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Grow Your Own City – Scaling Uptake of Structural Engineered Bamboo

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Abstract

This paper outlines an ambitious solution to catalyze the commercial adoption of structural engineered bamboo for the construction industry of Indonesia. Our approach looks to adopt a whole value chain approach that connects rural village-based agroforestry with the fast-growing urban centres of Indonesia, unlocking a multitude of socio-environmental benefits across the bamboo supply chain.

Keywords Bamboo; Restoration; Construction; Climate change; Environment

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1. Introduction

Laminate bamboo is a pioneering innovation that has the capacity to displace current emissions-intensive materials within the building sector and is a zero carbon material that can be grown, manufactured and utilized within Indonesia and exported to overseas markets. In doing so, the Grow Your Own City partnership aims to develop a commercially-viable business model that will see the emergence of "restoration buildings" that can be quantified for their ecological, social and economic benefits. In our theory of change, 'early adopter' developers incorporate structural engineered bamboo into landmark projects in a variety of urban and semi-urban settings, as proofs of concept that will stimulate broader adoption of the technology in densely-built parts of Indonesia in the longer term.

To reach this goal, our partnership connects value chains within Indonesia, from forested landscapes to construction sites. Promoting buildings made from structural engineered bamboo will generate a 'pull' factor that will create incentives for rural communities to plant and process more bamboo in existing bamboo supply chains. Our experience has shown that bamboo planted in an agroforestry system generates a multitude of benefits that extend well beyond the commercial value of bamboo, making rural communities more resilient. The proposed solution simultaneously tackles several of the UN Sustainable Development Goals, namely SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production). Beyond that, research has shown that the climate, soil and water benefits that ripple out from the use of bamboo in construction address every single one of the SDGs.

Globally the built environment accounts for nearly 40% of global CO_2 emissions due to the construction and operation of buildings. Furthermore, 60% of global resource consumption and 50% of global waste generated can be attributed to the built environment. If as a global society we are to confront the challenge of climate change and ecological degradation then steps must be taken to reduce the ecological impact of the built environment and the materials that we consume. The manner and rate at which the construction industry consumes materials is driven by two trends: a growing and increasingly urban population, and an increase in consumption per capita. As countries transition towards a lifestyle modelled by the global north, there is a concurrent growth in urban development that leads to a demand for construction materials that are largely non-renewable and energy-intensive. In 2020 (+-6), anthropogenic mass surpassed all global living biomass (Elhacham et al. 2020), almost half of which is concrete, and an approximate 30% due to associated aggregates such as gravel. The growing reliance upon concrete is forecast to continue increasing 48 percent from 4.2 billion to 6.2 billion tons by

2050 (Slanger 2023). Given that concrete currently accounts for 8% of global emissions (Ibid), this is a worrying trend and a major contributor to global warming. Not only does this cause associated emissions and ecological degradation but it also negatively influences the environments we inhabit causing 'urban heat islands' that exacerbate the global heating trend.

This paper seeks to confront these challenges by outlining an ambitious initiative that seeks to redefine the way we consume resources and consider the entire value chain of material sourcing and consumption. The Grow Your Own City initiative is based on the concept of a regenerative built environment, where the building materials we use are either bio-based or re-used, and creating positive social and environmental impact.

The idea of bio-based building as a mechanism for carbon sequestration and storage is not an idea that is limited to bamboo alone. Alan Organschi of Yale University, has championed the notion of the "Timber City", where cities function as an urban carbon sink creating a systemic shift from a mineral- to forest-based building economy (Organschi et al). Within this system, supply chains would be designed to create resilient, bio-diverse forests that are in synergy with densely populated urban centres. This is a vision that cannot be achieved through the sole reliance upon timber alone. A recent study by WWF titled "Everything from Wood" highlighted that the current global demand for timber exceeds the sustainable supply capacity (Beck-O'brien 2022). This means that materials like bamboo are critical to developing a range of bio-based building solutions to ensure demand for renewable building products does not degrade ecological systems.

The Grow Your Own City initiative looks to stand upon the shoulders of the pioneering work of bamboo champions who have strived to redefine bamboo as a contemporary building material. In particular, the project derives its name from the seminal text "Grow Your Own House" published by the ZERI Foundation and Simon Velez following the construction of the ZERI Pavilion for the 2000 Hannover Expo. The text makes a strong argument for how bamboo can be used in construction as a locally available, sustainable resource. In the years following the publication of this seminal text and the associated pavilion, there have been significant transformations in the way bamboo is perceived as a building material. The work of Velez alongside seminal works by Ibuku, Anna Herringer, VTN and many others have redefined bamboo as a sustainable building material with unique structural and material characteristics, promoting bamboo as a locally available bio-based material that also supports the continuation of local craft and vernacular knowledge.

The design solutions employed through these types of projects have increased awareness of the potential of bamboo as a sustainable material and generated new knowledge for bamboo construction. These architectural forms are successful because they are a response to local climate, technical knowledge, and economics, celebrating the use of bamboo in its natural form. But it is for this very same reason that this style of construction is limited in application as knowledge transfer is limited by context. Constraints such as differing building regulations, a lack of skilled craftspeople or the economic capacity to construct boutique architecture requiring one-off technical solutions all limit the global implementation of these construction typologies.

For bamboo to be implemented at a global scale as a bio-based material with strong ecological credentials, it must be processed for easy use and meet modern construction standards (De Flander and Rovers 2008). While there are many different contexts and ways of working with bamboo, that ensure round pole construction is also of importance, laminating bamboo creates a standardised product that can be used in a broader range of contexts, both within and outside of cultures with a history of use. The processing of bamboo also shifts its perceived value by transforming bamboo into a new material with high durability and standardised mechanical properties (De Flander 2008). However, to avoid the over-exploitation of bamboo or the degradation of ecosystems to plant bamboo, it is critical that the cultivation and processing of bamboo consider the social, cultural, economic, and ecological impacts at every stage of production (Reubens 2012).

The Grow Your Own City vision is to catalyse the commercial adoption of structurally engineered bamboo for the construction industry of Indonesia. Our approach looks to adopt a whole value chain approach that connects rural village-based agroforestry with the fast-growing urban centres of Indonesia, unlocking a multitude of socio-environmental benefits across the bamboo supply chain. By promoting the uptake of structural engineered bamboo, we look to generate a ‘pull’ factor that will create incentives for rural communities to plant and process more bamboo in existing bamboo supply chains.

A central tenet of the Grow Your Own City project is the notion of restoration. As outlined above, the construction industry has a significant negative impact on the health of our planet through the extraction of resources and the associated emissions in the construction and operation of buildings. The current aspiration for a “sustainable” built environment then shifts the focus to how we define sustainability across the multitude of global contexts and how do

we set thresholds of moderation, excess and waste within the construction industry. Our goal is to champion a new form of construction that regenerates ecological systems rather than degrades. Bamboo is well suited to this vision as its fast rate of growth, annual harvest, and capacity to be grown on degraded land and hold water, make it a pioneer species that can be used to generate rural livelihoods while restoring degraded land.

To achieve this vision, a clear and transparent value chain is a critical first step in demonstrating how cities can be connected to forestry systems. The Bamboo Village Trust and Indobamboo are looking to role model this process by connecting Bamboo Villages in the Ngada regency of Flores with the Indobamboo factory in Bali. Working in collaboration with Cave Urban, Indobamboo has been prototyping a series of pilot projects that demonstrate how engineered bamboo can be used as a structural building product. By creating a vertical value chain from harvest to construction, Indobamboo and its associated partners can ensure quality control and transparency, demonstrating how multiple SDGs can be achieved in this process, in particular SDG 1: No Poverty, 5: Gender Equality, 8: Decent Work and Economic Growth, 9: Industry, Innovation and Infrastructure, 11: Sustainable Cities and Communities, 12: Responsible Consumption and Production, 15: Life on Land, and 17: Partnerships for the Goals.

Over the past 10 years, there has been a growing awareness of the opportunities presented by engineered bamboo, and particularly it's potential as a structural building product. Through the work of various research and commercial institutions the development of standards and in particular ISO standards has been a key step towards creating products that can be structurally certified. Indobamboo has been working closely with several champions in this field, in particular Dr Mateo Gutierrez, Dr David Trujillo, Bob Kilpatrick and Atelier One to test and verify its products. A key learning from this process has been the importance of quality control once products become structural. Through the support of Partnerships for Forests (P4F) and Partnerships for Growth (P4G), the Grow Your Own City initiative will continue to conduct this research in cooperation with Indonesia's Ministry of Public Works and Public Housing (PUPR) and the National Research and Innovation Agency (BRIN).

The vision of the Grow Your Own City partnership to catalyse the commercial adoption of structurally engineered bamboo is not something that can be done in isolation by a single entity. It requires cooperation between industry, research institutions, government agencies, advocacy bodies and funding organisations to achieve. Similarly, the work we are doing in Indonesia is not unique. We acknowledge that organisations such as Rizome or the University of British

Colombia are undertaking similar projects in other contextual settings. As such, collaboration and the sharing of knowledge is also a key component of this process. While the undertaking of research and the development of partnerships is critical to achieving the vision outlined above, there is also a need to look outwards and raise awareness within broader communities through proofs of concept projects that demonstrate the viability of structural engineered bamboo as a building product.

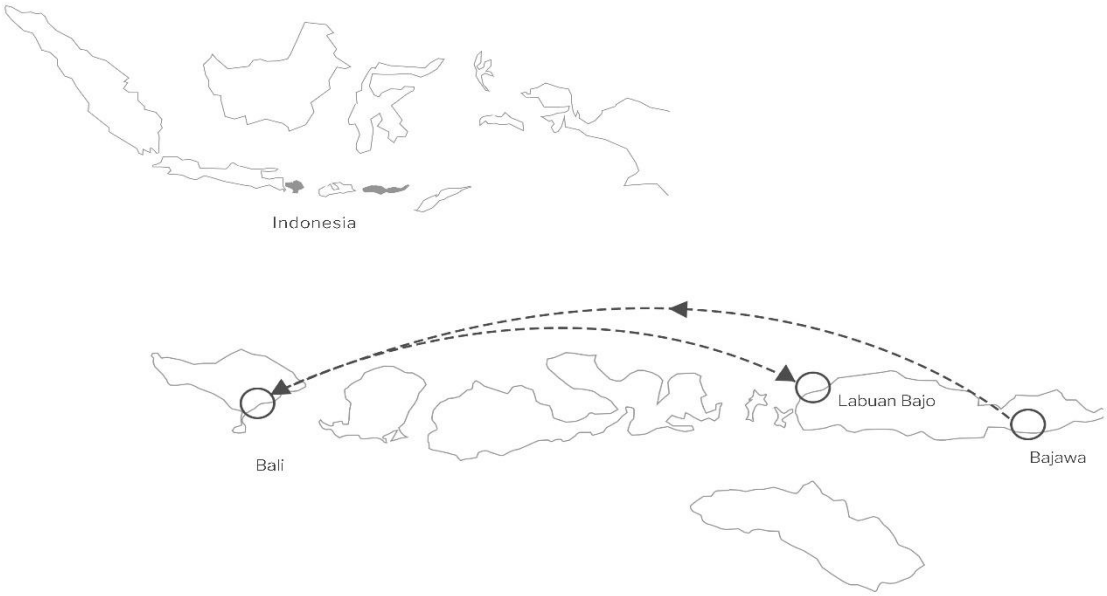

Fig. 1. Value Chain for Labuan Bajo Pavilion (Image: Indobamboo)

A most recent example of this process is a pavilion designed and constructed for the Labuan Bajo Tourism Authority. Run as a design-build collaboration between Indobamboo and Cave Urban, the project drew upon prior experience building laminate bamboo structures in Indonesia and Australia. The project site sits in the hills above Labuan Bajo, the entry point to Flores. Built from locally harvested bamboo, the pavilion serves as a demonstration of how rural farmers in Flores can grow bamboo that can be transformed into a standardised construction product for contemporary design. The pavilion is designed to serve as a demonstration of how structurally engineered bamboo could be used for mass timber construction. Designed as a kit of parts the columns, beams and wall panels were prefabricated at the Indobamboo factory and then shipped to Labuan Bajo for assembly onsite. Built in 3 weeks, the pavilion was constructed from $6m^3$ of laminate bamboo, resulting in 9.9 tonnes of CO_2 sequestered in the product.

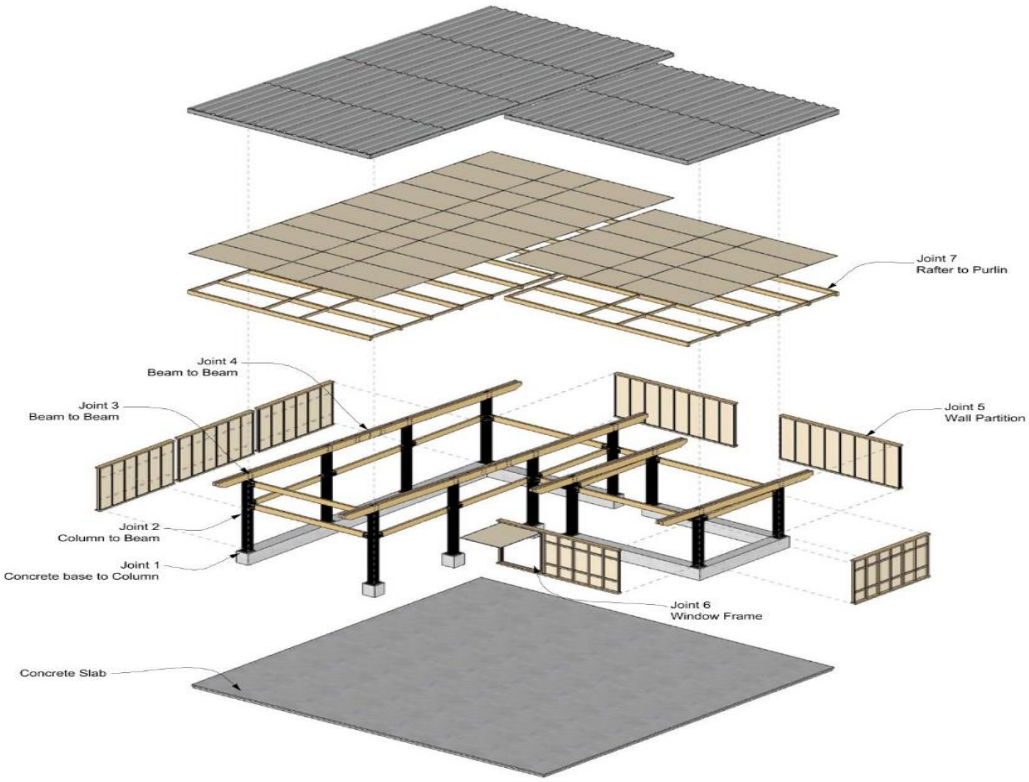

Fig. 2. Exploded Axonometric of the Pavilion (Image: Cave Urban)

The structure also has a 16kw solar panel array on the roof, making the building carbon-negative for both construction and operation. It has been well received by the client and they are already planning additions to be made to the building. The building serves as a showcase for how new construction in Labuan Bajo can be made from locally sourced bio-based building materials that restore rather than degrade the local environment.

Fig. 3. Connection Details (Image: Jed Long)

Building on the success of the Labuan Bajo project, Indobamboo and Cave Urban currently have a further 5 buildings underway for construction in 2024 in Bali and Australia. The goal of these upcoming projects is to refine the prefabrication process for quick assembly on site and to demonstrate how laminate bamboo can be used as a durable and standardised material for contemporary construction.

Fig. 4. Labuan Bajo Pavilion Stage 1 (Image: Jed Long)

The Grow Your Own City partnership is at the beginning of its journey but is building upon the prior experience of Indobamboo and Cave Urban alongside the global efforts of other bamboo pioneers. Through collaboration the partnership aims to encourage further uptake of structurally engineered bamboo within Indonesia and in overseas markets. To achieve these goals, concurrent efforts are being taken to develop new regulations and standards, create new technical knowledge, demonstrate proof of concept and promote engineered bamboo to increase awareness in the wider construction industry. Through the vertical integration of the bamboo value chain from harvest to construction, it is possible to showcase the latent potential of bamboo to become a key bio-based building material and solution to the overwhelmingly negative ecological impact of today's built environment.

Conflict of Interest

The authors declare there is no conflict of interest

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