Bamboo in a temperate climate: what potential for integration and application(s) in sustainable, low-carbon, and circular architecture?

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1. Introduction

1.1. Context and background

Europe aims for a circular, carbon-neutral economy with energy-efficient buildings by 2050. The construction sector must increase renovation rates to 3% annually, using low-impact, long lifespan materials with high reuse and recycling potential [1]. Biobased materials, particularly wood, are seen as eco-friendly alternatives. However, pressure on forest resources calls for new solutions. Bamboo, with high productivity and diverse architectural uses in South America, Asia, and Africa [2], could be a viable alternative in Europe [3,4]. Nevertheless, its cultivation in temperate European climates and use in construction remain underexplored [4]. Europe's energy renovation goals will drive a significant demand for thermal insulation, creating a strategic opportunity for the construction sector to expand bamboo use, which, due to its wood-like properties [5], is a promising alternative for new applications.

1.2. Goal of the research

The research aims to (1) demonstrate the sustainable cultivation of bamboo species in temperate climates and (2) show their potential contribution to Europe's goals for sustainable and circular renovation. Aligned with the ambitions of the Strategic Innovation Initiative ValBoWal [6], the first goal focuses on the Walloon region in Belgium, with its temperate climate, its diverse soils, landscapes, and growing interest in bamboo cultivation and bio-based materials. The second explores bamboo's potential for insulation applications, studying all parts of the plant (stems and leaves) in various forms.

2. Description of the methodological steps

The research is structured into four methodological steps, as shown in Figure 1. Currently, it focuses on the first step "Potential for the integration of bamboo species in a temperate climate." A selection of bamboo species was made based on a literature review, using two key criteria: adaptability to the Walloon context and favourable morphological traits. Building on this and following the structure of the *Fichier Écologique des Essences* [7], the current step involves developing detailed species profiles that outline their ecological requirements, local morphological traits, and physiological behaviour. Data compiled will serve as a basis for creating a database of species potentially suitable for construction applications, as well as for mapping potential cultivation zones in Wallonia. The map will rely on a cross-analysis between the

ecological needs of the selected species and regional characteristics. Data used for this territorial analysis will be sourced from institutional databases, including the Royal Meteorological Institute of Belgium (RMI) [8], the Walloon State of the Environment [9], and the Geoportal of Wallonia [10] in addition to literature review.

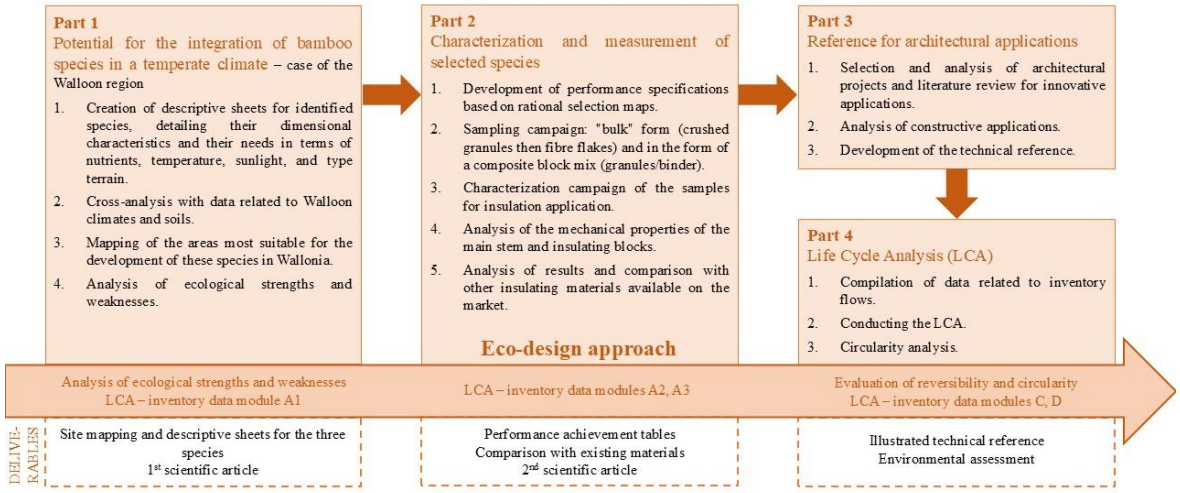

Figure 1. Diagram outlining the methodological steps of the research project – Source: A. Romboux

3. Preliminary studies and early findings

The first research step has already been investigated in preliminary works. Among fifty species from the *Phyllostachys* genus [11], known for their adaptability to temperate climates, three have been identified for their constructive potential: *P. edulis*, *P. iridescens*, and *P. makinoi*. A first cross-analysis, based exclusively on literature, led to a preliminary mapping of bamboo cultivation areas in Wallonia, highlighting agricultural landscapes of the northwest as the most favourable (cf. Figure 2). In addition, the ecosystem services of bamboo were analysed in relation to those cultivation areas, which face various ecological challenges and could benefit from bamboo's services, such as soil stabilization, reduced runoff, land restoration, and contributions to climate change mitigation through carbon sequestration [2,12].

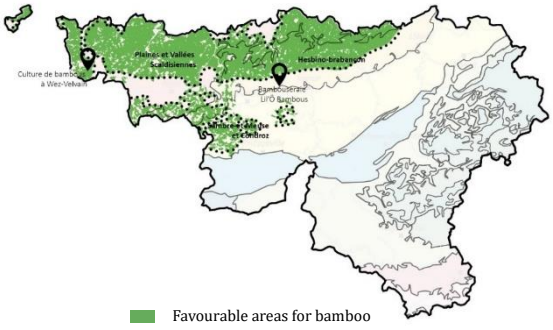

Figure 2. Favourable areas for bamboo development in Wallonia – Results of preliminary studies - Source: A. Romboux

However, to justify its large-scale introduction, further studies are needed to assess the impact of bamboo species on local biodiversity and ecosystems [13], along with life cycle and circularity

analysis. Despite promising results, scientific gaps remain regarding their specific ecological requirements, as well as their morphological and physiological characteristics in local conditions.

4. Conclusions et perspectives

The goal of this research is to highlight the feasibility of bamboo cultivation in European temperate climates and its potential applications in construction for a more sustainable and circular architecture. The first step focuses on identifying bamboo species suited to local conditions and assessing their ecological relevance. Three species have been selected for their adaptability to the Walloon climate and their morphological traits suitable for construction applications. A first mapping of cultivation areas has been produced, and the ecosystem benefits of this crop have been analysed. Despite these promising results, scientific gaps remain regarding the specific ecological requirements of these species and their performance under local conditions. Ongoing work involves developing descriptive species sheets for each species, based on literature, in situ measurements and expert interviews to refine mapping and deepen understanding of local behaviour. The next step will explore their potential for thermal insulation applications by analysing physical properties and insulating performance in different forms and processing techniques. These findings will support the development of sustainable, bio-based materials aligned with European goals for renovation and circular economy.

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