Innovation and Resilience Through Bio-artifacts and Circular Design

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CiD

To Manuel Gausa Navarro
with the gratitude of those
who will continue to advance
architecture and design
with open minds.

This book grows out of a series of research experiences we had the privilege of sharing with Manuel, colleague, mentor, and friend.
In those moments, we came to know and appreciate his extraordinary humanity, his intellectual vitality, and his rare ability to combine rigour with curiosity, openness with depth, turning every encounter into a meaningful exchange, and every project into a truly collective learning experience.
His generous and forward-looking vision fostered encounters across disciplines, cultures, and perspectives, leaving a lasting impression on all those who had the good fortune to work with him, the mark of a research practice that was alive, humane, and shared, always accompanied by his distinctive joyfulness and convivial spirit.

Contents

Introduction

Raffaella Fagnoni, Jörg Schröder

In the effort for a transition of our ways to live and habitats to sustainability and resilience, environmental and technological approaches are in the foreground of debates and actions in society and politics. With this book, we aim to advocate for creative and cultural approaches to urban transformation and working with nature, two of the core themes when it comes to realise transition for everyday life. We believe that creativity and culture, in this perspective, can also contribute to enhance innovation – for a green economy, competitiveness, but also social innovation in communities and networks, oriented to advance resilience as forward-looking empowerment and necessary capacity. Thus, we claim that complex urban – and territorial – as well as natural dynamics can be understood and re-directed in the sense of a 'Laboratory of Survival' driven by research as well as emerging practices in society and economy.

Bio-artifacts and Circular Design are brought forward as two major research fields in this context, explored and set in dialogue in a series of research efforts at Università Iuav di Venezia, by the Interactive Design group, and at Leibniz University Hannover LUH, by the Territorial Design group.
This interdisciplinary cooperation has been initiated with the international conference 'Laboratory for Survival' organised by the two groups in June 2023 at Iuav Venice and developed with a joint international research workshop and doctoral colloquium in November 2023 at LUH Hannover. The exchange between the researchers from both part-

ners has been the basis for joint research projects of groups of doctoral candidates, their publications in this book have been validated through an independent peer review process. In the first part of the book, essays from researchers from Iuav and LUH present recent research in the fields of bio-artifacts and circular design (Schröder et al. 2023). In the second part, the research projects of joint groups of doctoral candidates are presented. The highly productive tension and interaction in this joint research and publication, between urban-territorial and design oriented approaches, is set on a stage of circular thinking and circular economy, in order to 'territorialise resilience' (Schröder, 2021).

This research and book has been inspired by and contributes to the work of the EU-project Circular Design Innovation Alliance (CiD). It supports to fill the gap in skills and knowledge about circularity and circular economy in the sectors of architecture, urban design, product/service design. CiD is offering a radically new model on how to link design to circularity and urban transformation, inspired by the paradigm to regenerate environments and living spaces - and not only to recycle materials and use renewable materials. This principle can influence also the uptake and upscaling of design innovation – in a broad sense, across different scales and fields – to transform towards a Circular Economy, since "design is at the core" (Ellen MacArthur Foundation, 2017) to reconfigure all sorts of processes in the material expression of human life.

The essay 'Laboratory of Survival' by Davide Crippa, Raffaella Fagnoni, Annapaola Vacanti (Università Iuav di Venezia) brings a novel perspective for the topic of waste, fundamental in the move towards a circular economy. In a design approach, a new and holistic integration between products, services, territory, culture, and traditions is articulated. The concept of 'Hyperlocal Design' is presented as expression of a paradigm shift towards more localised and human-centred models to build economies, fostering community participation and civic responsibility (Fagnoni et al. 2024). The following three essays position circularity concepts for urban transformation, transferring ideas from a focus on materials to a focus on space. The essay 'Lagoon. Thinking Venice archipelagically' by Alissa Diesch (LUH) offers a cultural perspective on the islands of the Lagoon of Venice, insprired by Edouard Glissant, a Caribbean poet and philosopher. By highligthing hybrisation of cultures and ecosytems, a new understanding for regenerative approaches in the context of circularity is promoted.
The essay 'Venice. A Vision for Sustainable and Circular Transformation' by Federica Scaffidi (LUH) discusses regeneration in the context of circularity with a focus on the re-use of urban space and stresses the role of foundations and associations play as hybrid actors, connecting institutions, citizens, and grassroots practices. The essay 'Venice as stage and medium for ideas of circularity' by Riccarda Cappeller (LUH) is exploring filmmaking as tool and platform for urban knowledge creation in a range from use in

Fig_01
Photo from the “Laboratory for Survival” seminar held at the Iuav University of Venice

education, for research, and for awareness and discussion in society. Its focus is on a reframing of contemporary spatial agency, to understand and work with existing urban space, its trajectories and potential of transformation and circular dynamics involved. The research articles by the interdisciplinary and international groups of doctoral candidates start with ‘Collective eco-innovation. Designers and citizen communities promoting ecological change through informal practices by André Araújo Almeida (LUH/ Mackenzie Presbyterian University Sao Paulo UPM/UNIFOR), Carmelo Leonardi (Iuav), Maria Manfroni (Iuav), and C. Mattia Priola (Iuav). The article focuses on informal methods and open design approaches which can foster small but impactful change realised by community-driven initiatives. Cooperative design practices in promoting sustainable development are examined with a selection of case studies in four categories: bio-communities, low-impact communities, social communities, and self-planning communities. The article ‘Circular Tools and Processes in Architecture and Design: A Shared Framework’ by Massimilano Cason Villa (Iuav), Christian Corral (LUH/UPM), Michele De Chirico (Iuav), and Carmen Digiorgio Giannitto (Iuav) analyses the impact of sustainability assessment tools in the fields of architecture, specifically adaptive reuse and sustainable construction, and product design, with a focus on eco-design for exhibitions and circular prototyping. It asks about the role of these instruments in the formulation of design strategies for the development of a multidi-

sciplinary framework for close-loop projects and research. The article ‘Bridging Circular Design and Territorial Planning through rice waste enhancement: the Ricehouse case’ by Francesca Ambrogio (Iuav), Fernanda Paz Gómez (LUH), Andresa Lêdo Marques (LUH/UPM), Eugenia Morpurgo (Iuav), and Luciana Varanda (LUH/UPM) presents a novel perspective on the actual sustainability of circular processes for biomaterials. Based on a case study of a startup currently producing biomaterials from industrial rice waste that fosters synergies among diverse stakeholders within a circular approach in the Piedmont region of Italy, the article identifies key overlaps, gaps, and opportunities that arise from the integration of bioproducts design, territorial planning, and circularity.

The multidisciplinary approaches and results achieved in these joint research and publication clearly highlight interdependencies in promoting sustainability in a trans-scalar perspective from products and services to territories, combining different fields of knowledge and innovation to bring together design of bio-artifacts and circular transformation. Ultimately, a key outcome of this international collaboration, and of the book itself, was the process through which it unfolded: initiated through mutual study visits and workshops between Hannover and Venice, and developed through over a year of regular long-distance meetings, it led to shared research contributions and the definition of a common methodological framework.

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Fig_02
Remote group photo of the project team

Fig_03
Photo from the workshop held at Leibniz University Hannover, where the Phd students involved in the project presented their

Fig_04_05
Photo from the “Laboratory for Survival” seminar held at the Iuav University of Venice

Bridging Circular Design and Territorial Planning through rice waste enhancement

The Ricehouse case

Ambrogio F., Gomez Paz F., Lêdo Marques A., Morpurgo E., Varanda L.

1. Introduction

Design choices at both micro and macro scales - from product design to interior design to landscape planning - play a crucial role in managing input materials and disposal chains, shaping the circularity and sustainability of processes and territories. These decisions profoundly impact material selection, waste generation, product longevity, urban infrastructure sustainability (De Luca et al., 2017; Bistagnino, 2016), and space. As such, this article explores the intersection of territorial planning and circular design, investigating how these concepts can be integrated in order to promote circularity. Based on the Ricehouse case, a startup enterprise that produces byproducts and promotes collaboration among stakeholders within a circular economy approach, the article aims to identify key overlaps, gaps, and opportunities that arise from the intersection of bioproduct design and territorial planning.
The environmental and climate crises have forced the development of frameworks centered on sustainability across various disciplines. These configurations challenge the traditional take-make-waste industrial model and expose the complexity of interconnectedness and interdependence. The concept of Circular Economy (CE) came into play as a viable tool to shift from the current linear production model, recognised as economically, environmentally, and socially unsustainable, to the adoption of a

circularity framework that has considered "any waste stream as a resource that can be used by sharing, reuse, repair or recycling" (Furlan et al., 2022, p. 32).
Over recent decades, circular production systems have been developed to foster "healthier urban and territorial metabolisms" (Amenta et al., 2022). However, achieving circularity remains challenging, especially when it involves applying circular principles at the territorial level (ibid.).
According to Arsova et al. (2022), current academic literature on CE implementation addressed strategies across three different levels: the micro (i.e., a single company or an individual consumer), the meso (i.e., an eco-industrial park, a supply chain), and the macro (i.e., a city, a province, a region, a nation). From a design perspective (the micro), industrial ecology and symbiosis concepts emerged as having spatial implications and are, therefore, connected to territorial planning (the meso and the macro). According to Van Berkel et al. (2009), "industrial symbiosis" has focused on creating more sustainable systems by closing the loop on material cycles. In this sense, the waste from one facility has been a resource or input for another. Within that notion, geographic proximity has been essential, as it could optimize material flow and has created a network of industries that have worked together to minimise waste and share resources. In other words, industries that traditionally operate independently are brought together to work collectively (ibid.) (Figure 1).

Contemporary research on building materials increasingly moved toward regenerative solutions that complement traditional extractive materials and are centred on environmental sustainability. This focus is based on the ability of the resources used for such materials to regenerate rapidly and offer competitive economic and environmental advantages over conventional

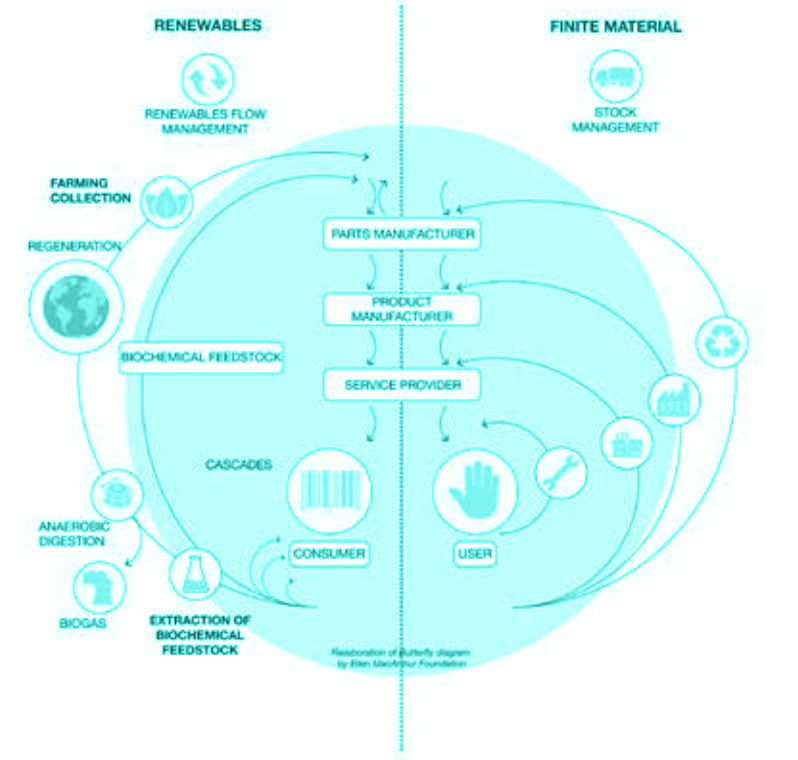

Fig_01
Circular economy systems.
Elaborated by the authors

materials (De Luca, 2019). The concept of regeneration, in this context, implies the adoption of natural resources that, through short life cycles, can be reintegrated into the ecosystem without long-term negative impact.

Within the broad framework of sustainability - understood as the ability to meet the present human generation's needs without compromising future generations' (Brundtland, 1987) - regenerative concepts emerged as central to the relationship between circularity and territory. Various authors have discussed ways to regenerate the territory through sustainable development strategies based on a multidimensional perspective (Alvim et al., 2022; Ceschin & Gaziulusoy, 2019). These approaches highlight that sustainability is not merely a sectoral response to environmental challenges; instead, sustainable development addresses a broader relational issue: the disconnection between civilization and its habitat or territory.
Shifting this paradigm requires a process that Magnaghi (2005; 2011) describes as re-territorialisation. This theory called for local communities to reclaim and manage their territories with autonomy and sustainable practices, moving away from extractive, centralised, and homogenised planning models toward a more self-determined and ecologically aligned perspective.
The reappropriation of territory and the recovery of the capacity to plan space sustainably or circularly also provoked discussion

about the role of spatial planning in transitioning to circular urban and regional developments. As has been stated by Williams (2020), "looping, regenerative and adaptive actions have been central to circular development [and] have designating space and infrastructure supportive of these three circular actions in the city-region is essential for the socio-ecological transition."
However, as Furlan et al. (2022) pointed out, it remains unclear how urban and regional planning could incorporate a circular approach to urban and territorial interventions.
The authors have acknowledged that spatial planning must recognise the importance of scales and locations within the circular economy to ensure structural continuity and systemic flexibility for a future economic system with a "still unknown territorial morphology" (p. 38).
In this context, the contributions of Magnaghi (2005; 2011; 2020) have stood out. The author elaborated a specific approach to the formulation of sustainable development linked to the importance of the territory, integrating issues such as basic needs, self-sufficiency, and eco-development with the growing and relevant role of local and regional development. Within this approach, two concepts are worth highlighting: the 'bioregion' and 'local self-sustainable development,' which reestablish a harmonious relationship between the environment, culture, and history through innovative approaches that have strengthened society's ties to the territory (Magnaghi, 2005; 2011). Both are widely debated within the Territorialist

School and recently at the forefront of the Design discipline.
A bioregion is delimited based on natural characteristics, such as river basins, ecosystems, and landscapes, rather than administrative divisions disconnected from the environmental dimension. In this way, territorial governance is established on respecting and valorising natural cycles and biodiversity, aiming to close biochemical cycles at a regional level, and promoting self-sufficiency in food production, energy, and other resources necessary for everyday life. The latter involved recognising local economies and short production and consumption cycles (Magnaghi, 2020).
The bioregion concept articulated the idea of "local self-sustainable development," derived from the territory's potential and social participation in a constant process of exercising citizenship.
According to Thackara (2019), bioregions have reconnected "us with living systems", such as watersheds, foodsheds, fibersheds, and food systems. The same author also pointed out that a significant challenge for the design process was the shift from a linear to a holistic, socio-ecological approach to agriculture when re-localizing regional food and fiber systems. In this context, farmers were not just producers of agricultural commodities for the city; they became "stewards" of an agroecological system in which water, soil, landscape, energy, and biodiversity are interconnected (ibid.), creating a sustainable agrifood supply chain.
A sustainable agrifood supply chain requires an open, circular system that optimises internal and external output-input processes (Bistagnino, 2012). In this model, reusing agricultural waste became a pivotal opportunity to develop sustainable supply chains, foster local micro-economies, and strengthen the regions and communities from which these byproducts originate. The primary sector and industry have formed new synergies by enhancing agricultural byproducts and promoting sustainability and innovation (European Commission, 2020).
Consequently, "bioregional design" has created value by caring for living systems and reinforcing new local development networks that have enhanced existing resources (Tackara, 2019). Under the bioregion design concept, using agricultural waste materials reduces waste dependence on non-renewable resources. The transition towards circular economic models, in which agricultural waste has become a resource, has been a crucial step towards a more sustainable and resilient economic system (Kirchherr, Reike, & Hekkert, 2017) and, therefore, more sustainable urban and regional developments.
As such, based on a real case study in Italy, where a company connects biomass input producers (rice farmers) with building product manufacturers (among others), this analysis seeks to explore how circularity in bioproduct design and production processes can be incorporated by territorial planning.

Design choices at both micro and macro scales – from product design to interior design to landscape planning – play a crucial role in managing input materials and disposal chains, shaping the circularity and sustainability of processes and territories. These decisions profoundly impact material selection, waste generation, product longevity, urban infrastructure sustainability, and space.

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Morpurgo E., Varanda L.

1.1 Methodology

This research proposes a methodology combining a literature review of theories related to circular and bioregional design with a qualitative case study analysis, focusing on the intersection between territorial planning and circular design.

Specifically, the article examines the case study Ricehouse through a semi-structured interview with the case study's CEO and co-founder Tiziana Monterisi (conducted in August 2024), the analysis of territorial data from the Piedmont region and spatial data on rice crop locations. Diagrams and infographics serve as a shared tool for interpreting and narrating the context under investigation, supporting the overall research aim and providing a higher level of insight.
The analysis results are approached from the perspective of micro, meso and macro scales, with the meso scale being the point of intersection between circular design and territorial planning. The micro-scale addresses the bio-product condition and the circular design perspective; the macro scale explores circularity in planning instruments, and the meso scale accounts for bioregion as the intersection between the concepts.

2. The case study: Ricehouse

Rice is the primary source of nutrition for 66% of the world's population and is cultivated in more than 120 countries, covering all five continents (FAO, 2020). Italy is the largest rice producer in Europe, with a production volume of 1.5 million tons, corresponding to 229.000 hectares (Regione Piemonte & UNISG, 2022).

Figure 2 shows the main areas of rice crops, which are in the Northern region of Italy between the regions of Piedmont and Lombardy, where 92% of rice production is concentrated in approximately 3,400 farms in the districts of Vercelli and Novara (Regione Piemonte & UNISG, 2022). Although rice is an important food source, its cultivation has a negative environmental impact. According to the Centre for the Promotion of Imports from Developing Countries (CBI), rice cultivation is one of the most significant sources of methane emissions, contributing 10 to 12% of global emissions (CBI, 2021). Additionally, irrigated rice farming significantly impacts water use and accounts for 20-40% of the world's freshwater consumption (ibid.).
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Fig_02
Location of rice crop areas in Italy (2018).
Elaborated by the authors based on satellite data from Copernicus, a component of the Earth Observation and Monitoring of the European Union Space Programme.

Company	Rice house
Location	Piemonte (Biella) - Italy
Founding year	2016
Typology	Società Benefit
Type of by-product	Rice hay, rice husk, clay from rice fields, chaff, starches, ashes and waste water from rice boiling
Original supply chain	Rice supply chain
By-product source	Rice farmers and rice processing industry
Waste derivation phase	Rice supply chain
Waste re-use supply chain	Construction supply chain
Stakeholders	Farmers in the rice sector; Building companies; Polytechnic University of Turin;
Values	Building as the 'third skin' of individuals; Sustainability of the process;
Goals	Product competitiveness Extension of the process for the replacement of polluting components in the building industry; Finding other applications for reusing rice husk
Output	Finished products and semi-finished products
Type of output	Panels for thermal and acoustic insulation
Scale	Italy and Europe
Impact	Reducing polluting building products; Recyclable products; Reduction of CO2 emissions from waste combustion

Table_01
Ricehouse's analysis. Elaborated by the authors.

3. Integrated analysis: bioproduct design and territorial planning

The integrated analysis proposed here considers three scales: micro, meso and macro.
The micro perspective dives into the scale of the circular material and product, the macro takes the territorial perspective, and the meso, represented by the bioregion, is where the two disciplines, design and territorial planning, meet, theoretically and in practice.

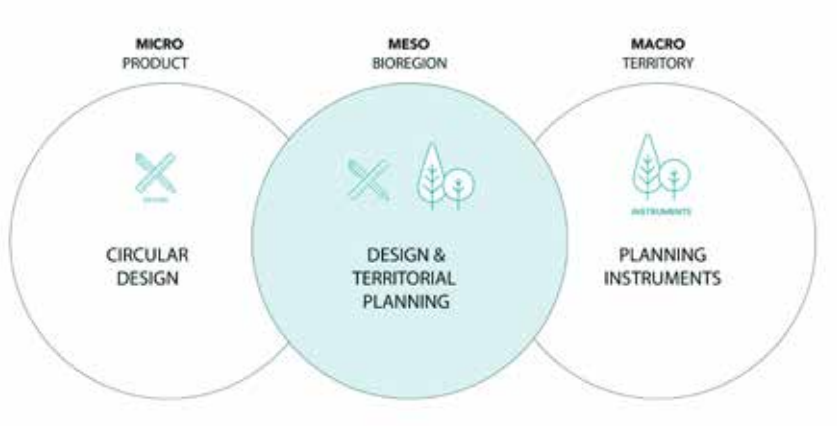

Fig_03
Proposed Integrated Analysis

3.1 micro perspective: Bioproduct Circular Design

Over the years, Ricehouse has built a resilient network of companies, collaborating with small and medium-sized rice producers who supply raw materials such as rice husks, hay, and clay, forming the foundation of Ricehouse's supply chain. This interconnected network enables Ricehouse to collect resources from various stages of rice production for more than twelve companies that process them into materials and components for the construction and design industries. The hay and clay are left in the fields after the harvest. Partner processing companies that clean, cook, and refine rice provide other valuable byproducts: husks, chaff, starches, ash, and wastewater from rice boiling (Figure 4).

Figure 4: Ricehouse conceptual processes. Elaborated by the authors.
The collaboration between research centres and specialised companies has played a crucial role in transforming agricultural byproducts into materials suitable for industrial production. A representative case is the partnership between Ricehouse and Sanmiro, an Italian company based in the province of Lecco, which led to the creation of the RiceUp project in 2020. Through this initiative, rice husks are repurposed within the production of pot handles in a co-branding and co-design effort, ultimately reaching a broad consumer base, in-

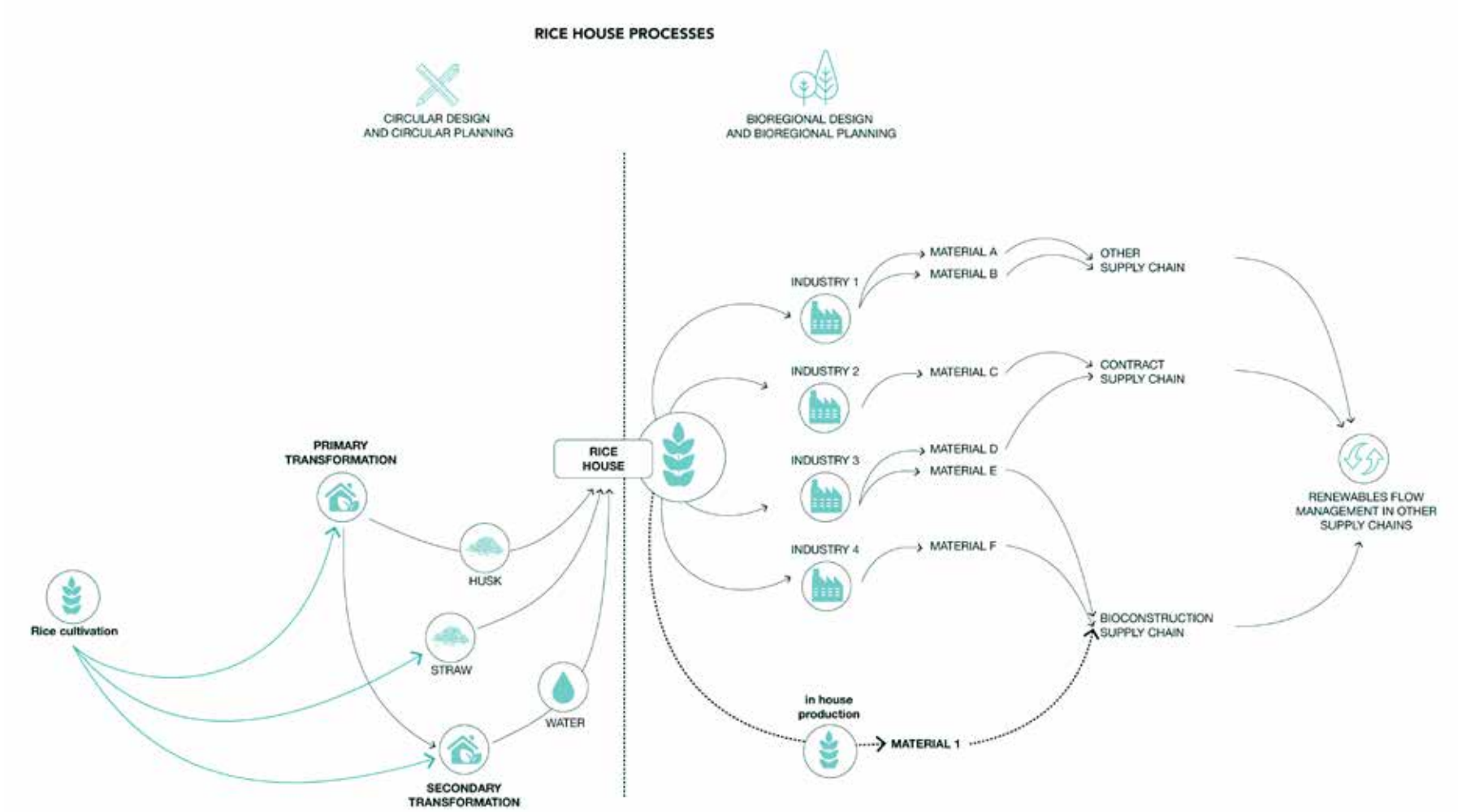

Fig_04
Ricehouse conceptual processes.
Elaborated by the authors.

cluding large retailers like Lidl. This example highlights how agricultural by-product valorisation can foster synergies between the primary sector and industry, advancing sustainability and innovation (European Commission, 2020).

Ricehouse is also sensitive to the environmental impact of the technologies employed, favoring the so-called “cold processes,” which effectively reduce energy consumption in the production and fabrication of building components. These processes, in which elements are dry-assembled, promote sustainable production and easy disassembly and recycling of buildings at the end of their life cycle (Gupta et al., 2021). The above is crucial for reducing the ecological footprint during the production phase and facilitating the life-cycle management of buildings, possibly extending their lifespan to 70 years before dismantling (Mazzarella & Pasetti, 2021). Additionally, as Tiziana mentioned, when rice waste is used as insulation material, the CO2 captured during the plant’s growth cycle is retained for decades, contributing to the reduced climate impact of buildings and the plant itself.
For the farmers, collaborating with Ricehouse means an innovative income opportunity. Traditionally, straw and clay are low-value byproducts of rice cultivation, with straw often burned in the fields to regenerate soil fertilisation - a practice now prohibited due to its high CO2 emissions. Given the limited commercial value of straw, the primary income for farmers comes not from selling the biomass itself but from providing services related to its storage and delivery to industries that use it in construction materials for Ricehouse. This partnership allows farmers to derive value from materials that would otherwise go to waste, fostering a more sustainable and profitable agricultural model.

From a design perspective, shifting toward regenerative materials and energy-efficient production processes is essential for addressing the challenges of climate change. The construction and design industries are increasingly urged to prioritise renewable natural resources and integrate sustainable technologies to reduce CO2 emissions and promote a circular, regenerative approach across the sector. This shift mitigates environmental impact and supports long-term resilience and innovation in the built environment.

3.2 micro perspective: Bioproduct Circular Design

The region of Piedmont, which hosts most of the rice farms, coincides with Ricehouse having two of its three headquarters. The area is quite heterogeneous and is home to 4.2 million inhabitants. According to the Voluntary Local Review, a document drafted by the Piedmont Region and the Metropolitan City of Turin, the northeast quadrant (Verbania, Vercelli, Biella, and

Novara) stands out as a logistics hub, with companies specialising in valves, taps, fittings, and textiles, as well as vast rice fields.
The region's territorial planning policies provide guidelines for spatial development supported by strategic plans and initiatives. For instance, the Voluntary Local Review (VLR) aims to ensure coherence among various planning instruments to effectively integrate the 2030 Agenda for Sustainable Development goals into local contexts.
An example is the Regional Sustainable Development Strategy (RSDS), which established a circular economy in Piedmont's agri-food sector (GOLD, 2022). This initiative closely aligns with the Prosperity goals of the 2030 Agenda, where circular economy mechanisms are considered essential for reducing waste, fostering a market for secondary raw materials, and "dematerialising" the economy to drive sustainable growth (ibid.).
Another instrument is the Circular Economy and the Agri-Food System Report, presented in 2022. It deepens the understanding of certain aspects of the RSDS by focusing on five key food chains within the Piedmont region, analysing their current state, and offering public policy recommendations. In the case of the rice supply chain, the report identifies waste as a significant challenge facing the rice industry. It also highlights the urgent need to valorise waste and byproducts to improve sustainability and resource efficiency within the sector (Regione Piemonte & UNISG, 2022).

In this regard, Regione Piemonte and UNISG (2022) argue that the private sector has developed a byproduct chain for generating construction materials; however, substantial challenges remain in guiding rice producers on sustainable waste management practices within a circular economy framework. As a public policy response, the report proposes valorising rice straw, husk, and chaff, which requires further research on byproduct traceability, development of local innovation, promotion of participation in European projects, and support for rice producers in establishing a sustainable byproduct and waste supply chain (ibid.).
The transformation of rice husks into a competitive building material, which required extensive testing and eventual acceptance across Europe (Fava & Parmiggiani, 2019), is an excellent example of this transformation. A major obstacle has been meeting Italy's Minimum Environmental Criteria (CAM) for sustainable materials in public projects. Initially, natural byproducts like rice husks were not CAM-compliant; however, with an important role played by Ricehouse lobbying for this amendment, recent regulatory updates now allow by-products, fostering the use of regenerative materials in construction (Ministero della transizione ecologica, 2022).
Notably, Ricehouse is applying for a European fund to establish its first plant in Biella. By situating the production plant near these rice plantations, Ricehouse aims to cut costs by minimising transporta-

tion needs.
The analysis of the existing territorial plans reveals that the Piedmont region has made significant efforts to integrate circular economy principles into its territory. The Piedmont Regional Territorial Plan (Ptr) was approved in 2011, and the Regional Landscape Plan was approved in 2017. These plans are complementary and were developed within a single process. They share common strategies, emphasising research, innovation, and economic-productive transition strategies (Regione Piemonte, 2011). Despite the progress described above, full implementation is still pending. Mapping the stakeholders involved in circular processes can enable the creation of localised instruments and incentives, fostering synergies across sectors. During the interview, Tiziana emphasised the importance of network-building among all stakeholders, from the farmers at the beginning of the supply chain to those involved in the final product manufacture.

3.3 micro perspective: Bioproduct Circular Design

One of Ricehouse's main characteristics is its "open-minded mission". Instead of focusing exclusively on the production phase of bio-based materials, Ricehouse creates cooperation (synergy) with various companies.
In addition to developing biomaterials and low-energy production processes, Ricehouse has been addressing sustainability by questioning the scale of its supply chain and its impact on the territories in which it operates. Indeed, enhancing agricultural waste represents a crucial opportunity to promote local microeconomies and strengthen the specific supply chains and the territories from which waste originates (Vezzoli & Manzini, 2007).

Aligned with bioregional design principles (Thackara, 2019; Boelen & LUMA Arles A c. Di, 2023; McGuirk, 2024), Riceouse establishes specific limits on transportation distances for sourcing and distribution, which vary according to each product. This approach reflects a commitment to minimising environmental impact by prioritising local supply chains.

For instance, transporting prefabricated houses over long distances is economically and environmentally unsustainable due to their substantial weight. For that reason, Ricehouse sets a maximum distance of 250 km between resource extraction, production, and consumption for such products. For lighter products, which are more efficient to transport, Ricehouse targets a maximum radius of 2.000 km from Biella, covering much of the European market. While bioarchitecture traditionally advocates a 100 km radius for sourcing, processing, and applying raw materials in construction, Monterisi highlights that in a globalised market - where resources can travel up to 15.000 km - striving for a 2.000

km radius for sustainable construction materials is already a significant accomplishment (Figure 5).
To expand its market and increase revenue,

Fig_05
Ricehouse location and buffers of sourcing and distribution. Elaborated by the authors based on satellite data from Copernicus, a component of the Earth Observation and Monitoring of the European Union Space Programme.

Riceouse is exploring activating multiple bioregional supply chains based on the know-how acquired and developed in Biella. In line with this approach, Ricehouse is currently in discussions with a potential industrial partner in Puglia to produce bricks and plaster walls locally made from rice husk sourced from farmers no farther than Sicily. Such a setup would replicate the 250 km radius supply chain model for heavy products already tested in Biella.
This approach can allow other markets to develop additional production hubs in different regions. During the interview, Tiziana stressed the potential for replicating the Ricehouse model worldwide based on rice waste enhancement. This model can, for instance, positively affect the territory of rice producers like Asia, where 90% of the world's rice is produced (Bhandari, 2019).
Setting territorial boundaries has influenced the evolution of the company. As such, for the first time, Ricehouse has chosen to invest in developing its own facility to produce a specific insulation material, thanks to LIFE project funding. The reason behind this choice is the nonexistence of companies with the capacity to produce this specific material, which Ricehouse believes has immense potential in the construction market for distribution within a radius of 400 km. The product is expected to become more economically accessible, thanks to the reduced transportation costs. The factory will be installed in Biella, where Ricehouse's headquarters is located, and the straw will be sourced within a radius of 15

km directly from the “field to the factory.” Tiziana details some key suppliers associated with Ricehouse in the interview. The primary raw material supplier for Ricehouse is Gallo Riso, based in Robbio, 67 km from the Biella warehouse. As for the manufacturing of products, bricks are produced in Verona, Veneto region, located 261 km from the Biella warehouse. Vimark and Sarotto Group process the rice husk and green binder used in production in Cuneo, approximately 204 km away. Additionally, the pot handles are manufactured by Sanmiro, a plastic production company located in the province of Lecco, in the Lombardy region, 135 km from the Biella warehouse. For example, with the Verona-based company specializing in concrete bricks, Ricehouse has introduced the production of bricks made with rice husk. This product currently covers 10% of the company’s production. Still, it has the potential to gradually increase following market demand, helping to mitigate economic risks associated with transitioning to the biomaterial market. In another cooperation, the transition has been accomplished: initially, this company produced prefabricated houses with concrete and polystyrene. However, since working with Ricehouse and incorporating materials such as husk+vikrat (at Ricehouse’s request), the company has fully transitioned, and its operation is exclusively focused on sustainable and renewable alternatives.
In short, Ricehouse plays a valuable role in fostering local innovation and sustainable

transition in the region by creating synergies and collaboration with companies from both sides of the circular economy system: renewables flow management and product manufacturing (finite materials).

4. Conclusions

The transition toward circular economic models, where agricultural waste becomes a resource, is a crucial step toward a more sustainable and resilient financial system (Kirchherr, Reike, & Hekkert, 2017). Enhancing agricultural waste materials reduces waste, decreases dependence on nonrenewable resources, and cuts carbon emissions associated with production processes.
The analysis of the Ricehouse case reveals not only the environmental benefits of biomaterials but also the territorial dynamics that shape their production and implementation across multiple scales. At the micro scale, Ricehouse stands out as a pioneering model, illustrating how waste-based biomaterial processes have the potential to transform local economies and promote spatial sustainability and regional circularity. By converting agricultural byproducts into market-valuable building materials, the company strengthens local economic networks, reduces waste, and lowers environmental impacts at the regional level in Piedmont. At the meso scale, represented by the bioregion, the most significant findings emerge since this is the

scale where the disciplines of design and territorial planning intersect. Ricehouse's approach defines spatial limits for sourcing and distribution based on ecological and logistical reasoning rather than administrative borders. Localising the production of building materials from agricultural waste allows the model to activate regional supply chains, reduce environmental externalities, and align innovation with place-based realities. However, while the company's model is inspiring, at the macro scale, a more structured, policy-driven approach to circular territorial planning could amplify these benefits further, supporting widespread innovation and regenerative regional economies. The Piedmont region has a total area of approximately 215.134 hectares of rice crop with an estimated waste of around 2.151.340 tons for every harvest, a potential that is not fully explored. Research on integrating circular product design and territorial planning is still new and highly interdisciplinary. It faces challenges such as limited data access, the complexity of integrating diverse knowledge and practices, and the need for further research and collaboration to unlock its full potential. From a design perspective, the analysis evaluated the environmental impact of the input materials. It showed that biodesign (i.e., bioproduct design) can reduce resource consumption, enhance agricultural waste, and support circularity. The choice of materials is guided by sustainable criteria, favoring renewable resources with rapid regeneration cycles (i.e., straw and rice husks). These materials undergo low-impact "cold processes," minimising energy and water use, enabling dry assembly, and simplifying disassembly and recycling at the end of a building's life. Ricehouse's goal is to create long-lasting products that can be easily reused, reducing CO2 emissions and enhancing the sustainability of the building sector.
The study of planning instruments from a circular perspective emphasises the importance of advancing research on supply chain traceability as a driver of innovation, highlighting the importance of distances in the production process. In this way, mapping the supply chain is essential for the flow of materials and connecting local farmers with the industry, creating a value chain that optimises agricultural byproducts. Moreover, as the bioregion is defined, these tools should focus on the operational area of the supply chain rather than strictly adhering to administrative boundaries. In line with this approach, fostering local self-sustainable development requires continuous engagement and empowerment of local communities, ensuring their active participation in shaping and benefiting from the transformation. Improving planning in terms of circularity would require new governance frameworks to coordinate efforts across sectors and regions.
This article demonstrates how the synergy between bio-based materials and territory design can foster sustainable solutions, advancing the circular economy and regio-

nal regeneration. Centering the research and development of bioproducts around a specific agricultural supply chain allows for envisioning the reproduction of the productive model in other bioregions characterised by the same type of agriculture and opening new perspectives on the path to transition toward a bio-based circular economy.

Finally, a sustainable, just and profitable transition relies on developing territorial governance across multiple scales. This requires a holistic approach, which includes the development of bioproducts and bioregional design, ensuring sustainability across the entire process, accounting for the logistical distances involved in each stage, and fostering collaboration among local actors. As the Riceouse co-founder points out, integrating territorial planning with circular design in bioproducts remains a work in progress.

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