Additive Manufacturing from Bioresource Materials for Innovative Construction: A Systematic Review

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The study highlights the promising use of renewable materials in 3D printing such as flax, wood, and bamboo. These materials have demonstrated potential for lightweight construction components, architectural elements, customized panels, and sustainable composite structures produced through additive manufacturing techniques such as FDM, FFF, SLA, and ILF. These solutions enable the integration of additive manufacturing with advanced architectural geometries, replacing traditional materials with lower-impact bio-based alternatives and creating optimized, adaptable components. Key challenges include the need for consensus on large-scale production of 3D-printed elements in construction through standardized parameters and codes, as well as further studies on durability and performance under adverse conditions and in both structural and non-structural applications.

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INTRODUCTION

The construction sector has increasingly demanded innovative manufacturing approaches capable of producing complex geometries, reducing material waste, and improving sustainability in building processes. Within this context, Additive Manufacturing (AM), also known as 3D printing, has emerged as a technology that transcends conventional boundaries in the development of functional products and prototypes, (Lauxen Spohr *et al.* 2021). With the growing interests, industries and governments for products derived from renewable and sustainable resources, 3D printing processes using wood-based materials have emerged (Fazekas *et al.* 2023). Despite notable examples such as Smart Dynamic Concrete, XTree, TotalKustom, and WinSun, the incorporation of AM into routine construction practices remains limited. This hesitation is associated with the conservative nature of the sector and with technical, economic, and social challenges that still need to be overcome, reinforcing the need for strategic innovations to enable its adoption (De Schutter *et al.* 2018). In practical construction scenarios, additive manufacturing is not necessarily expected to completely replace conventional systems. Hybrid approaches combining 3D printing with timber, steel, concrete, prefabricated panels, and engineered wood products may represent more realistic and technically viable solutions for large-scale implementation. In this context, additive manufacturing can be particularly advantageous for customized components, architectural details, non-structural elements, and geometrically complex parts integrated into broader construction systems. Several studies have been designed using concrete for construction (Paolini *et al.* 2019).

Additive Manufacturing is a key technology for high-precision manufacturing, enabling the creation of complex geometries through layer-by-layer fabrication based on computer-aided design (CAD) models (Estakhrianhaghighi *et al.* 2020).

Among these technologies, different additive manufacturing approaches have been applied in construction, including material extrusion techniques such as Fused Deposition Modeling (FDM) and Fused Filament Fabrication (FFF), vat photopolymerization methods such as Stereolithography (SLA), powder-based systems such as binder jetting, and sheet lamination approaches such as Laminated Object Manufacturing (LOM). To provide a systematic overview of these relationships, a conceptual classification framework is proposed, as illustrated in Fig. 1.

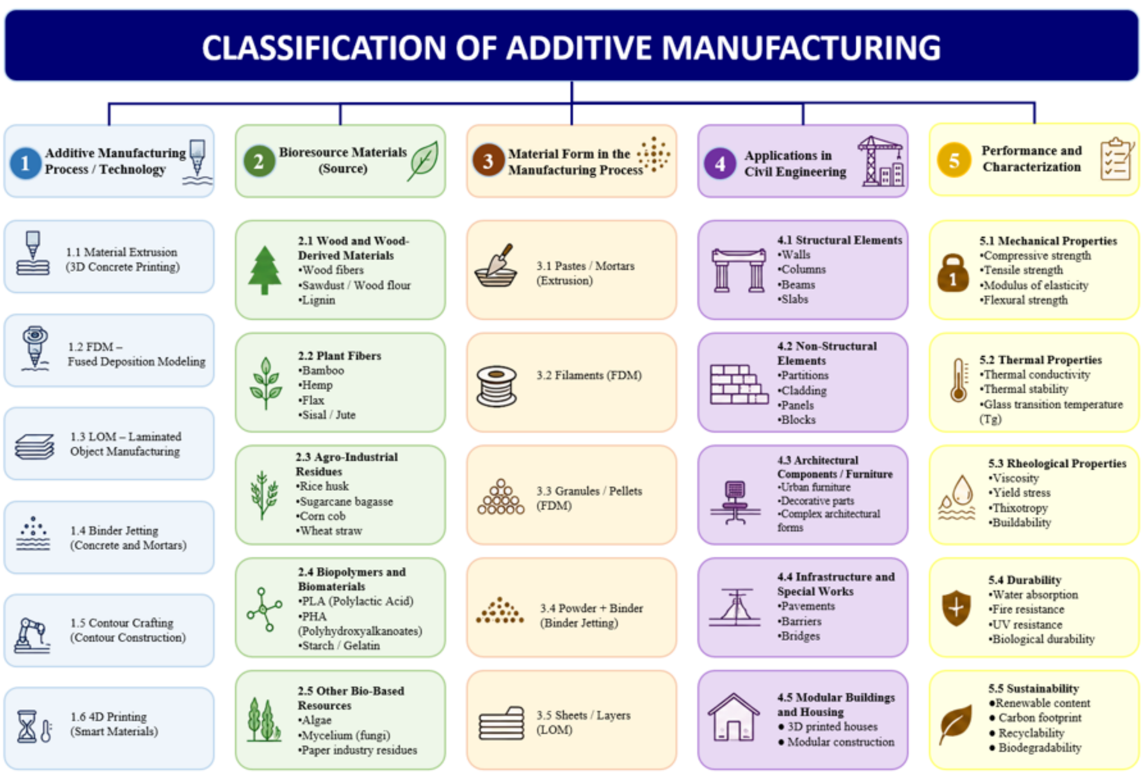

Fig. 1. Proposed classification framework of additive manufacturing applied to civil engineering using bioresource materials

Fused Deposition Modeling (FDM) stands out due to its simplicity, reliability, accessibility, multi-material capability, and adaptability to new materials and composites, making it one of the most widely used techniques in 3D printing (Estakhrianhaghighi *et al.* 2020). In this process, the filament is extruded through a nozzle to form successive layers, which can be achieved through fused deposition, piston-based, or screw-based approaches (Gardan *et al.* 2025). FDM technology is commonly employed to fabricate thermoplastic structures, with recent studies highlighting incorporation of lignocellulosic biomass particles, such as wood flour, sawdust, and other plant-derived fillers, into Polylactic acid

(PLA) matrices (Bhagia *et al.* 2021). These materials consist primarily of cellulose, hemicellulose, and lignin, which together contribute to the sustainability and functionality of the resulting composites. Among these constituents, cellulose is particularly noteworthy due to its high mechanical strength, renewability, low cost, and biodegradability, making it one of the most promising reinforcing components for the development of green biocomposites (Estakhrianhaghighi *et al.* 2020).

The use of biodegradable plastics such as PLA addresses the need to replace non-biodegradable materials with more sustainable alternatives. PLA is widely applied in FDM technology and in the production of composites reinforced with lignocellulosic materials, aligning with global strategies for bio-based materials (Bhagia *et al.* 2021). In this context, Estakhrianhaghighi *et al.* (2020) developed a methodology for incorporating wastewood-based fibers into PLA, producing sustainable filaments (WF-PLA) with thermomechanical properties and innovative cellular microarchitectures, demonstrating the potential of low-cost waste in advanced material development.

Despite the global presence of 3D-printed concrete structures, technical challenges remain due to limitations in high-performance cementitious materials. Techniques such as Active Rheology Control (ARC), Active Stiffness Control (ASC) and Digitally Fabricated Concrete (DFC) are expanding the material applicability and improving the cost-effectiveness, although further studies are required to validate these advances. Additionally, Laminated Object Manufacturing (LOM) stands out for its speed and cost-efficiency in making solid objects, highlighting the potential of additive manufacturing to enhance both timber and concrete construction (Gardan *et al.* 2025). Challenges in concrete additive manufacturing include balancing support capacity and fluidity to prevent defects such as cold joints. The use of viscosity-modifying additives, such as bentonite, has shown promising results, increasing structuring rates and improving cohesion and buildability (Hasse *et al.* 2020).

The transition toward sustainable construction is driven by the need to reduce environmental impacts. Additive manufacturing contributes by enabling the use of eco-efficient materials, reducing waste, and minimizing the use of formwork.

In this context, bioresource-based materials have attracted increasing attention due to their renewable origin, lower embodied energy, biodegradability potential, and compatibility with circular economy principles. Natural fibers and lignocellulosic residues also represent promising alternatives for reducing dependence on petroleum-based materials while promoting the valorization of agricultural and wood-processing by-products. Additional advantages include reduced material waste during fabrication, potential weight reduction of printed components, greater architectural flexibility, and the possibility of producing customized geometries with lower environmental impact. These characteristics reinforce the growing interest in applying bioresource-based composites in sustainable construction systems (Paolini *et al.* 2019; Landes and Letcher 2020; Zhang *et al.* 2021; Fazekas *et al.* 2023). The main environmental, technical, and economic advantages associated with the integration of bioresource-based materials and additive manufacturing are summarized in Fig. 2.

Materials such as clay and earth have gained prominence due to their low environmental impact and potential negative carbon footprint. In this context, the rheological behavior of materials is critical, and the use of additives, artificial intelligence, and computational tools supports the optimization of mechanical and functional properties.

When dealing with anisotropic materials such as wood, factors such as geometry, layer orientation, and deposition sequence influence performance. Thus, stratoconception combined with 4D printing emerge as innovative solutions, enabling the creation of complex and responsive structures. This article addresses developments in Additive Manufacturing with a focus on sustainable wood-based materials for construction. Despite several studies, the literature still lacks coverage on bioresource, including composition, processing parameters and scale.

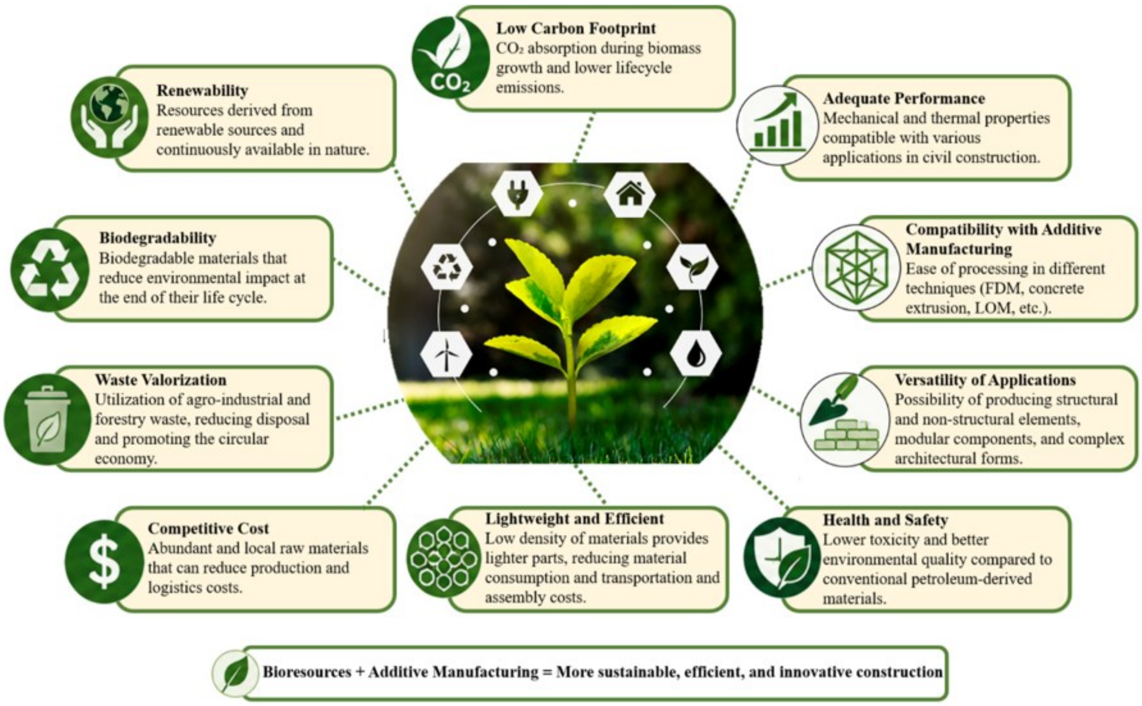

Fig. 2. Main environmental, technical, and economic advantages of combining bioresource-based materials with additive manufacturing for sustainable construction applications

To address this gap, this work presents a Systematic Literature Review (SLR) that consolidates dispersed knowledge and establishes connections between material behavior, manufacturing processes, and structural applications. This integrated perspective becomes a key contribution to support the development of efficient, sustainable, and technically reliable solutions, facilitating the advancement and adoption of additive manufacturing in the construction industry (Binega Yemesegen and Memari 2023; Gardan *et al.* 2025).

EXPERIMENTAL

Methodological Context

The Systematic Literature Review (SLR) is a structured scientific method, aimed at the search and analysis of articles within a specific scientific field. This method allows for the mapping of published works, enabling the synthesis of existing knowledge on the topic (Conforto *et al.* 2011; González and de Toledo 2011; Fernandes *et al.* 2016; Cuer *et al.* 2019). SLR was adapted from the framework proposed by Conforto *et al.* (2011). The review was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which provide recommendations to ensure clarity, transparency, and methodological rigor for SLRs (Conforto *et al.* 2011).

Classified as a theoretical-conceptual study, the article focuses on conducting a SLR, categorizing itself as exploratory with a quantitative approach. This approach is present in the classification and analysis of bibliographic data using quantitative methods (Munaretto *et al.* 2013). The structuring and categorization of data related to the topics addressed in the research follow an inference logic, utilizing an inductive analysis method (de Benedicto *et al.* 2012). Bibliometric analysis is a meta-analytical tool that reveals connections between articles by examining the frequency of citation of an article in other articles, demonstrating significant research areas for any specific topic (Page *et al.* 2022). This review was structured according to bibliometric and bibliographic analyses for each observed topic.

Conducting the SLR Protocol

The conduction of the Systematic Literature Review (SLR) was based on the model proposed by Conforto *et al.* (2011). Thus, this review process comprises three fundamental stages: retrieving existing studies from the academic database; applying bibliometric analysis methods to identify statistical attributes and the structure of the research field; and conducting content analysis to define the focus, themes, and gaps in the research.

Input

The construction of the search strategy (strings) followed a process of selection, testing, and adjustments, through the combination of terms and the use of Boolean search operators. To define the bibliographic contribution, the Scopus database was used, which offers publications from journals and research by influential scholars (Van Eck and Waltman 2010), Web of Science, ScienceDirect, and CAPES Periodicos platform journals.

To make the search process more systematic, the problem and the objective to be achieved were defined. Given the above information, primary sources were adopted along with some inclusion, qualification, and search method criteria as outlined in Table 1.

Table 1. Structured Input Parameters for the Systematic Literature Review

Section and Topic	#	Checklist and Content Description based on PRISMA 2020
Title	A	Systematic Literature Review on additive manufacturing in construction based on bioresources
Objectives	B	To map and analyze the additive manufacturing of buildings using bioresource-based materials
Information Sources	C	Scopus, Web of Science, ScienceDirect, and CAPES Journals
Search Strategy	D	Three search strings for each database (See details on Table 3)
Eligibility Criteria	E	Inclusion: English- and Portuguese-written publications from 2010 to 2025 related to 3D printing and bio-based construction
		Exclusion: reviews, theses, unrelated themes.
Selection Process	F	Six filters: (1) year; (2) language; (3) document type; (4) area of concentration; (5) title/abstract/keywords; (6) abstract, introduction, and conclusion
Data Collection	G	Manual download and organization of articles. Extraction of metadata (*e.g.*, authors, keywords, materials, technologies, *etc.*)
Data Items	H	Elements extracted: country, year, type of material, manufacturing technique, and co-occurrence of terms
Synthesis Methods	I	Descriptive synthesis and bibliometric mapping using VOS viewer software and qualitative categorization of content

Processing

Inclusion and exclusion criteria were used to limit consideration to the most relevant articles. Filter 1 established the period from 2010 to 2025 to observe the evolution of studies related to Additive Manufacturing of bioresource-based construction. Filter 2 considered articles written in English and Portuguese to assess both national and international ambits. Filter 3 categorized articles according to relevance to the scope. Filter 4 identified the areas of concentration on Additive Manufacturing and bioresources in construction (Appendix Fig. A1). The management of the selected documents in the databases used Rayyan Software. By this software, the identification and removal of duplicate articles was done. After, Filter 5 stage involved a thorough reading of the title, keywords, and abstract of the articles. To finalize the selection, Filter 6 involved reading the abstract, introduction, and conclusion (Appendix Table A1). The exclusion criteria were established based on incompatibility (Table 1).

To be included in the final sample, articles had to: (i) address concepts related to civil construction and additive manufacturing as the main topic, (ii) address aspects related to bioresources and product/service offering of construction systems, and (iii) address the context of additive manufacturing technologies. Articles that did not meet these criteria were excluded (Wu *et al.* 2016; Xiao *et al.* 2018).

Output

Articles that met the selection criteria were retrieved and retained in a spreadsheet file (.ris). This file was imported into VOSviewer, whose software was utilized. This tool enables the creation of networks through distance-based maps (Van Eck and Waltman 2010). The bibliographic coupling is used to perform various analyses such as documents, journals, authors, *etc*. The "bibliographic coupling" or "documents" was used as the unit of analysis and the method employed was "fractional counting". All data was tabulated. Bibliographic coupling and co-occurrence analysis were discussed. The most cited articles in a specific domain can be identified and visual graphs of the citations can be obtained, as followed by Van Eck and Waltman (2010), to define the state of the art on the subject.

RESULTS AND DISCUSSION

Bibliometric Analyses

Input impact

According to the established structure, the articles were classified into three categories of search strings. The sequence of criteria application is presented in Table 2.

Processing outcomes

Continuing with the SLR, the filters described were applied for document selection, as detailed in Table 3 (Scopus, ScienceDirect, Web of Science, and CAPES Journals).

After Filter 5, a total of 62 articles remained. The percentage distribution of selected articles from each database was as follows: Scopus, 5% (3 articles); ScienceDirect, 85% (53 articles); Web of Science, 5% (3 articles); and CAPES Journals, 5% (3 articles). Upon importing all articles into Rayyan, this software automatically identified some duplications, which were subsequently excluded. The remaining articles were manually, alphabetically organized to facilitate the identification of titles. This process resulted in the identification and removal of 4 duplicate articles.

Table 2. Search Criteria and Results According to Scientific Database

	Scopus	ScienceDirect	Web of Science	CAPES Journals
Search String 01	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”)
RESULTS	**4.707**	**20.146**	**3.458**	**5.330**
Search String 02	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”)
RESULTS	**16**	**1.104**	**8**	**25**
Search String 03	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)
RESULTS	**3**	**463**	**3**	**3**

From Filter 5, 58 articles were selected. The resulting distribution was: duplicates, 6% (4 articles); included, 23% (14 articles); and excluded, 71% (44 articles). Sequentially, the no-compliance of Filter 5 criteria justified the removal of non-aligned studies (e.g., automotive, electronics, software, pharmaceuticals, healthcare, and biology). Filter 6 was applied to 14 articles selected from Filter 5, which resulted in a total of 10 articles in the final sample, where: Scopus, 0% (0 articles); ScienceDirect, 70% (7 articles); Web of Science, 10% (1 article); and CAPES Journals, 20% (2 articles).

Overview of the sampled literature - Output

The construction of relationship topics between the inclusion criteria and the selected articles was carried out through the application of filters and criteria using the Rayyan software. Figure 1 highlights the interconnection of the research object, a systematic literature review on the use of Additive Manufacturing in bioresource-based constructions, with the databases Scopus, ScienceDirect, Web of Science, and CAPES Journals.

Table 3. Applying the Filters and Results According to Scientific Database

	Scopus	ScienceDirect	Web of Science	CAPES Journals
***FILTER* 01** Period	2010-2025			
RESULTS	**3**	**463**	**3**	**3**
***FILTER* 02** Language	English and Portuguese			
RESULTS	**3**	**463**	**3**	**3**
***FILTER* 03** Document	Scientific Articles			
RESULTS	**3**	**289**	**3**	**3**
***FILTER* 04** Concentration	Engineering Materials	Engineering	Architecture Civil Engineering	Does not apply
RESULTS	**3**	**53**	**3**	**3**
***FILTER* 05** Reading: Title, Abstract, and Keywords	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)
RESULTS	**1**	**10**	**1**	**2**
***FILTER* 06** Reading: Abstract or Introduction and Conclusion	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)	(“additive manufacturing” OR “3D printing”) AND (“construction” OR “edification”) AND (“renewable resources” OR “biodegradable materials”) AND (“bioresources” OR “biomass” OR “wood” OR “bamboo”)
RESULTS	**0**	**7**	**1**	**2**

The systematic review approach allowed for the understanding of the applied tools and the initiation of studies on the application of Additive Manufacturing (AM) based on bioresources in the construction sector.

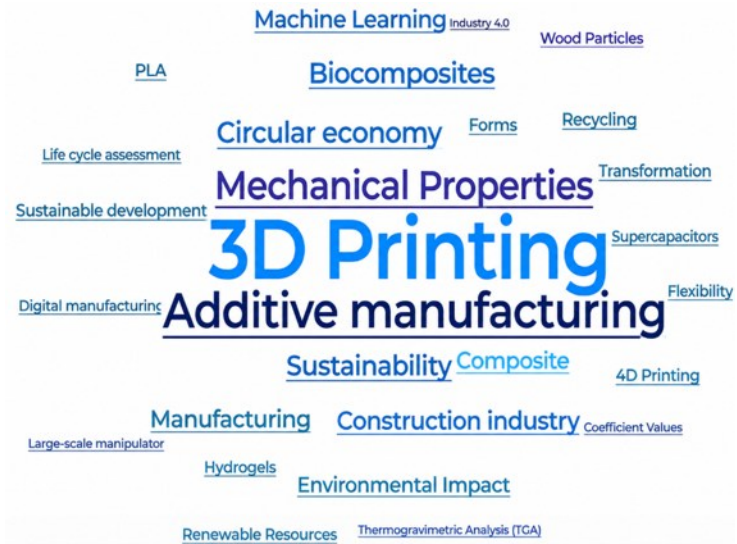

Fig. 3. Relationship map of the topics of the selected articles

Regarding the number of documents published per year, considering the exclusion of review studies, Fig. 4 reveals that academic production in this area remained at one publication per year between 2016 and 2020. A higher concentration of publications was observed in 2021, when four studies meeting the established criteria were identified. Although the distribution of publications remained irregular in the following years, the results still indicate growing scientific interest in additive manufacturing applications based on bioresources for construction. This trend indicates a significant rise in attention to AM in recent years, demonstrating the active involvement of researchers in developing efficient methods for successful construction applications.

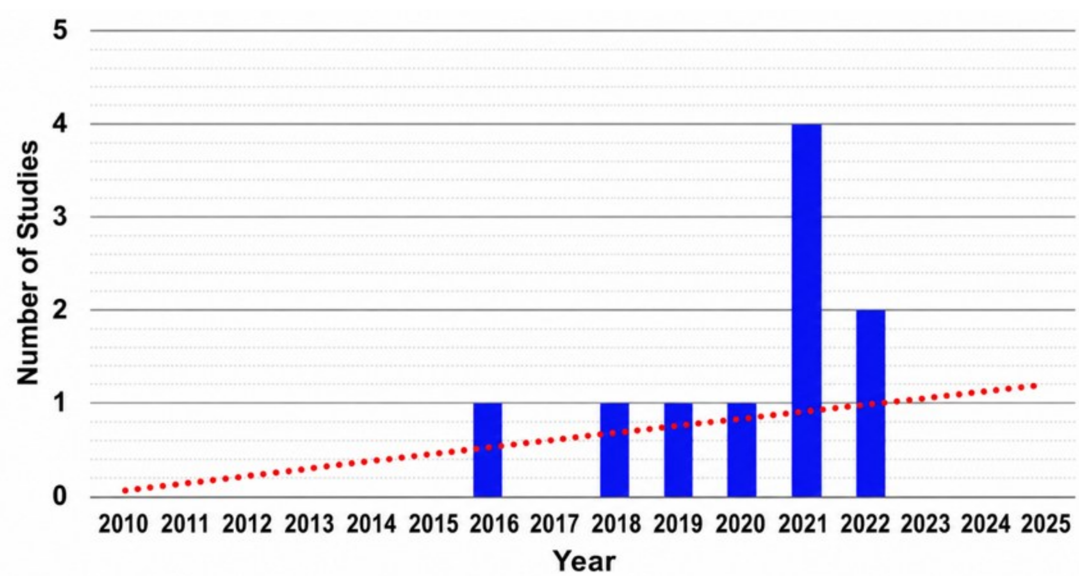

Fig. 4. Historical trend of studies published on AM (period 2010–2025)

The absence of publications in 2024 and 2025 in the final sample is associated with the strict eligibility criteria established in this review, especially the specific focus on bioresource-based additive manufacturing applied to construction. Although broader studies on additive manufacturing continue to be published, many recent works did not meet all inclusion criteria adopted in the present SLR. The low and irregular frequency of publication still comes up against the high cost of additive technologies, becoming an impediment to access to academic laboratories.

Table 4 highlights the articles from nine journals that served as dissemination channels for Additive Manufacturing (AM) methods based on the use of bioresources in construction. The distribution of studies is almost evenly divided among journals in the fields of civil and architectural engineering, sustainability, and materials science. Given the limited number of publications, it is evident that the topic still has received only limited interest.

Table 4. List of the Top 10 Journals on AM for Sustainable Construction

JOURNAL TITLE	Publication Number	Total Percentage of Publications	Year
Materials & Design	2	20%	2021
Journal of Materials Science	1	10%	2022
Journal of Building Engineering	1	10%	2022
Structures	1	10%	2021
Polymers	1	10%	2021
Journal of composites science	1	10%	2020
Renewable Energy	1	10%	2019
Composites Science and Technology	1	10%	2018
Composites Part B: Engineering	1	10%	2016

Bibliographic coupling analysis

The bibliographic coupling map set of documents that share the same bibliographic reference for categorization across the four analyzed databases. Figure 5 presents the group of authors who follow more or less the same line of research. Authors positioned close to each other on the map are involved in the same article, indicating collaboration or co-authorship. On the opposite end are authors who pursue a more distinct research line and are consequently positioned farther apart on the map.

A total of 10 clusters were identified, indicating the presence of 10 groups of authors that are not interconnected. The closer clusters share similar bases, while clusters at the extremities use a more distinct bibliographic base. Of the 48 items, only 6 show a connection, as illustrated in Fig. 6. These connections do not necessarily represent direct collaboration among research groups, but rather indicate that the corresponding studies cite one or more references in common. The network layout, including node positions and the curvature of connecting lines, was generated automatically by VOSviewer based on the strength of bibliographic coupling. As a result, some curved links may visually overlap or appear to pass near intermediate clusters. These apparent intersections are solely a consequence of the software's automatic optimization and do not imply additional or indirect relationships between the clusters involved.

In some cases, the observed relationships may also reflect similarities in database searches, recurring keywords, and the use of common reference sources within the additive manufacturing research field. Therefore, the principal contribution of this analysis is to reveal the extent to which the literature is either consolidated around shared scientific foundations or fragmented into distinct and relatively independent lines of investigation.

In another analysis (Fig. 7), overlay provided a temporal perspective. Clusters with a more yellowish color indicate more recent periods, while those with a bluish tone represent older periods. Hinchcliffe, Hess, and Srubar III use an older data source, as Chen, Ni, Liu, Xia, and Gao are more recent and likely utilize a more updated data source (Fig. 7).

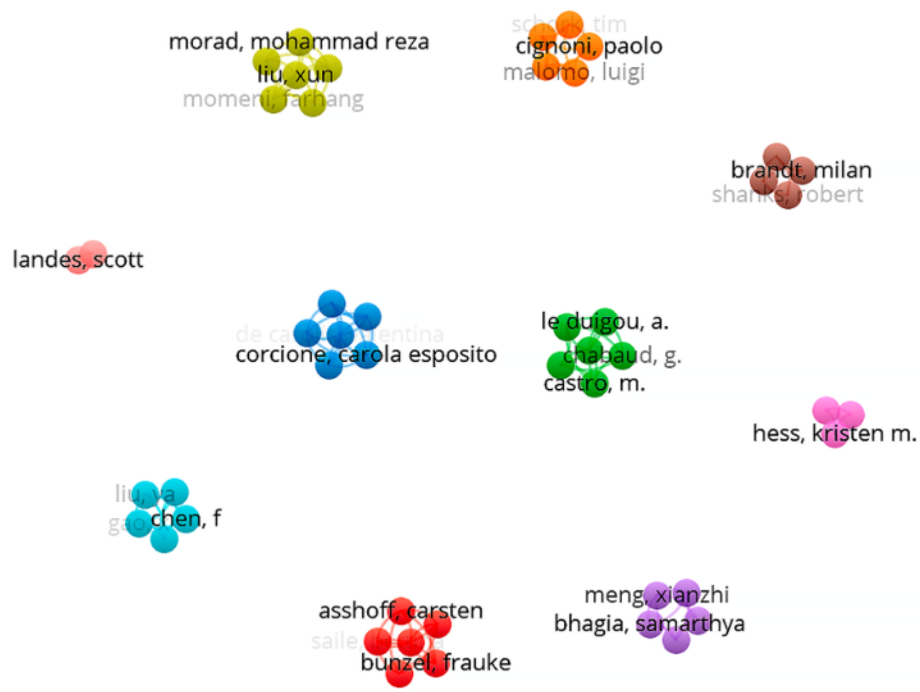

Fig. 5. Main clusters of authors on bioresource-based AM

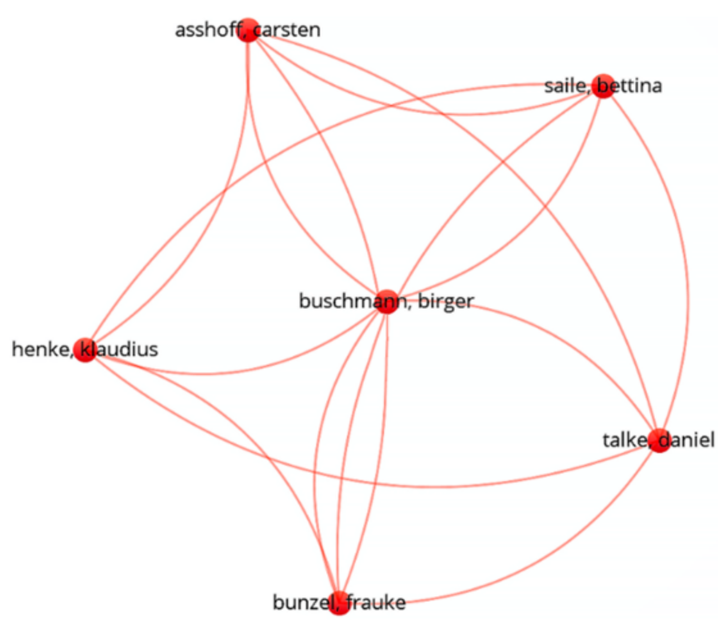

Fig. 6. Cluster of interconnected authors on bioresource-based AM

In the bibliographic coupling analysis based on co-citations, a link was established between two articles when both were cited by the same document. The analysis conducted considered references with a minimum of one citation within the set of all articles. Based on references, the network mapping highlights that the larger spheres represent a greater number of citations, reflecting the strength of the link. Conversely, smaller spheres indicate fewer citations associated with reference. This dispersed configuration is typical of emerging and multidisciplinary research areas, where different groups address similar challenges using diverse materials, processing strategies, and analytical methods. This can be confirmed by the studies of Le Duigou, Fruleux, Matsuzaki, Chabaud, Ueda, and Castro, as well as the work of Zhang, Bhagia, Li, Meng, and Ragauskas, both published in the Materials & Design journal. This can be explained by the different geographic location of each group of authors, highlighting the influence of regional characteristics on the diversity of approaches adopted to solve the problem in question.

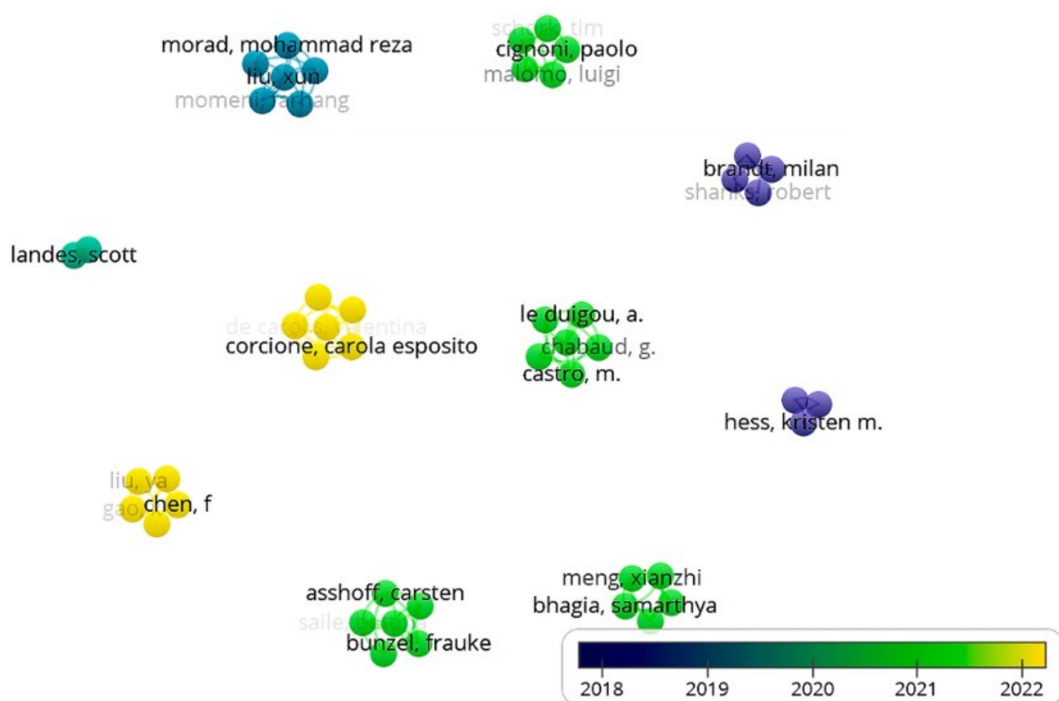

Fig. 7. Chronology of the main bibliographic references

Keyword co-occurrence analysis

The keyword co-occurrence network analysis is a distance-based map representing the strength of the relationship between two keywords (Zaalouk *et al.* 2023). However, the presentation of labels is repetitive. To overcome this limitation, the text-based data carried out by the VOSviewer software – through a multiple assessment, using the Scopus, ScienceDirect, Web of Science, and CAPES Journals databases – allows the analysis to be performed from Title and Abstract, Title only, or Abstract only. The selected option was Title and Abstract, as this approach uses the most significant and frequent terms, making it more representative. The analysis considered binary counting, meaning only the presence or absence of a term in a document, is relevant, without accounting for the number of occurrences. The visualization of the term network map was configured for a minimum of three occurrences (Fig. 8).

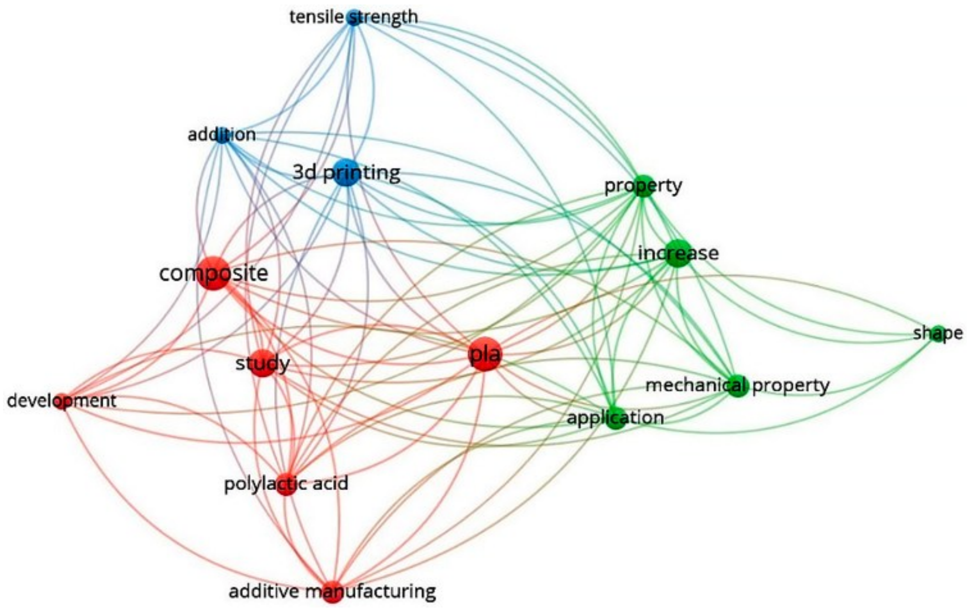

Fig. 8. Main research areas in bioresource-based AM

From initial 409 terms, 14 were selected with 60% relevance. This relevance threshold was adopted to prioritize the most representative and recurrent terms within the dataset, reducing the influence of low-frequency expressions with limited contribution to the interpretation of the research trends. The selection procedure also improved the readability and organization of the co-occurrence network generated by the VOSviewer software.

The term network map revealed the presence of three clusters (Fig. 8): Cluster 01 and Cluster 02 each consist of 3 items, while Cluster 03 comprises 2 items. The most frequent terms were “increase” (5 occurrences), “additive manufacturing” (4 occurrences), and “mechanical property” (4 occurrences).

Among the 14 terms identified by the VOSviewer software, those with the highest relevance were “development” (2.63), “additive manufacturing” (1.64), and “tensile strength” (1.10). All terms have at least one interconnection, with the term “application” being centrally positioned and connected to all others. The associative analysis between the frequency of occurrence and the degree of relevance reveals that the term “additive manufacturing” stands out in both aspects, indicating ongoing research on the application of additive manufacturing.

A temporal spindle map was generated to illustrate changes in the research field over time (Fig. 9). Each node represents the average year in which the keyword is being used in literature. It is observed that studies related to the application of bioresources in additive manufacturing have gained momentum in recent years, particularly since 2020.

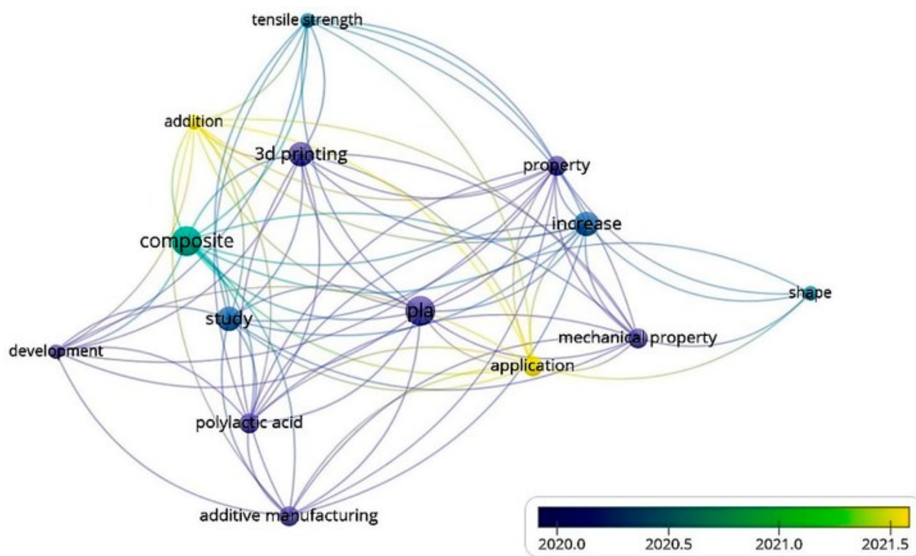

Fig. 9. Chronology of the main research areas

Analysis of influential countries

Using Microsoft Excel as an analytical tool and based on the contributions of countries regarding the authors, the objective was to explore which nations exert the greatest influence in the field of Additive Manufacturing research in bioresource-based constructions and the distribution of scientific publications in this area.

As illustrated in the chart presented in Fig. 10, the United States, Italy, Australia, and Germany emerge as the leading nations in this research field. Together, these countries play a crucial role in promoting research and development at the intersection of 3D printing and the use of bioresources, specifically wood, in construction. Their contributions have a direct influence on the evolution and global acceptance of these innovative technologies, shaping the future of sustainable construction. Regarding the advancement of this technology in the United States, substantial investments in research and development by both the public and private sectors justify this prominence. Both Europe and Asia have four representations, while the Americas have only one nation.

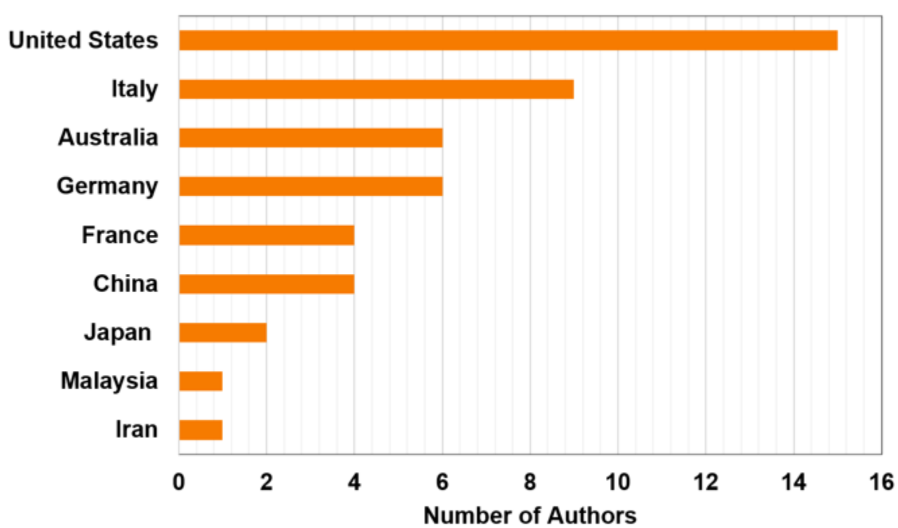

Fig. 10. Network of influential countries in bioresource-based AM research

Bibliographic Analyses

With the completion of the SLR steps, the selected articles were read in full to identify the country where AM was applied according to each author, the supply chain, tools used, and contributions made. For better understanding, Appendix B was prepared to provide a summary of the classification of the selected articles, including method, type of research, country, application scope, and the contribution of each item.

A complete review of the selected articles, as shown in Table 4, showed that most studies are concentrated in the United States (3 articles) and, therefore, most of the authors are from that region (Fig. 10). This concentration reflects the greater popularization of wood as a predominant material in civil construction, extending from structural to architectural aspects, enhancing its acceptance, and becoming a reference in the technological sector, influencing the adoption of new trends.

Five articles explore the application of wood in additive manufacturing. This emphasizes the growing use of this resource as a central element in construction systems, supported by studies that highlight its mechanical properties. These findings corroborate the focus of this research, with a total of nine works dedicated to this analysis.

Regarding the bioresources mentioned in the selected works, while reed and flax are lightweight and flexible textile fibers, wood is a denser and more structural material. Each has distinct characteristics and applications depending on the specific needs of a project or product. Flax was included in the present review because it appears frequently in studies involving natural fiber-reinforced composites and bioresource-based additive manufacturing applications, particularly due to its favorable mechanical properties, low density, and compatibility with biodegradable polymeric matrices. Like reed and flax, bamboo is a plant-based fiber classified as grass, but it has unique characteristics compared to these materials.

As for the type of filament used in 3D printers, polylactic acid (PLA) was employed in five of the included articles. The choice of PLA stems from its role as a more sustainable alternative to traditional plastics, being compostable under appropriate conditions and having a lower environmental impact than petroleum-based plastics.

The microstructural analysis of bioresources was addressed in seven articles. This analysis is crucial as it allows for detailed observation of the morphology and structure of materials on a microscopic scale across various dimensions.

The incorporation of renewable and biodegradable materials, such as flax, wood flour, bamboo, and cocoa shell waste, as reinforcements in the development of filaments for 3D printing, is still a relatively recent approach (Daver *et al.* 2018).

Investigations have been conducted to optimize the mechanical properties of polylactic acid (PLA). Hinchcliffe *et al.* (2016) employed an approach that combined PLA with additive manufacturing (3D printing) techniques, along with post-tensioning of natural fibers such as natural jute and flax yarns. The use of continuous yarns of these fibers, together with the inclusion of post-tension ducts in 3D-printed PLA samples, resulted in PLA-natural fiber composites in an initially compressed state.

The tests demonstrated notable improvements in specific tensile strength, stiffness, specific flexural strength, and rigidity compared to unreinforced PLA. The validation of the theoretical model confirmed an accuracy above 90%, emphasizing the effectiveness of the combined approach (Hinchcliffe *et al.* 2016).

Considering the analysis of mechanical properties, Daver *et al.* (2018) developed biodegradable cork-polylactic acid (PLA) filaments designed for Fused Deposition Modeling (FDM), an additive manufacturing technique. The addition of cork granules resulted in a reduction in tensile strength but promoted an increase in impact resistance. In the same research context, Landes and Letcher (2020) created a PLA composite filled with bamboo powder as a reinforcement material instead of fibers. The AM process using the Fused Filament Fabrication (FFF) technique was employed to produce parts with four raster orientations, demonstrating satisfactory results with minimal defects.

Sustainable bamboo natural reinforcement fibers offer an eco-friendly option to compete with other composites. Specifically, bamboo-infused PLA for AM is a topic with limited available data (Landes and Letcher 2020).

Le Duigou *et al.* (2021) explore the scenario of 4D printing in material manipulation, focusing on the Hygromorph BioComposite (HBC). The adaptation of 4D printing technology to this specific material opens up prospects for the development of sophisticated metamaterials with sequential responses. Composed of flax fibers and biodegradable matrices, HBC is significant due to anisotropic hygroscopic properties and bio-inspired architecture. The authors emphasize the sustainability of HBCs as smart materials derived from local renewable resources, promoting low environmental impact. The projected application in architectural and construction projects, particularly in zero-energy façades, highlights environmental awareness in material selection.

A comparison with wood-based hydromorphic materials reveals a discrepancy in equalization time due to the absence of vascular capacity in HBCs. The ability to control actuation kinetics using the same material but with distinct architectures opens possibilities for complex design and sequential transformation of HBCs (Le Duigou *et al.* 2021).

Among the bioresources used in additive manufacturing, wood stands out as a renewable resource that has gained increasing popularity as a raw material. The use of wood not only makes the process more accessible but also contributes to reducing environmental impact. Zhang *et al.* (2021) address the use of residues from industrial wood processes as fillers in thermoplastic matrices, such as polyethylene, polypropylene, and polystyrene, to produce wood-plastic composites (WPCs).

The study conducted by Buschmann *et al.* (2021) describes the production of thin panels (ILF) with individual contours using wood composites additively manufactured through binder jetting. The researchers produced various panels, manually stacked, and subsequently laminated with epoxy resin. The wood composite panels, made from spruce chips and adhesive, achieved a flexural strength of 52.4 MPa, meeting the mechanical requirements for use in the European construction industry.

Laccone *et al.* (2021) adapted the FlexMaps technique for configuring small-scale structured objects, specifically spiral mesostructured panels. This adaptation aims to achieve differentiated local stiffness through precise control of spiral parameters. A free-form structure was fabricated using 15 mm thick milled plywood panels, highlighting the substantial potential of this approach for architectural innovation. Despite the significant potential impact of bioresource-based additive manufacturing in construction, there is still a lack of consensus regarding large-scale production of 3D printed objects.

Zhang *et al.* (2021) were pioneers in incorporating wood flour into wood-plastic composites (WPCs) printed using Stereolithography (SLA) 3D. Their study presented satisfactory results for mixtures with 1 to 2% wood flour in methacrylate resin through simple blending, demonstrating a significant increase in the strength of the SLA-produced composites for complex and high-resolution WPC manufacturing.

Fico *et al.* (2022) proposed the design and characterization of an innovative composite for the Fused Filament Fabrication (FFF) process, composed of polylactic acid (PLA) and different amounts of olive wood chips, suitable for the rehabilitation of works of art in proportions of 10% and 20% by weight. The bio-filaments developed in their study are not considered suitable for structural/construction applications but are intended for the production of ornamental elements or the rehabilitation of non-structural objects.

Chen *et al.* (2022) attribute this limitation to the inadequate dispersion of wood residue (powder) in the PLA matrix and poor adhesion. They observed that the effects of different treatment methods on the crystallization, thermal, and mechanical properties, as well as the hydrophobicity of WF/PLA composites, can influence the results.

However, it is important to highlight that the environmental benefits obtained from using wood chips, especially those from olive trees, align with the European stance on the transition to a circular economy (Fico *et al.* 2022). Considering the premises of employing bioresources in construction systems from an environmental perspective, researchers' efforts to present sustainable alternatives are evident.

Momeni *et al.* (2019), observing the evolution of plant leaf vein patterns over time, culminating in a stable and ideal architecture to withstand environmental stresses, developed a project and fabrication of wind turbine blades with a laminar structure inspired by plant leaf networks using the 4D printing process. Although some analyzed aspects require improvement, the blade, still in the simulation phase, shows potential for relatively reduced internal deformation energy, higher static strength and rigidity, lower stress intensity, and greater fatigue durability compared to conventional blade structures. Additionally, it enhances aeroelasticity and simplifies turbine control.

The pursuit of solutions that enable construction using renewable resources, with low greenhouse gas emissions and resulting in high-quality architectural outcomes, is growing. They include efficient structural approaches that leverage material properties. The fields of Additive Manufacturing, Architectural Geometry, and Advanced Processing offer new perspectives to address some of these challenges (Laccone *et al.* 2021).

Trends in Additive Manufacturing Properties on Composite Materials

Appendix B was built to identify common features among studies and evaluate the correlation between printing parameters and the mechanical properties of materials. The analyzed parameters include technology type, printing speed, nozzle and layer thickness, nozzle and build plate temperature, and print orientation, focusing on the use of natural fibers such as jute, flax, bamboo, cork, and synthetic reinforcements in polylactic acid.

In civil engineering studies, FFF/FDM technologies were the most adopted, both based on thermoplastic filament extrusion, typically PLA. SLA technology was also used, enabling higher precision and surface quality, while ILF appeared less frequently due to higher costs. Overall, FFF/FDM showed advantages in productivity, whereas SLA offered superior accuracy for detailed components.

The results indicate that the mechanical properties of PLA composites reinforced with natural fibers are strongly influenced by printing parameters. Variables such as printing speed, temperature, and layer thickness directly affect part quality and strength, as demonstrated by Le Duigou *et al.* (2021) and Daver *et al.* (2018). Higher speeds may reduce manufacturing time but compromise surface quality and dimensional accuracy, as also discussed by Laccone *et al.* (2021).

Layer thickness plays a critical role: smaller values improve resolution, while larger ones reduce tensile and flexural strength due to increased porosity and reduced interlayer adhesion, consistent with findings by Chen *et al.* (2022). Similarly, excessive printing speed negatively impacts mechanical performance due to reduced layer adhesion, as observed by Buschmann *et al.* (2021).

Temperature control is essential to ensure proper material flow and adhesion between layers. While higher temperatures improve extrusion, excessive values may degrade mechanical properties, as reported by Fico *et al.* (2022). Similarly, inadequate thermal control may intensify porosity formation and reduce interlayer cohesion, directly affecting structural integrity and dimensional stability. These effects become particularly important for large-scale construction components exposed to variable environmental conditions.

The incorporation of natural fibers, such as wood, bamboo, and flax, generally enhances tensile and flexural properties, particularly when combined with optimized printing parameters. This effect is supported by studies from Hinchcliffe *et al.* (2016) and Landes and Letcher (2020), and depends on fiber–matrix compatibility. Treatments to improve interfacial adhesion further enhance composite performance, as suggested by Le Duigou *et al.* (2021). In addition, characterization techniques such as thermal analysis, rheological evaluation, tensile and flexural tests, and microstructural observations have been widely employed to assess filament quality and printing performance. These analyses contribute to understanding the relationship between processing conditions and the mechanical behavior of bioresource-based composites for construction applications.

The analysis of tensile strength, Young's modulus, and elongation demonstrates that fiber addition and print orientation significantly influence composite behavior. Fibers aligned at 0° tend to improve tensile strength, while additives such as tributyl citrate may reduce strength and increase elongation (Daver *et al*. 2018). Overall, fiber-reinforced PLA composites exhibit higher stiffness and mechanical resistance than pure PLA, although challenges related to fiber dispersion, interlayer adhesion, and preservation of base material properties remain significant. In addition, differences in printing orientation, layer thickness, filament composition, and environmental exposure may lead to variations in performance, reinforcing the need for standardized procedures and long-term durability assessments for structural applications. Most available studies are still restricted to laboratory-scale specimens and short-term evaluations, while creep behavior under sustained loading remains insufficiently investigated. Furthermore, direct quantitative comparisons with conventional structural materials, such as solid wood and engineered wood products, are still limited due to differences in manufacturing methods, testing procedures, and specimen configurations adopted across the literature.

The integration of natural fibers into 3D printing materials represents an important advancement toward more sustainable construction systems. These composites combine reduced environmental impact with improved mechanical performance, supporting the development of lightweight and efficient components, as highlighted by Le Duigou et al. (2021). In addition, additive manufacturing enables the fabrication of complex and customized geometries, contributing to innovative architectural and structural solutions in civil construction, as discussed by Laccone *et al*. (2021).

Although most studies follow ASTM and ISO standards for mechanical testing, there is still a lack of standardization regarding printing parameters such as orientation, thickness, and speed. Existing standard codes, including International Organization for Standardization ISO/ASTM 52939:2023 and ISO 17296 series, address general aspects of additive manufacturing but do not fully cover emerging challenges related to material variability, life cycle assessment, and large-scale applications (Gardan *et al.* 2025).

Thus, optimizing printing parameters combined with the incorporation of natural fibers enables the development of composites with improved sustainability and mechanical performance. Future research should focus on material combinations, process optimization, and standardization to expand the applicability of additive manufacturing in construction.

The Systematic Literature Review provided an understanding of the applications of Additive Manufacturing, particularly 3D printing, in civil construction, especially within the context of bioresources. The results highlight the importance of understanding the morphology and performance of bioresources, with a concentration of studies in the United States and PLA identified as the most commonly used filament.

An increasing trend in the incorporation of renewable materials, such as wood flour, bamboo, and flax, was observed, aiming to improve the mechanical performance of PLA-based composites. Advances also include studies on biodegradability and the development of innovative materials, such as Hygromorph BioComposites (HBC), reinforcing the potential of sustainable solutions in additive manufacturing. Wood is recognized as a promising renewable resource for 3D printing applications, although challenges remain for large-scale production.

CONCLUDING STATEMENTS

1. The mechanical and thermal characterization of composites reinforced with natural fibers, such as jute and wood, demonstrates strong potential to replace conventional materials, contributing to sustainability. Poly(lactic acid) (PLA) composites reinforced with natural fibers show significant improvements in stiffness and strength, essential for structural elements in construction, while reinforcing the potential of bioresource-based materials for sustainable additive manufacturing applications.
2. The reviewed studies indicate that these materials maintain adequate thermal stability for 3D printing, representing viable and environmentally friendly alternatives. The incorporation of biodegradable materials, such as bamboo powder and wood flour, also contributes to waste reduction and circular economy strategies, supporting the development of lower-impact construction materials and reducing dependence on petroleum-based resources.
3. Advanced approaches such as 4D printing demonstrate promising potential for developing adaptive architectural and structural systems capable of responding to environmental stimuli and improving functional performance. These technologies may contribute to innovative design strategies focused on energy efficiency, lightweight structures, and customized construction solutions.
4. Despite the promising advances identified in the literature, important challenges remain regarding large-scale production, standardization of printing parameters, long-term durability, and regulatory development for construction applications. In addition, limitations associated with interlayer adhesion, environmental exposure, and variability in mechanical performance still require further investigation.
5. Variations in printing orientation, layer thickness, filament composition, and environmental exposure may significantly influence the mechanical performance of printed components, reinforcing the need for standardized testing procedures and long-term performance assessments. These aspects are particularly relevant for future structural applications under real service conditions.
6. Future research should focus on construction-scale applications, economic feasibility, durability under service conditions, life-cycle assessment, and sustainability analyses

involving material consumption, waste generation, and environmental impacts. Additional studies addressing creep behavior, structural reliability, and large-scale manufacturing protocols are also necessary to support broader industrial implementation.

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APPENDIX

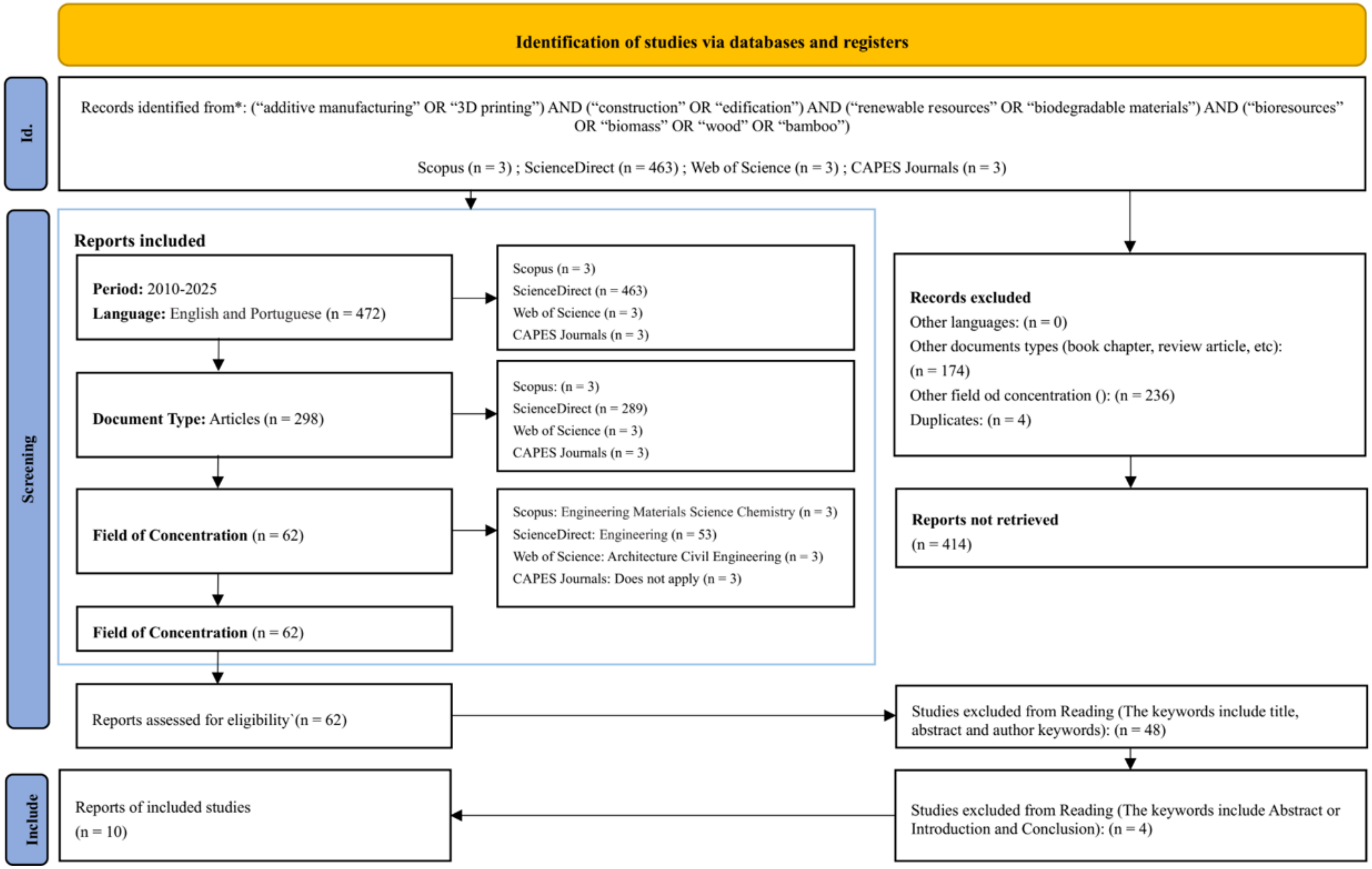

Fig. A1. PRISMA 2020 flow diagram based on protocol

Table A1. List of 10 Filtered Papers (Filter 6) of Research Contribution in AM

Id	Author	Classification	Contribution of the Article
1	Hinchcliffe, Sean A.; Hess, Kristen M.; Srubar, Wil V. (2016)	**Method:** Relationships between tensile and flexural strength-to-weight and stiffness-to-weight ratios **Type of Research:** Experimental **Country:** United States of America (USA) **Application Scope:** More efficient structural forms and continuous pre-tensioning of natural fiber reinforcement	This article highlights the improvement of the mechanical properties of polylactic acid (PLA) through 3D printing and the pre-tensioning of natural fibers such as jute and flax. A significant increase in strength, stiffness, and weight-to-stiffness ratio of PLA was demonstrated, with enhancements of up to 116% in tensile strength and 62% in stiffness, as well as 14% in flexural strength and 10% in rigidity compared to unreinforced solid PLA. Furthermore, an accurate theoretical model was developed to predict the mechanical behavior of these composite materials, which has significant implications for the customized and sustainable manufacturing of products.
2	Daver, Fugen; Lee, Kok Peng Marcian; Brandt, Milan; Shanks, Robert (2018)	**Method:** Characterization of mechanical, thermal, and morphological properties **Type of Research:** Experimental **Country:** Australia **Application Scope:** Fused Deposition Modeling (FDM)	The article describes the development of biodegradable cork-PLA filaments for 3D printing. Different composite compositions were tested, showing that the inclusion of cork specifically affected the mechanical properties: tensile strength decreased, but impact resistance improved. The use of a plasticizer, tributyl citrate (TBC), made the composites more flexible. The 3D printing of these composites showed subtle differences compared to compression molding, including a slightly lower elasticity modulus but greater elongation at break. This has implications for the manufacturing of biodegradable products using the FDM technique.
3	Momeni, Farhang; Sabzpoushan, Seyedali; Valizadeh, Reza; Morad, Mohammad Reza; Liu, Xun; Ni, Jun (2019)	**Method:** Wind tunnel tests, CFD, and performance analysis **Type of Research**: Experimental **Country:** United States of America (USA) and Iran **Application Scope:** Wind turbine blade that mimics leaf architecture	In this study, scientists observed that the veins of plant leaves have an optimized architecture that not only serves their biological functions but also supports environmental loads. They found that wind turbine blades designed to mimic this architecture exhibit advantages such as lower internal deformation, better static strength, reduced stress, and greater durability compared to conventional blades. The study proposes a new paradigm for the design and manufacturing of wind turbine blades using 4D printing technology, which combines beneficial attributes in a single blade. These blades mimic the structure of plant leaves, feature reversible curve-twist coupling, and address vibration challenges. This could lead to the development of more efficient, eco-friendly

Id	Author	Classification	Contribution of the Article
			wind turbines, demonstrating their applicability through wind tunnel tests and performance analyses.
4	Landes, Scott; Letcher, Todd (2020)	**Method:** Mechanical strength characteristics through tensile, flexural, compression, impact, and shear tests **Type of Research:** Experimental **Country:** United States of America (USA) **Application Scope:** Sustainable reinforcement materials for thermoplastic composite materials	The contribution of this article lies in the investigation of an eco-friendly composite material, additively manufactured, using polylactic acid (PLA) reinforced with bamboo. The study demonstrates that this composite exhibit mechanical strength comparable to certain bamboo fiber-reinforced plastics produced through conventional methods. Additionally, the research identifies that a raster angle orientation of 0° is the most effective for improving performance across various test categories. This suggests a more sustainable alternative for the construction and manufacturing of composite materials, leveraging renewable resources and additive manufacturing methods.
5	Buschmann, Birger; Henke, Cláudio; Talke, Daniel; Saile, Bettina; Asshoff, Carsten; Bunzel, Frauke (2021)	**Method:** Mechanical properties of the intermediate product (panels) **Type of Research:** Experimental **Country:** Germany **Application Scope:** Wood Composite Panels for Individual Layer Fabrication (ILF)	This article focuses on the introduction and detailed description of the additive manufacturing process known as "Individual Layer Fabrication (ILF)" using wood composite materials. The ILF process involves the additive manufacturing of wood composite panels, allowing the application of mechanical pressure to enhance mechanical strength and reduce the amount of binder required. The article also explores the mechanical properties of these wood composite panels, highlighting their suitability for use in the European construction industry due to the observed flexural strength. Additionally, these panels exhibit lower binder content compared to other additively manufactured wood composites. This represents a significant advancement in the production of sustainable and cost-effective structural materials using wood as a renewable resource.
6	Zhang, Shuyang; Bhagia, Samarthya; Li, Mi; Meng, Xianzhi; Ragauskas, Arthur J. (2021)	**Method:** Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), Gel content measurement **Type of Research:** Experimental **Country:** France and Japan	This article describes the use of poplar wood flour in 3D printed composites with methacrylate resin. The results show improvements in the mechanical properties of the composites, such as tensile strength and Young's modulus, with the addition of wood flour. Additionally, the study identifies a phenomenon of "whitening under stress" and discusses its possible causes. Overall, the article contributes to the effective use of wood flour as reinforcement in 3D printed products.

Id	Author	Classification	Contribution of the Article
		Application Scope: High-resolution manufacturing of complex and reinforced WPC (Wood Plastic Composites)	
7	Laccone, Francesco; Malomo, Luigi; Pietroni, Nico; Cignoni, Paolo; Schork, Tim (2021)	**Method:** FlexMaps method design and Structural Analysis **Type of Research:** Computational Design **Country:** Italy and Australia **Application Scope:** Design and manufacturing of complex plywood structures	The article describes a computational design framework that enables the development of flexible architectural structures with arbitrary curves. This framework involves a series of methods that allow the creation of complex 3D structures using flat 2D panels, whose mechanical properties can be locally adjusted through embedded spiral patterns. The resulting panels act as elements with variable stiffness and are optimized to achieve a desired shape after assembly. The article covers all stages, from design to digital fabrication, for creating architectural objects. The potential of this framework was demonstrated through an architectural-scale prototype, highlighting the successful integration of architectural design, computational simulation, structural engineering, and digital fabrication, paving the way for new applications in the construction sector.
8	Le Duigou, A.; Fruleux, T; Matsuzaki, R.; Chabaud, G.; Ueda, M.; Castro, M. (2021)	**Method:** Composite production by Fused Filament Fabrication (FFF) / Mechanical property characterization / Microstructure observations / Moisture absorption and hygroscopic expansion / Bending curvature analysis **Type of Research:** Experimental **Country:** France and Japan **Application Scope:** Sustainable metamaterials	The article addresses the application of 4D printing to create sustainable metamaterials using Hygromorph BioComposite (HBC), a material composed of flax fibers with hygromorphic properties. The study demonstrates that choosing an appropriate matrix, such as Polybutylene Succinate (PBS), can significantly enhance the transformation performance of HBCs. Furthermore, 4D printing with layer height control allows for local control of thickness and stiffness ratio, while variation in filament distance in the passive layer offers the opportunity to create smart surfaces with uneven reactivity. The article also proposes programming the spatial distribution of flax fibers to introduce heterogeneities in the microstructure, paving the way for the development of advanced materials with the ability to change shape in response to sequential stimuli.
9	Chen, F; Ni, XH; Liu, YA; Xia, XH; Gao, X (2022)	**Method:** Treatment methods in crystallization, thermal and mechanical properties, and hydrophobicity of WF/PLA composites	The study focuses on improving the properties of biodegradable polylactic acid (PLA) and wood flour (WF) composites, which face challenges related to poor dispersion and adhesion of wood flour in the PLA matrix. To address this, treatment methods were

Id	Author	Classification	Contribution of the Article
		Type of Research: Experimental **Country:** China and Malaysia **Application Scope:** PLA/WF composite materials combining humid air at high temperature (220°C), silane coupling agent A-187, and acetic anhydride with PLA, employing heat treatment (HT) and esterification methods	employed, including high temperature, a silane coupling agent A-187, acetic anhydride, as well as heat treatment (HT) and esterification. The results indicate that the combination of these methods reduced the crystallinity of the composites, improved the compatibility between WF and PLA, and resulted in a significant increase in tensile and flexural strength of the heat-treated composites compared to the untreated ones. Furthermore, the addition of heat-treated esterified WF to the WF/PLA composites in filament production for 3D printing demonstrated improvements in plasticization properties and cost-effective strength, suggesting promising future applications in 3D printing.
10	Fico, Daniela; Rizzo, Daniela; De Carolis, Valentina; Montagna, Francesco; Palumbo, Elisabetta; Corcione, Carola Esposito (2022)	**Method:** Analysis of elemental composition, morphology, and crystallinity degree / Rheological analysis / Environmental impacts of composite filaments **Type of Research:** Experimental **Country:** Italy **Application Scope:** Environmental benefits achieved by using olive wood waste as a substitute for conventional biopolymers in filaments for FFF	The article discusses the role of the construction industry in the transition to a Circular Economy (CE) in the built environment, focusing on rehabilitation, which often requires specialized labor. It highlights the use of the Fused Filament Fabrication (FFF) technique, a form of Additive Manufacturing (AM), for this purpose. The study focuses on the development and characterization of sustainable materials to reduce the environmental impact of conventional materials used in FFF, particularly polylactic acid (PLA)-based composite filaments and olive wood waste. These filaments are used in low-cost 3D printing to create initial architectural models based on wood powder. Additionally, a Life Cycle Assessment (LCA) is conducted to evaluate the environmental benefits of composite filaments with wood waste, showing that the inclusion of these wastes in PLA filaments results in a significant reduction in environmental impact (10% reduction with 20% wood), encouraging further research in this field..