas. The hight content of silicic acid in the outer skin of the bamboo poles guarantees a very good fire behaviour. A bamboo plantation is ready to be harvested and used for construction each 3-6 years, depending on the species. A forest full of Guadua Angustifolia[5] bamboo stems can count 5000/6000 culms of 10-

[4] *Cambridge Dictionary Online*, s.v. "Vernacular", accessed April 18, 2021, https://dictionary.cambridge.org/dictionary/english/vernacular.

[5] Guadua Angustifolia is one of the most important species of bamboo in South America: it is native to Colombia, Ecuador, Peru and Venezuela. The average diameter for Guadua Angustifolia is between 9 and 13 cm; the maximum reported is 25 cm. This specie of bamboo can grow 21 cm per day in height; that means that in the first six month of growth, it can reach its maximum height of 15 - 25 meters. A Guadua bamboo stem is considered mature in 4 to 5 years; after that it can be

12 cm diameter per hectare; furthermore, "1 ha of bamboo = (produces) 1 bamboo-frame house (175 m²) each year"[6]. The tensile strength of bamboo is way more efficient than its compression and it is totally comparable to the tensile strength of steel, considering the low weight and density of bamboo (height strength-to-weight ratio).
Although bamboo shows a lot of excellent characteristics, in order to be able to use it in the best way as a viable option in the construction field, it is necessary to know the disadvantages, too. First of all, bamboo is a plant and, hence, it is shaped by nature and its rules; the cylindric form is actually tapered while going from the bottom to the top and it can occur, sometimes, that bamboo poles have not a perfectly straight growth in height. Moreover, the hairy peak of the stems can propagate the fire very quickly in a forest during wind. Due to its nature, bamboo has a propensity for being attacked by insects, fungus, mould, humidity and natural decay that can compromise its mechanical properties. In fact, in order to use the bamboo in buildings, after the harvesting, the poles have to be chemically treated to ensure a better and longer duration in time; in the past, this was not conceivable but now it is possible to proceed with chemical treatments, mainly using Boric Acid and Borax (for indoor use), Copper Chrome Arsenic (CCA), capable to provide protection for more than 50 years and recommended for outdoor use, Copper Chrome Boron (CCB) or Creosote. Another issue is related to the jointing: it is still very hard to build connections able to transfer the bamboo tensile strength, even if the research is actually doing great efforts to overtake this problem, taking inspiration from the construction methods typical of the vernacular architecture that used dowels and rope lashings to tie the poles together. Finally, so far there are not regulations to refer to worldwide; some countries, such as Colombia, Peru, India or China, have their own local regulations that, however, while contributing to keep the bamboo materials local, need to be reformed and standardized.
According to the latest environmental, social and economic issues that are affecting the entire planet, also underlined by the 17 Sustainable Development Goals (SDGs)[7] of the 2030 Agenda, adopted by the United Nations Member States in 2015, the construction industry is one of the most engaged field due to the high quantity of polluting emissions related to the industrialization, building, demolition and disposal processes. The building materials waste result to amount to half of the sum of solid waste produced annually worldwide, number that is predicted to reach 3.40 billion tonnes in 2050 (a footprint of 1.25 kilograms per person per day). For this reason, the tendency is to learn how to reduce the impact of the building industry by using eco-friendly material, working with low

harvested, treated and used as pole or engineered into panels, beams, etc. Guadua bamboo is comparable to the Phyllostachys edulis (known as Moso Bamboo or Tortoise-shell Bamboo), its counterpart in Asia: it is native to North-Central China, South-Central China, Southeast China, Taiwan. The average diameter for Moso Bamboo is between 8 and 18 cm; the average heigh is between 10 and 23 meters. After being harvested and duly treated, it can be used for timber, plywood, flooring, construction material, furniture, etc.

[6] K. De Flander, R. Rovers, "One Laminated Bamboo-Frame House per Hectare per Year", *Construction and Building Materials* 23, no.1, (January 2009), accessed April 20, 2021: 210-218, https://doi.org/10.1016/ j.conbuildmat.2008.01.004.

[7] Related thematic issues: water, energy, climate, oceans, urbanization, transport, science and technology, future of work, rural economy, gender equality, productivity, youth employment.

emission industrialization processes, recycling and giving second life to products (enhancing the fundamentals of the Life Cycle Assessment). Bamboo perfectly fits in this scenario and it is currently being studied all around the world, considering the important predecessors found in the vernacular architecture of the tropical and sub-tropical regions in which it grows naturally.

Specifically, part of the credit for the rediscovery of this green gold belongs to four architects[8] (two from Asia, two from South America) that, over several years, are trying to reduce the gap between vernacular and modern architecture by designing and building massively with bamboo. This paper would like to focus on the work of the Colombian architect Simón Vélez.

After a terrible earthquake that destroyed the city of Manizales, birthplace of Simón Vélez, the inhabitants rebuilt using local materials, easy to find and cost effective: bamboo poles and clay. Simón Vélez noticed that bamboo seemed to be very resistant to earthquakes; moreover, one of his first client asked him to build a horse shelter using Guadua bamboo[9]; from that moment, the young architect started experiment with the raw material. In fact, he has never done any calculations for his early projects, due to the inexperience and the lack of literature to refer to, but he has always sketched the buildings and gave them a try while testing the final result. By trying, Simón Vélez had to face the jointing issue: he wanted to create longer span and cantilevers and to do that he attempted to use bolts and to secure the nodes by the injection of mortar into the bamboo poles. The intuition was great, echoed worldwide and contributed to switch the general vision about bamboo structures: the feeling of safeness conferred by that invention was the first step for promoting bamboo from "the poor man's timber"[10] to the "the green steel of 21st century"[11].

Simón Vélez had success in moving closer the vernacular architecture of his region to the modern concept of architecture by designing more than 200 projects. As a matter of fact, in 1995, after a strong earthquake that damaged the main cathedral of Pereira, Our Lady of Poverty Cathedral, in Colombia, the architect built a temporary cathedral made of bamboo poles (fig. 2); it was built in 5 weeks, it was characterized by one central nave and two aisles made of bamboo ogival arches and it had cost just 30k American dollars. In 2000, Simón Vélez designed the ZERI pavilion (fig. 3) for the World Expo in Hannover, Germany; the pavilion was in the first place built in Manizales, Colombia, underwent a lot of scientific tests run by several universities, such as the University of Braunschweig, the University of Stuttgart, and the Science University of Bremen, then built again in

[8] Simón Vélez, born in Manizales, Colombia, in 1949. He is a successful architect known all over the world. Juvenal Baracco, born in Lima, Peru, in 1940. He is a civil engineer and an architect; he is currently a professor for the Architecture Department in the Ricardo Palma University in Peru. Shoei Yoh, born in Kumamoto, Japan, in 1940. He is an architect leading his own firm Shoei Yoh + Architects in Japan. Rocco Yim, born in Hong Kong, Republic of China, in 1952. He is an architect leading his own firm Rocco Design Architects Associates Ltd in Hong Kong.

[9] We refer to note 5.

[10] Hari Prasath, Balasubramanian, "Bamboo…".

[11] Von Trong Nghia Architects, "Bamboo…".

Hannover. The pavilion was mainly made with 40 Guadua bamboo poles and 40 Aliso[12] stems; it covered a site area of 2150 square meters, it was 14.40 meters high and it had a 7 meters overhang made of bamboo canes. The ZERI pavilion has been thought as a social place for sharing and meeting, becoming a symbol of pride and glory of the incredible mixture between the vernacular architecture basics and the modern concept of architecture.

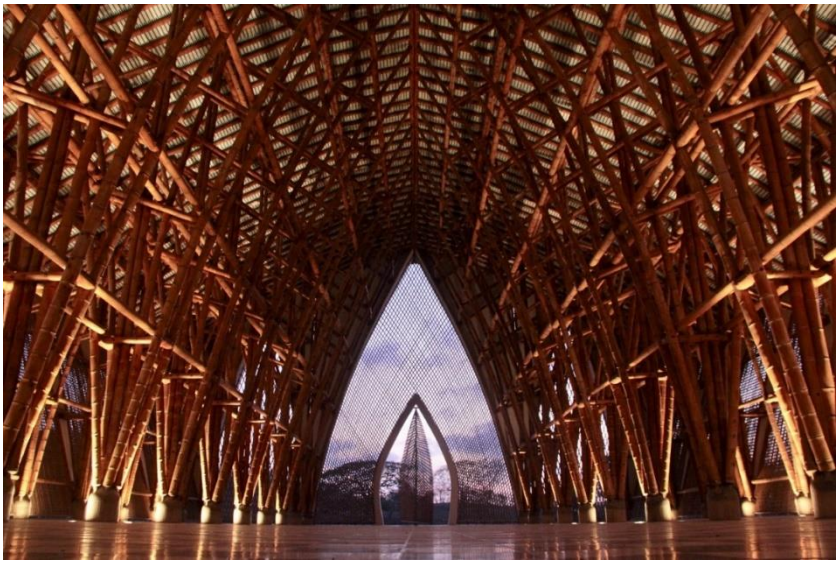

Figure 2: Namagool, *Spiritual Temple designed by Simón Vélez*, 1999 (Wikimedia Commons).

If slowly the vernacular architecture is washing off the bad connotation that has connected it for years to poorness, roughness and primitiveness, another issue has been raised: is it conceivable to plant bamboo canes in areas in which it is not native to, such as Europe for instance?

After the bamboo ascent, North America and Europe started to demand for products made from bamboo raw material: furniture, flooring, cladding, textiles, etc. Consequently, the price of the finished objects slowly started to increase due to the basic rules of the demand and supply. For this reason, it has occurred to think if it was environmentally possible to make the bamboo grow in the regions that were asking for bamboo products. Analysing the cost/benefit advantages, it would be much more cost convenient growing the raw material and then industrialized it than importing the finished products; moreover, the bamboo plantations will produce jobs while reducing the polluting emissions and so the carbon footprint. It is crystal clear that bamboo has a great adaptability to climate conditions and so a try was quite due. In Europe, some attempts of bamboo farms are now hopefully ongoing in the south regions (especially Italy, Portugal, Spain). It is to mention

[12] Aliso belongs to the Betulaceae family. It is native to South America (Peru, Bolivia, Chile, Venezuela, Ecuador). It can grow a diameter of 75 cm and a height of 35 m.

the project for bamboo plantations launched by BambooLogic[13], trying to make Phyllostachys Edulis Moso Bamboo[14] grow in Portugal. Stealing the words of Hans Friederich[15]: "We must try this. Why not? It fits in with the European policy, it fits in with the natural priorities, it fits in with the ecological thinking of European customers and it will provide you with a building material that is basically the building material of the future"[16].

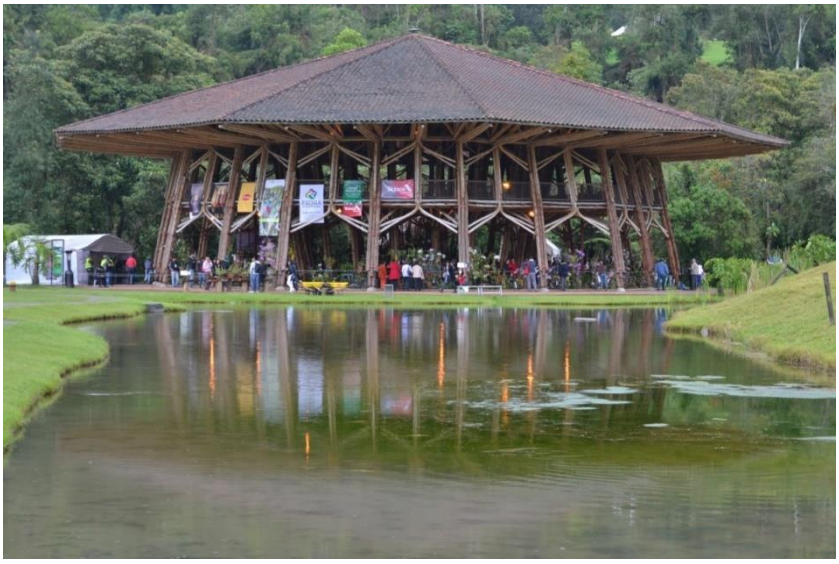

Figure 3: Camilo Ramírez Castaño, Pabellón Seri Manizales, 2014 (Wikimedia Commons).

Conclusion

Bamboo is clearly a viable natural resource to take into consideration to build a more sustainable future in the construction industry. Its excellent properties make it a suitable and eco-friendly substitute to bricks, concrete and steel. Nevertheless, the urgent need for standards to rules the construction is worldwide required, as well as more specific research and studies on the long-term behaviour of the bamboo engineered buildings.

The vernacular architecture, restored in its precious meaning, can teach a lot about how to use the regions' peculiarities for the best and even how to adapt them to get better and

[13] BambooLogic is a European Bamboo Plantation Program, based in Netherlands, divided in 3 phases: a first start-up pilot project in Alcoutim, Portugal, that expects to plant 150 hectares; a second phase of expansion to reach 2000 hectares in total; the last one expecting to extend the program to other European countries.

[14] We refer to note 5.

[15] Fourth Director-General of the International Bamboo and Rattan Organisation, INBAR, since 2014.

[16] Orin Hardy, interview with Hans Friederich, *Bamboo Farms in Europe*, (August 6, 2020), 16:29, accessed April 12, 2021, https://bamboo-u.simplecast.com/episodes/farming-bamboo-in-europe.

better, about how to respect the land we spoil every day, about how to make a virtue of necessity. Facing all the environmental issues, nowadays, it is on the architects and engineers of the future to think out of the box, considering that the past and the future can live together and can contaminate to create innovation.
Bamboo poles can be the answer to restore the balance between humankind needs and nature basics, to fill the gap between tradition and innovation and to turn back to a gentler dimension towards the environment. This green gold could also be the best ally to fight the discrimination on underdeveloped countries, helping them to increase their local economy and welfare state by establishing construction regulations and a worldwide fair trade.
"Bamboo is flexible, bending with the wind but never breaking, capable of adapting to any circumstance. It suggests resilience, meaning that we have the ability to bounce back even from the most difficult times."[17]

[17] Ping Fu, MeiMei Fox, *Bend, Not Break: From Mao's China to the White House* (New York: Portfolio/Penguin, 2012), https://www.penguin.co.uk/books/186873/bend--not-break/9780670922031.html.

El paisaje es hoy un tema crucial en el debate arquitectónico, urbanístico, artístico, territorial, político, ecológico y antropológico. En la pregunta sobre qué es un paisaje se entrecruzan muchas de las grandes cuestiones que tienen que ver con la construcción y con la percepción de nuestro entorno, en un momento determinado por una crisis global que convierte a la mirada sobre nuestro hábitat en un asunto marcado por la urgencia. La centralidad del paisaje en la cultura contemporánea es un fenómeno tan reconocido que ha dado lugar a elaboraciones teóricas específicas tendentes a dar cuenta del mismo. Está claro que hoy las cuestiones relacionadas con el paisaje, en su sentido más amplio, constituyen uno de los núcleos conceptuales en los que en mayor medida se entrecruzan naturaleza, cultura, historia y contemporaneidad.

La complejidad y variedad de temas que el paisaje convoca solo puede abordarse desde una mirada transversal y desde la complementariedad de diferentes saberes y disciplinas. Tal fue el objetivo que se propuso el Congreso Internacional *Arquitectura y paisaje: transferencias históricas, retos contemporáneos*, celebrado en Granada del 26 al 28 de enero de 2022, cuyas aportaciones se recogen en el presente volumen.

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