/Can wood be urban?

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Can wood be urban?
Inquiring the extent to which wood is a sustainable building material for use in urban environments.

MASTER'S THESIS
Architecture for the sustainability design

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Abstract

The aim of this thesis is to explore the extent of the sustainability of wood as a possible building material for an ecological transformation of a city. The very hypothesis is that timber construction solutions, at an urban scale, are a critical tool in the global effort to mitigate climate change by turning dense urban cities into a continuous "carbon sink" that functions alongside the capacity of forests that are its renewable source.

In addition, the second hypothesis of this work is that timber construction and wood are not inherently sustainable, and that the extent to which they are sustainable when applied to urban building technologies should be investigated and possibly modelled. In this sense, such an inquiry and modelization may be useful not only in terms of wood research but also in terms of urban strategy planning, as it may provide a set of quantitative and qualitative indicators that could frame planners' choices and size the specific guidelines each strategic plan states.

The thesis is divided into three parts. The first one, "Wood," explores the relationship between forests and humans by pointing out not only some emergent aspects of its evolution and geographies but also delving into the processes of timber production (making trees artificial) and, more specifically, the wood's benefits in terms of carbon footprint.

The second and third parts are instead more specifically focused on wood as a building material for cities. While the second part provides some examples of the use of wood on different urban scales, the third one tries to inquire into the very research question of the thesis: Can wood be urban?

To address such a complex and difficult question, the research proposes a synthetic model, focusing on a specific wood technology (timber construction) on a specific case study (the urban transformation zones defined by a Greener Transition Urban Strategic Plan) in a specific context (Torino). Such a model provides these main guidelines:

The geographical availability of timber in terms of quantity, typology, and proximity is related to its sustainability.

Wood sustainability depends on the systems of production, distribution, and infrastructure of timber, which means CO2 emissions.

Timber sustainability depends on CO_2 absorption capacity while in use. Such a balance between availability through time and space plus CO_2 emissions and absorption is the rough evaluation model explored in this work.

The thesis tests this model on the pilot case of Torino. After exploring its planning strategies for a supposed green transformation, it defines an archetype intervention and its Urban Transformation Zones (ZUTs) and applies the model to a project sample.

Far from defining wood as a perfect solution for cities, the thesis explores critical and technical tools for making informed choices in planning and architecture.

Key words: *Wood, Forest, Mass Timber, Urbanization, Transition, Climate Change, CO_2.*

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List of Content

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May wood make cities more sustainable?

The demand for the materials needed to build a city will rise exponentially as urban areas expand, as well as the infrastructure in consequence. So the massive rise in the use of land, energy, and resources that will result from this demographic transition, spatial morphologies of human habitation, industrial components, and the techniques used in their construction is crucial (Organschi et al., 2016).

With the increased supply of buildings in urban areas and the relative efficiency of space, surface, and infrastructure utilization, the production of structural materials with significant carbon footprints grows (Ewing et al., 2008). Aside from the devastation to the planet's atmosphere and landscape, this technological advancement also occurred at a time when material resources were almost depleted. Today, man-made carbon emissions account for more than a third of humanity's yearly carbon footprint (Lucon et al., 2014).

Part of these emissions also are caused by the use of construction materials, but for better management of these sources, it's also vital to consider how we get them, where they come from, whether they're legal, how they affect the environment, how the industry is governed, and so on. Nonetheless, when we introduce the use of timber, we are also talking about the relationship with the forest, and how we harvest timber from the forest. Because trees are, a living species, and they raise ethical problems in our society about what it means to manufacture when you deal with another species with which you share the planet's eco-habit.

The very hypothesis is that, timber construction solutions, at an urban scale, may be a key in climate change mitigation strategies, since such a technologies may turn dense urban cities into a continuous "carbon sink" that functions alongside with the capacity of forests that are its renewable source.

The second hypothesis of this work is that timber construction and wood are not sustainable per se, and that the extents of their sustainability when applied to urban building technologies shall be inquired and possibly modelized.

An attempt is therefore made to identify the sustainability component of this material both by the geographical availability in terms of quantity, typology, and proximity and also by describing essential performance aspects and by defining its carbon capability that can be analysed by an indicator, the Embodied Carbon impact indicator. Analysing case studies from recent years associated with architectural interventions at various urban scales, emphasising the fundamental role that design can play in our environment, and how a strategic plan can provide a set of parameters that could frame planners, force them to look beyond their standardised boundaries of the built environment.

Urban planning can and must try to convert growing awareness of environmental issues into the knowledge of trees and its potential, allowing for more educated and collaborative responses.

The discussion of the design techniques and characteristics will show how these design decisions have affected the environmental aspects. It will underline the theory that architecture and design decisions have a role in maximizing these opportunities for the benefit of a city and the impact that the building has on the architecture-nature relationship.

The hypothesis will try to be addressed by using the city of Torino as a case study.

This case is thus handled by first addressing the issues of Torino and its strategies for sustainable transition gathering information form the Urban Strategic Plan of the city.

At that point, one "Archetype" is chosen, and the quantity of the actual tranformation areas proposed are calculated.

Then a model project based on this archetype is used, and an attempt is made to identify its carbon footprint assesing also at an urban scale scenario. Moreover, how much wood can be provided, in percentage terms and subsequently in more disaggregated ones.

Having this done, we try to respond to the extent to which the use of wood can be useful and/or possible for the ecological transition of a city through various representations, far away from defining wood as a perfect solution for Torino, the critical and technical tools for making aware choices in planning and architecture.

This will help us understand how the designs are created and interpreted, as this may serve as a model for potential architects, and how these material can help us mend, renovate, and design buildings that respect the objectives.

The integration of mass timber architecture in Torino will provide, in the future, not only an increase in demand for products such as wood but will also generate more harvesting patterns and produce a valuable stock of carbon sequestration products and a carbon sink city to act upon.

Torino, taking into account both mitigation and adaptation strategies adopted in recent years, could use wood as one of the mitigation strategies to take measures for a more sustainable transition and appropriate city design.

The study of wood as a tool to achieve the goal of reducing CO_2 emissions can great positive results, considering that climate change problems could decrease.

Having these limitations in mind, the study begins in the following section.

CAN WOOD BE URBAN?
CAN IT BE A MAYOR MATERIAL FOR BUILDING CITIES?

/ Adopting Torino, a European city, as a case study.

1 /
Wood

/ THE RELATION BETWEEN FORESTS AND HUMANS

OVER THE TIME

2 Billion y.Ago

The great oxygenation process caused microscopic organisms in the ocean to release large amounts of oxygen into the atmosphere, which permanently affected the equilibrium of the atmosphere and created the worst pollution problem ever seen on Earth.

500 Million y.Ago

Plants began to spread on land, and in order to survive, they developed a three-dimensional structure called lignin (or wood) to counteract gravity and prevent collapse or dehydration.

500 000 y.Ago

Humans began to harvest and mold wood into tools and crafts, and as they did so, they began to view trees as objects to be felled for construction and fire, rather than as natural elements to be climbed for rest and protection.

Burning wood releases heat energy for cooking and allowed humans to process food ingredients they previously couldn't, allowing them to move to colder regions and increasing their geographic dispersion.

For this section, the main source is a research based on wood called Cambio conducted by the studio Formafantasma.

10.000 y. Ago
Agricultural revolution transforms relationship between humans and forest, leading to reduction of forest cover and formalization of territorial management through disciplines like geometry and law.

1240
The study of trees and techniques for land clearance, domestication, and fertilization was in line with the belief that the earth reflected God's glory.

1492
The exploration of the Americas had a significant impact on botanical science and arboreal taxonomy, exploitation, transplanting, and regeneration.

The split of the world into colonizers and colonized marked the beginning of a system of commerce and appropriation that developed into modern global capitalism.

1664
John Evelyn's "Sylva, A Discourse on Forest-Trees and the Propagation of Timber in His Majesty's Dominions" discusses forest management and suggests planting trees as a national initiative.

1700
Hans Carl Von Carlowitz developed the term "sustainable" in his book "Silvicoltura Economica" and argued for ongoing research and sustainable use of wood, but his ideas were met with opposition from later generations of scientists.

Late 18th century
French naturalist Georges-Louis Leclerc in his book "Histoire naturelle, générale et particulière" shift the focus of European thought from studying natural phenomena to biblical concepts and advocated for utilitarian progress, denying conservation's inherent value.

1829
Nathaniel Bagshaw Ward created "Wardian case", which is a paradynamic system of wood and glass box that uses the triennial principle to circulate moisture and admit sunlight while enclosed. It enables the transplantation of commercially significant specimens from their native habitats to cultivation in new nations for new markets and propels scientific advancement into the gray area between pure theory and practical involvement.

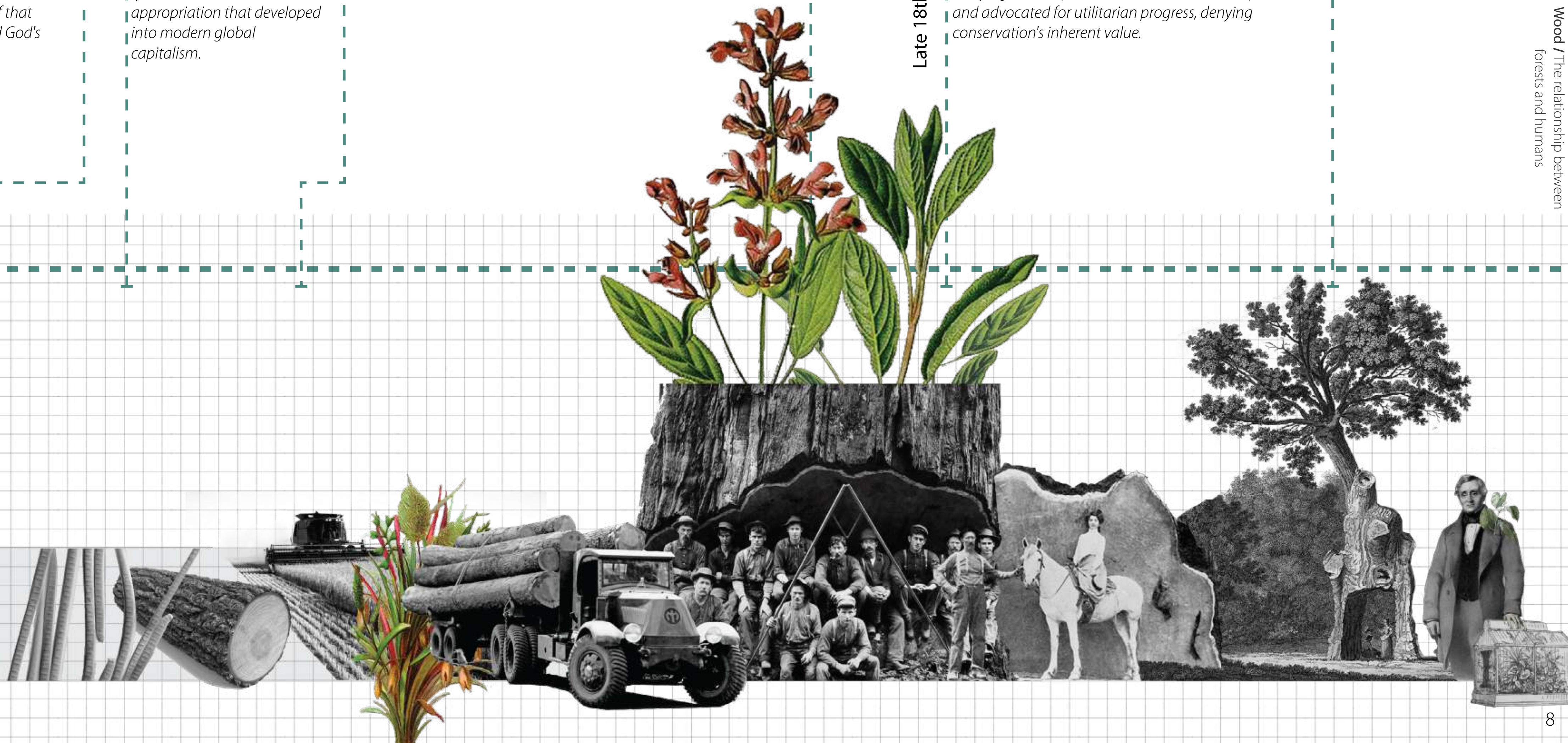


Figure 1. Timeline. Own work.

Wood / The relationship between forests and humans

1847 *Sir William Jackson Hooker starts the economic botanic collection at the Kew Royal Botanic Gardens, gathering a range of timber specimens, plant types, and manufactured indigenous items to demonstrate the transformation of materials into useful goods.*

The exhibition is held in the Crystal Palace, a massive glass building constructed by Joseph Paxton, but it focuses on the human issue, turning plants into ornaments and trees into material samples.

Before the industrial revolution, the subdivision of land under the present economy allowed different initiatives to coexist in forest spaces.

Environmental historian Mauro Agnoletti notes that in Roman times, the word "Selva" was used for both wood and pasture, with trees and animals cohabiting on farmland.

1864 *American naturalist George Perkins Marsh publishes "Man and Nature," in which he claims that without massive and urgent afforestation, the earth may be declared unsuitable for human settlement.*

1880 *Joseph Swan, a British inventor, gets a patent for a new, stronger filament for incandescent light bulbs.*

Late 19th century *Despite growing concerns about pollution, the process of industrialization engages trees not only as sources of timber but also as fuel.*

1891 *"Man and Nature" influences American politics, leading to the creation of the Forest Reserve Act.*

Figure 2. Timeline. Own work.

Wood / The relationship between forests and humans

1912 *Arthur Clarence Pillsbury used time-lapse photography to record the movement of flowers in Yosemite National Park, leading to a unanimous agreement for field preservation.*

Technological developments prove fundamental to fighting deforestation.

1971 *NASA educated Brazilian cartographers to address the absence of data in the Amazon region, using earth-sensing technology to create Radial Amazonia, or Radam- However, this cartographic documentation was also used to favor deforestation and loss of biodiversity.*

1972 *The book "Should Trees Have Standing?" written by Christopher D. Stone, a legal scholar and professor at the University of Southern California Law School, raised the idea of granting legal rights to natural elements and its impact on the community's view of itself.*

1990 *Indigenous people from Santa Cruz and Beni in Bolivia protested official policies that kept them out of their traditional lands and lack of legal recognition of connections to wildlife, plants, rivers, rocks, and lakes, leading to Bolivia becoming a leader in tropical forest preservation and sustainability certification.*

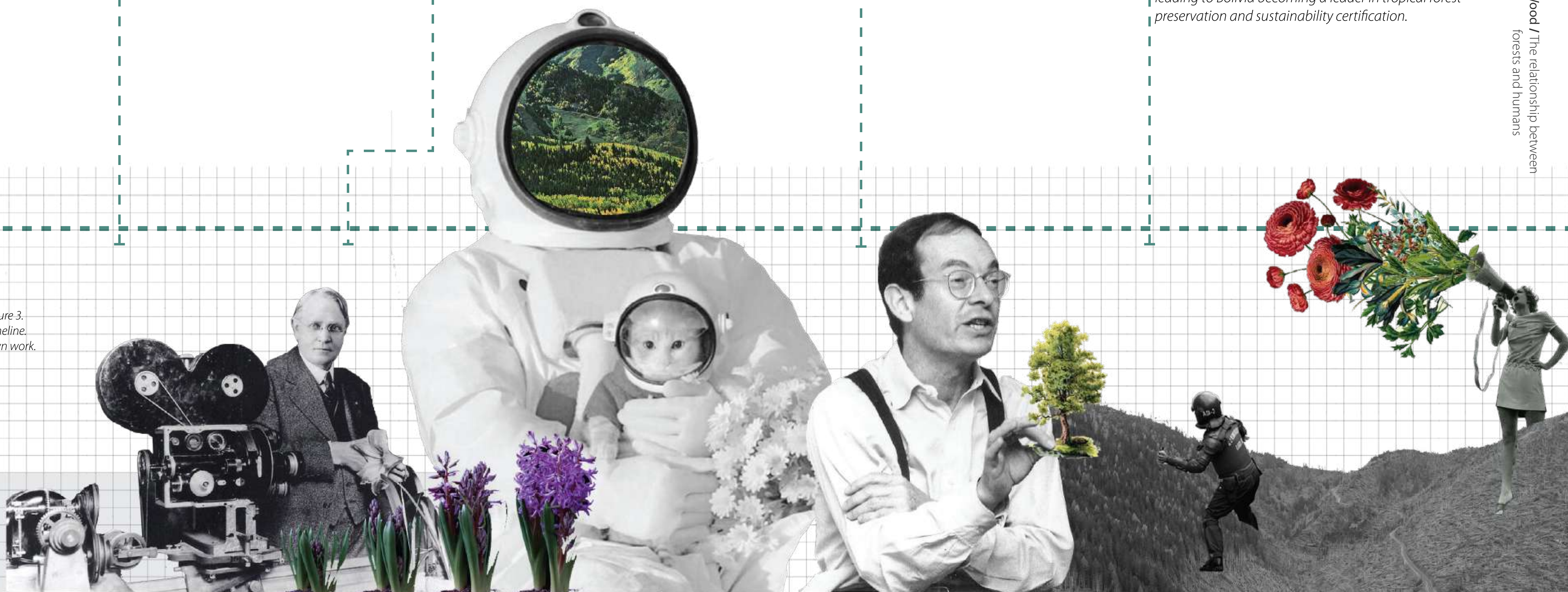


Figure 3. Timeline. Own work.

Wood / The relationship between forests and humans

2011

According to Peter Dauvergne and Jane Lister's book "Timber," since the early 1960s, the world's consumption of timber has increased by 70%.

Northern hemisphere consumes more than 70% of the world's commercial timber to support a fraction of the population, while southern hemisphere is also seeing an increase in demand for commercial timber.

Ingvar Kamprad, the founder of IKEA, introduces assembly-required, inexpensive furniture with democratization as a primary priority.

Western furniture production moves to lower-cost regions in Asia, Africa, and Latin America due to cost-competitive flat pack industry.

Long-term changes in human-forest interactions lead to increased concern for wood and understanding of appropriate uses. Other factors such as storms, droughts, fires, and climate change also affect forests. This raises awareness about the treatment and maintenance of forests, preventing them from being simply used for commercial gain, and ensuring their conservation.

Figure 4. Timeline. Own work.

IKEA KATALOG 1990

Wood / The relationship between forests and humans

OVER THE SPACE

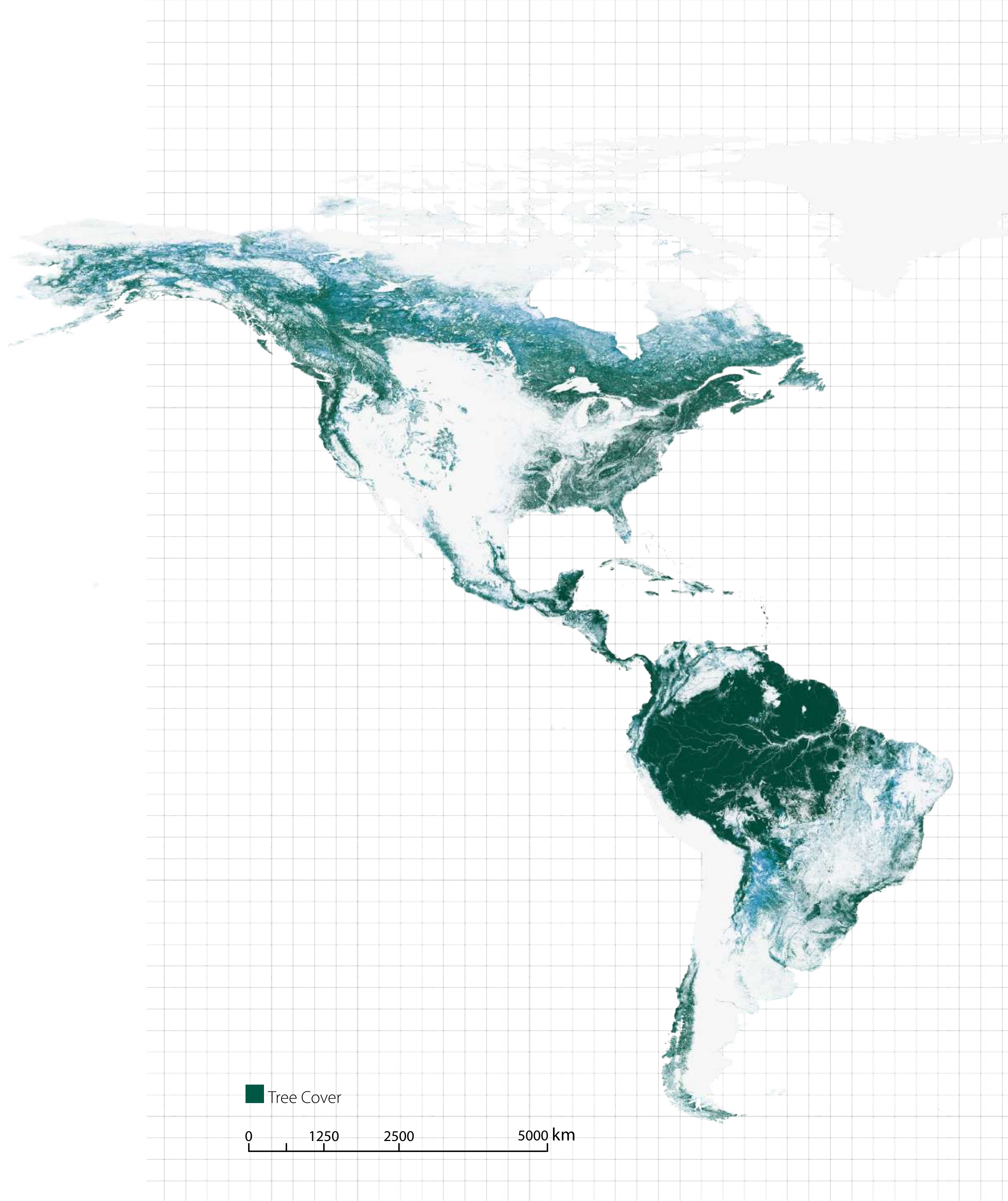
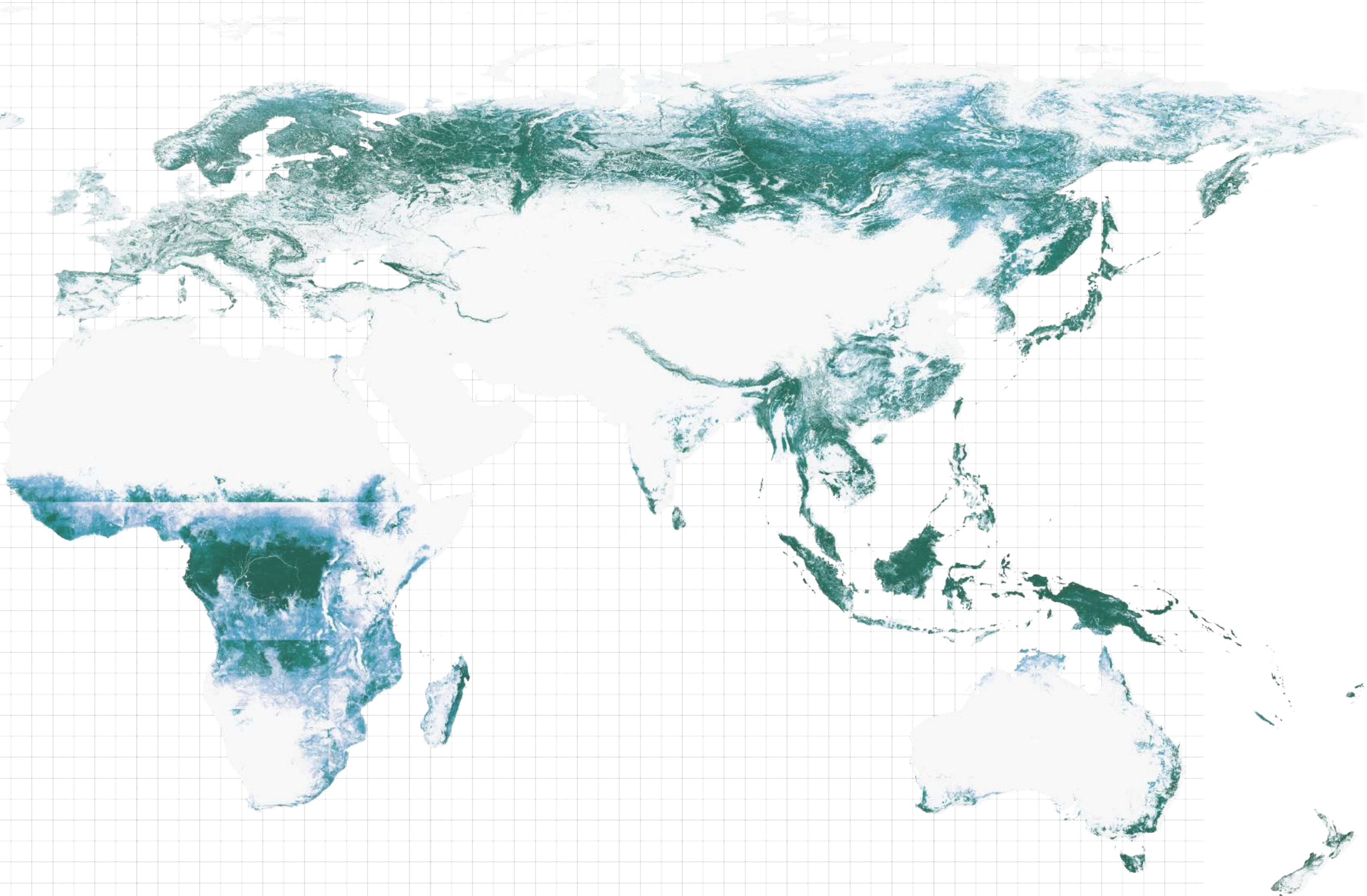
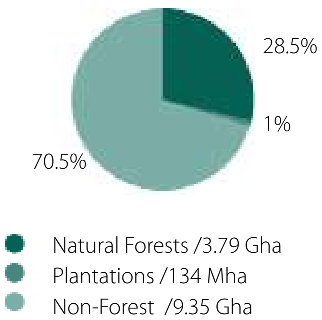


Figure 5.
Display of Tree Cover all global land (except for Antarctica and a number of Arctic islands) for the year 2010.
Illustrated by the author, on the bases of GFW Data, (2022).
/ Data obteined from Global Forest Watch shows that, 29% of the world's land cover was identified as tree cover as of 2010.
/ Forests were found to be most abundant in Russia (755 Mha), Brazil (498 Mha), Canada (421 Mha), the US (272 Mha), and the Democratic Republic of the Congo (198 Mha).
/ The "Tree Cover" areas are identified;The land cover was divided into 3 categories: natural forests (3.79 Gha), plantation forests (134 Mha), and non-forest areas (9.35 Gha).
/ The countries with the highest percentage of tree cover also tend to have the most land.

*[1] The global hectare (**Gha**) is a measurement unit for the ecological footprint of people or activities and the biocapacity of the Earth or its regions.*





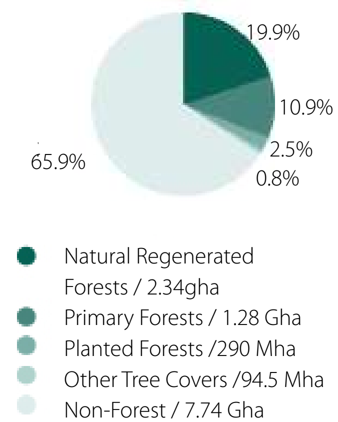


Figure 6.
Display of Tree Cover over all global land (except for Antarctica and a number of Arctic islands).
Illustrated by the author, on the bases of GFW Data, (2022).

Figure 7.
Display of FAO forests over all global land.
Illustrated by the author, on the bases of GFW Data, (2022).

Figure 8.
Display of Forest Cover In European Territory.
Illustrated by the author, on the bases of Forest Europe, (2011).
/ The analysis of 19 countries, including the Russian Federation, showed that the highest-density forests in Europe are in the northern and mountainous areas. In the last decade, the EU's forests were estimated to total 159 million hectares, or 39% of its land area, and have expanded by 10% since 1990. Five EU members (Finland, Sweden, Slovenia, Estonia, and Latvia) had over half of their land covered by forests, while the Netherlands, Ireland, Denmark, Cyprus, and Malta had less than a fifth of their area covered (Eurostat, 2021).

Figure 9.
Val Brandet.
Image from Albergo Miramonti.

Wood / The relationship between forests and humans

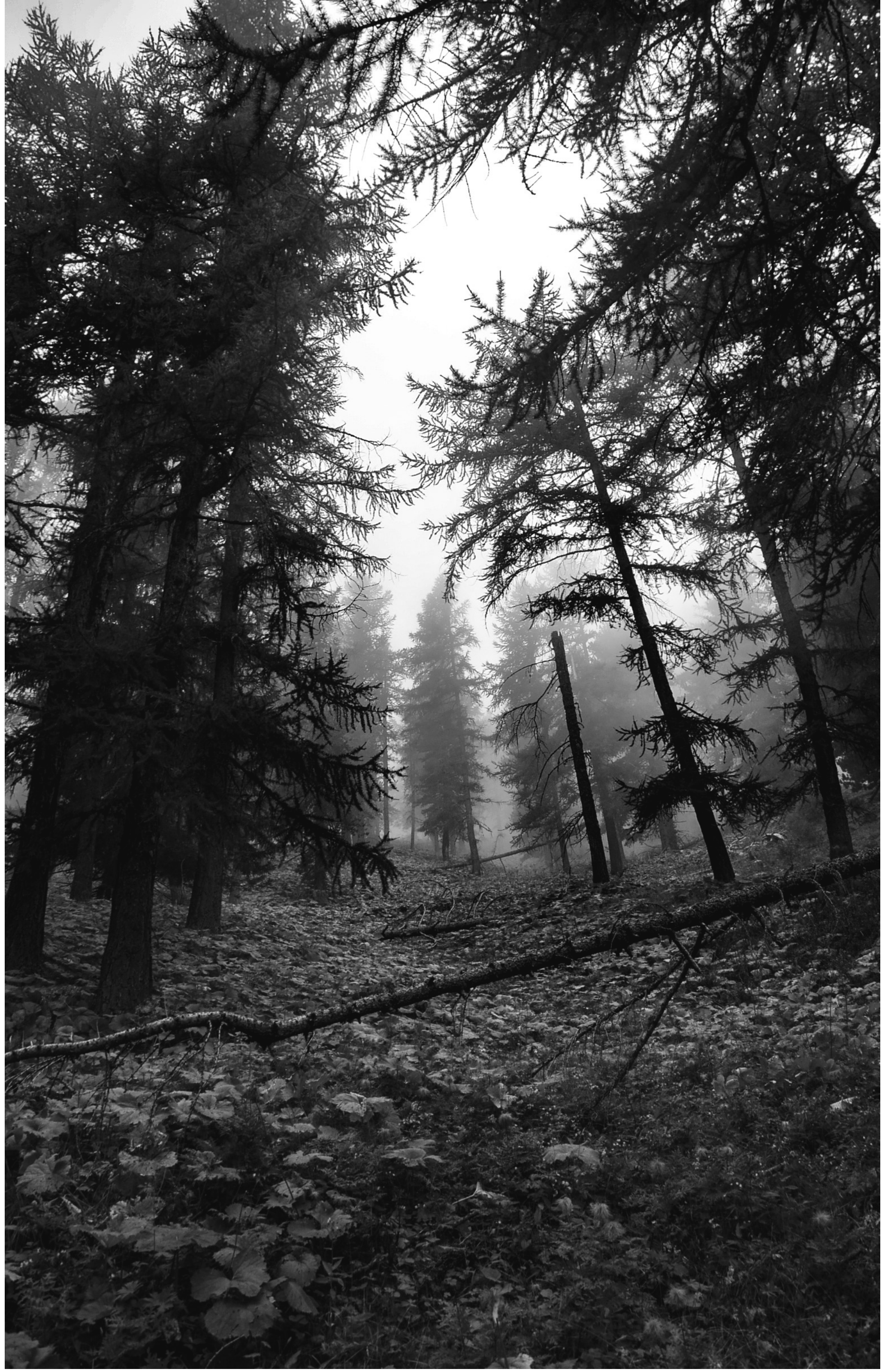


Figure 10.
Great Salbertrand Forest, Piedmont.
Image courtesy of F. Viani.

/ MAKING TREE ARTIFICIAL

Wood has been used in a variety of ways and for a variety of purposes throughout human history, specially in the case of the Construction. Within this category timber in turn has a long history of use as the main building structure material until the arrival of steel, concrete together with stone and brick.

But in the last few years, the standard construction materials began to be overshadowed after the arrival of mass timber solutions that called the attention of professionals for projects of all types, both large-scale and small-scale, such as multi-family projects and commercial offices, as well as emblematic public buildings and high timber towers.

Mass wood construction consists of several layers of solid wood glued or fixed together, forming exceptional strength and stability that can be used for structural walls, columns, and beams as well as interior finishing materials.

This innovative wood use, in addition to offering great structural properties as well as design choices, is chosen over other materials also because it promotes thermal properties and is energy-efficiency (Think Wood, 2022).

This section focuses on the reasons why this material is considered sustainability, as well as why is a great low-carbon alternative to concrete and steel, and on the product's lifetime, from tree harvesting to manufacturing, transportation, construction and disposal or recycling of mass timber.

Wood / Making tree artificial

FORESTRY

To be able to talk about forests, it is necessary to be clear about what is meant by the term "forest," as there are several interpretations of this topic. According to the Food and Agriculture Organization of the United Nations (FAO), a forest is "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ." It does not include land that is predominantly under agricultural or urban land use. (Office of Assistant Director-General Forestry Department, 2020).

It is known that forests are the primary source of timber, and part of the process of obtaining timber from forests is by logging, but this does not mean that the timber for construction purposes can be obtained in any way or from any forest.

In the case of forests, the way to regulate their use of it is by sustainable forest management, which is defined as «a dynamic and evolving concept, that is intended to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations» (ibid, 32).

If they are responsibly regulated, there should be no concern about their scarcity of it, which would be deforestation. This material, thanks to the responsible use of its resources, is capable of increasing its stock, to reforest the forests (Verkerk et al., 2015).

This is reflected, for example, in the forests of Europe, which have increased by approximately 107 hectares, i.e., 6%, since 1990 (Ibid.).

In turn, there are popular certifications that guarantee sustainable forest management, traceability, legality, and responsible use of the timber production process. The two most popular systems in Europe (FSC and PEFC).

The Forest Stewardship Council (FSC) certification is an international, independent, and third-party certification, specific to the forest sector and products derived from forests. There are two types of FSC certification: "Forest Management Certification" and "Chain of Custody Certification" (FSC, 2022).

While Programme for the Endorsement of Forest Certification (PEFC), is «an international non-profit, non-governmental organization dedicated to promoting Sustainable Forest Management (SFM) through independent third-party certification. As an umbrella organization, it works by endorsing national forest certification systems developed through multi-stakeholder processes and tailored to local priorities and conditions.» (PEFC, 2022).

Timber obtained from areas where policies and controls are not followed to the letter causes big issues for suppliers and other business owners because the tracking of timber during processing is lost or obtained illegally according to the rules and laws of the forest area (Waugh Thistleton Architects, 2018).

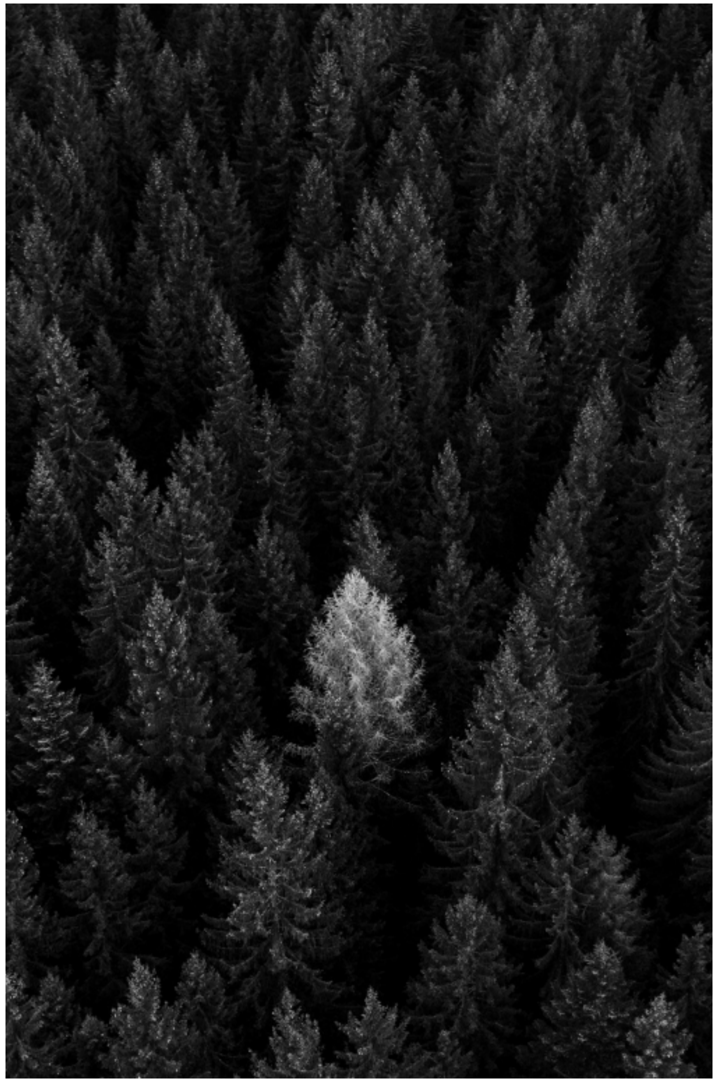


Figure 11.
A forest in the Dolomites.
Image from Abstract Aerial Art/Getty Images.

TIMBER

One of the key elements of obtaining timber for construction is its selection. Not every tree is used for this, and even within a species, a tree's growth may vary depending on its surroundings, the climate, and the region.

The tree needs to grow in a healthy environment.

Coniferous, evergreen softwoods, mostly spruce, as well as varying proportions of Douglas fir, western larch, and pine, are the tree species that are typically used for mass timber construction (Waugh Thistleton Architects, 2018).

As seen in (Fig. 13), the Conifer family of trees typically reaches maturity at an age of around 50 years, making it, in a way, a great choice for production as it reduces the time needed for restocking the timber selected (Ramage et al., 2017).

Also the majority of structural timbers used in Europe come from coniferous forests that are sustainably maintained.

A conifer tree is more likely to produce stiffer, stronger, and less knotty wood as it ages. Softwoods are often graded with better strength as a consequence (Ibid.).

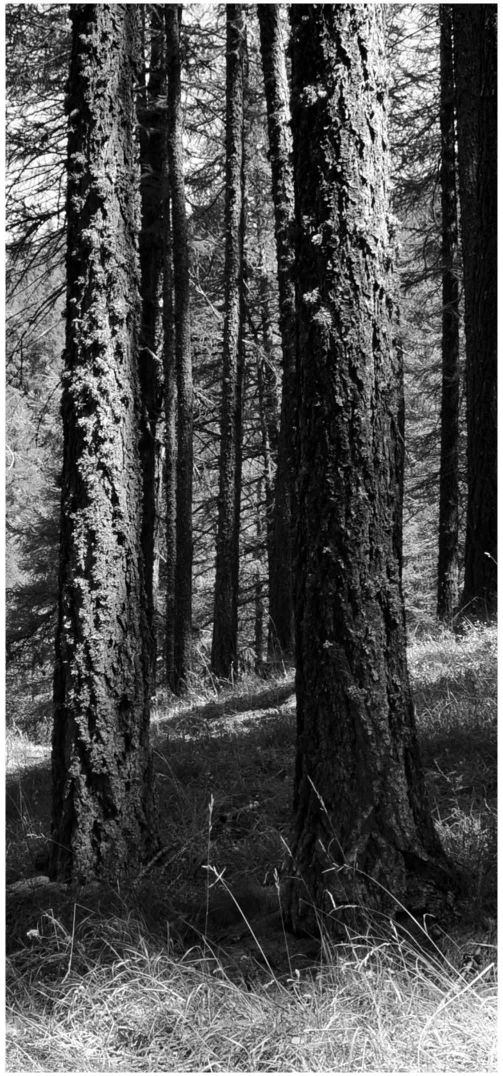


Figure 12.
Great Salbertrand Forest, Piedmont.
Image courtesy of F. Viani.

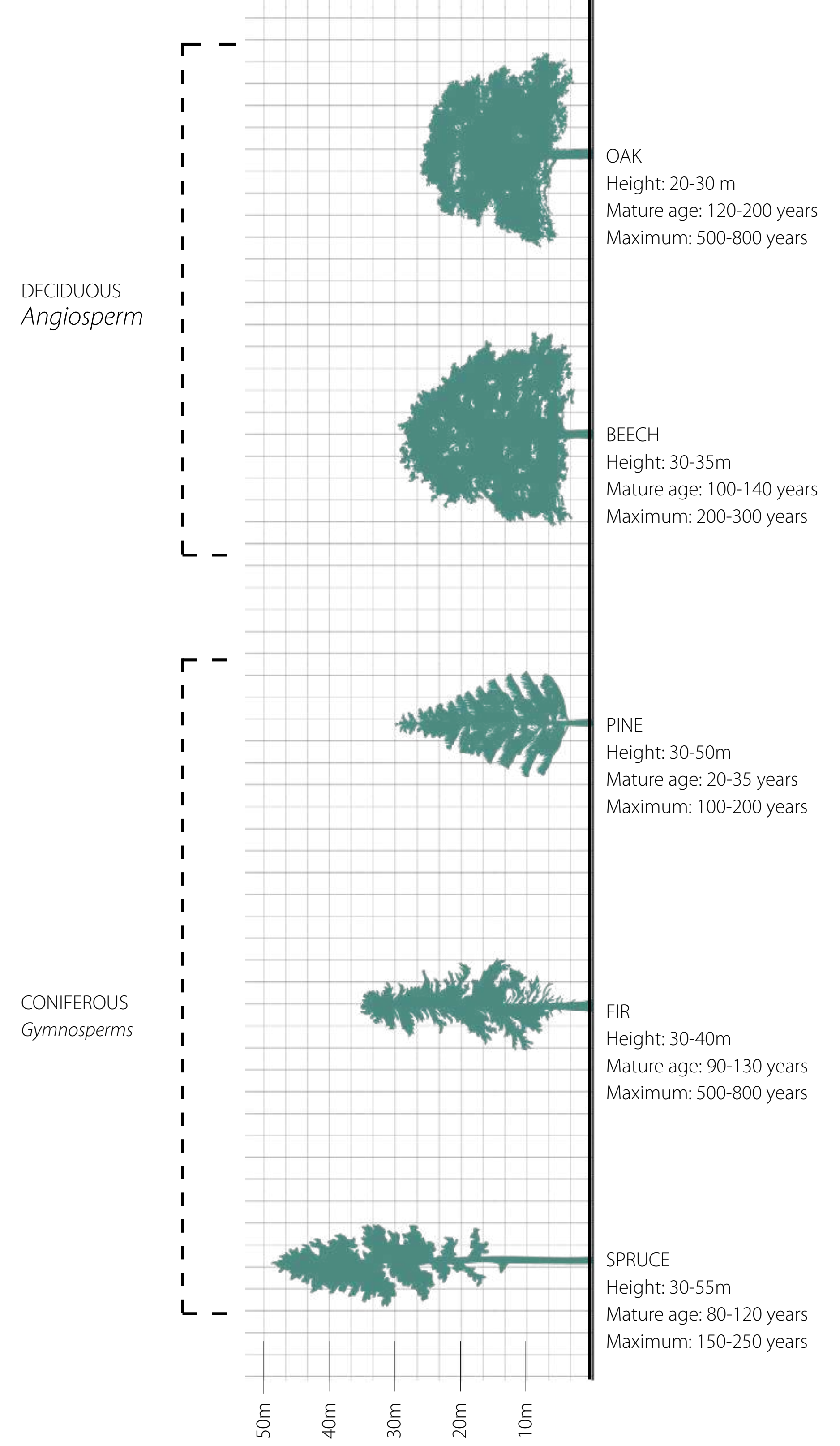
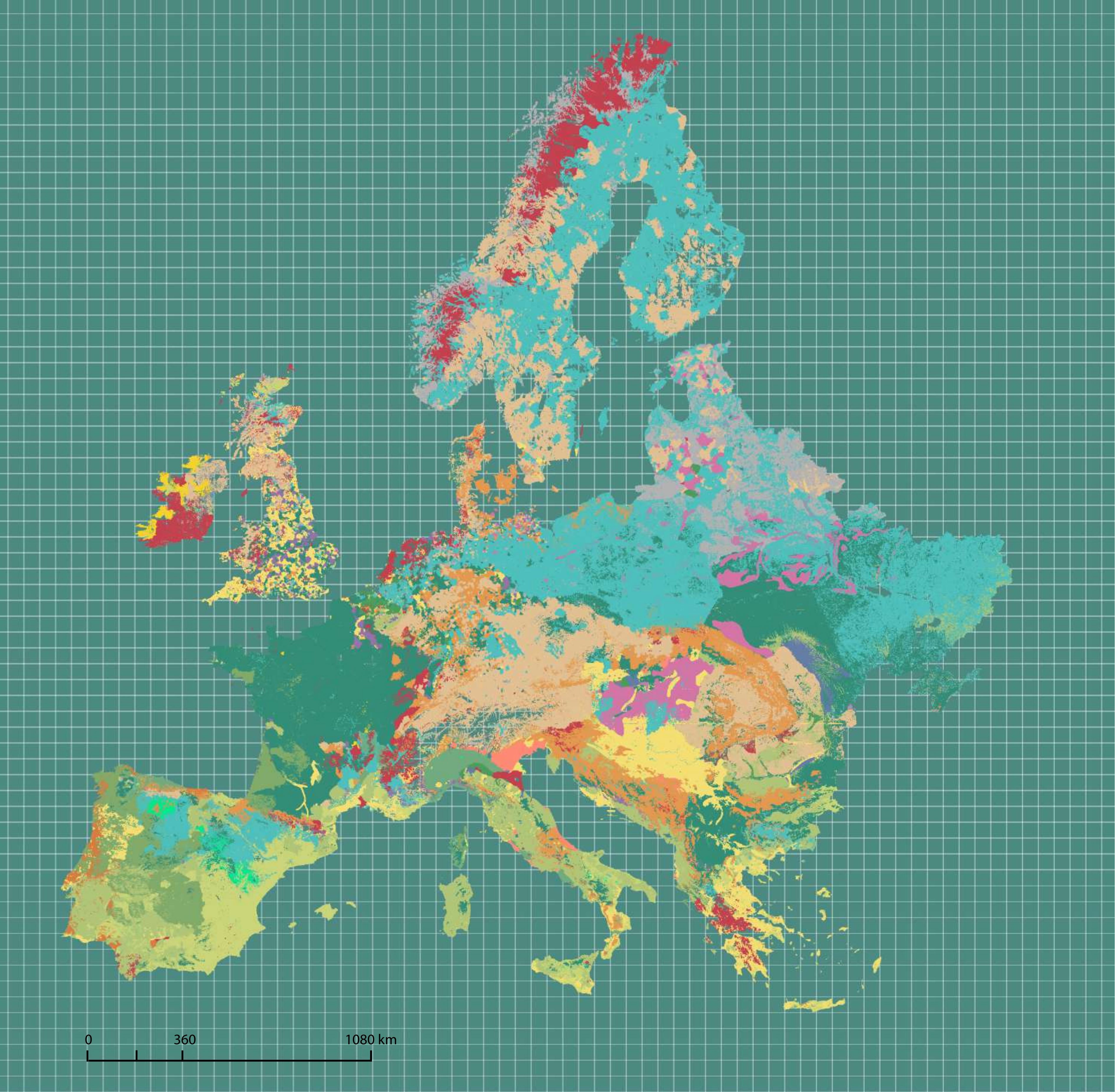


Figure 13.
Comparing the fast growing softwoods used in mass timber manufacture with typical hardwoods.
Illustrated by the author, on the bases of Waugh Thistleton Architects, (2015).

Wood / Making tree artificial



- Abies spp
- Alnus spp
- Betula spp
- Other Conifers
- Other Pinus
- Other Quercus
- Picea spp
- Pinus pinaster
- Pinus sylvestris
- Populus spp
- Pseudotsuga menziesii
- Quercus robus & Quercus petraea
- Robinia spp
- Other Broadleaved
- Carpinus spp
- Castanea spp
- Eucalyptus spp
- Fagus spp
- Fraxinus spp
- Larix spp
- No Data.

Figure 14.
Comparing the Aggregated results showing the dominant species in Europe.
Illustrated by the author, on the bases of Brus et al. (2011).
/ As previously mentioned, the same tree species can be found in different locations, varying their growing seasons, among other things. This does not imply that one species of tree can grow in any geographic condition, rather, it simply means that depending on the species, it can adapt to different climates, always falling within a fairly similar range. The same species, such as Abies or pines, may be found in various areas of Europe: this map, shows the distribution of the 20 most common tree species.

HARVESTING

According to an article from Encyclopedia Britannica, wood harvesting is very different from harvesting other plants. The planting of trees is different from other types of plants: trees, during annual growth, cannot be split off from the living plant (Tsoumis, 1998).

On the contrary, a new tree is inseparably added to the preexisting growth until the whole tree is harvested, after a waiting period that varies greatly according to the specie and the purpose for which it will be used of the wood, for example, Coniferous trees including Pine, Fir, Spruce, and Larch that are the source of softwoods. Before they are ready for harvest, approximately these trees need to grow for about 40 years. In the case of Oak, Ash, and Beech trees, which are the source of hardwoods, they grow much more slowly and can take up to 150 years to reach harvestable size (Ibid.).

The harvest method used may include clear-cutting huge regions or selective cutting of individual or groups of trees as shown in (Fig. 15). The volume of timber removed at frequent intervals in a forest harvested under the sustained-yield concept is determined by the net growth of all trees during that time. This idea, when paired with natural and artificial seeding and planting, enables continued wood production and forest conservation. Efforts have been undertaken to develop proper ecological labeling of marketed wood and wood products. To support sustainable management (Ibid.).

As sunlight reaches the forest floor during harvesting, grasses, shrubs, and forbs develop diverse micro-habitats that lead to a more complex forest. After a mature tree has been harvested, a fresh seedling replaces it. As a result, the cycle repeats (Ibañez et al., 2019).

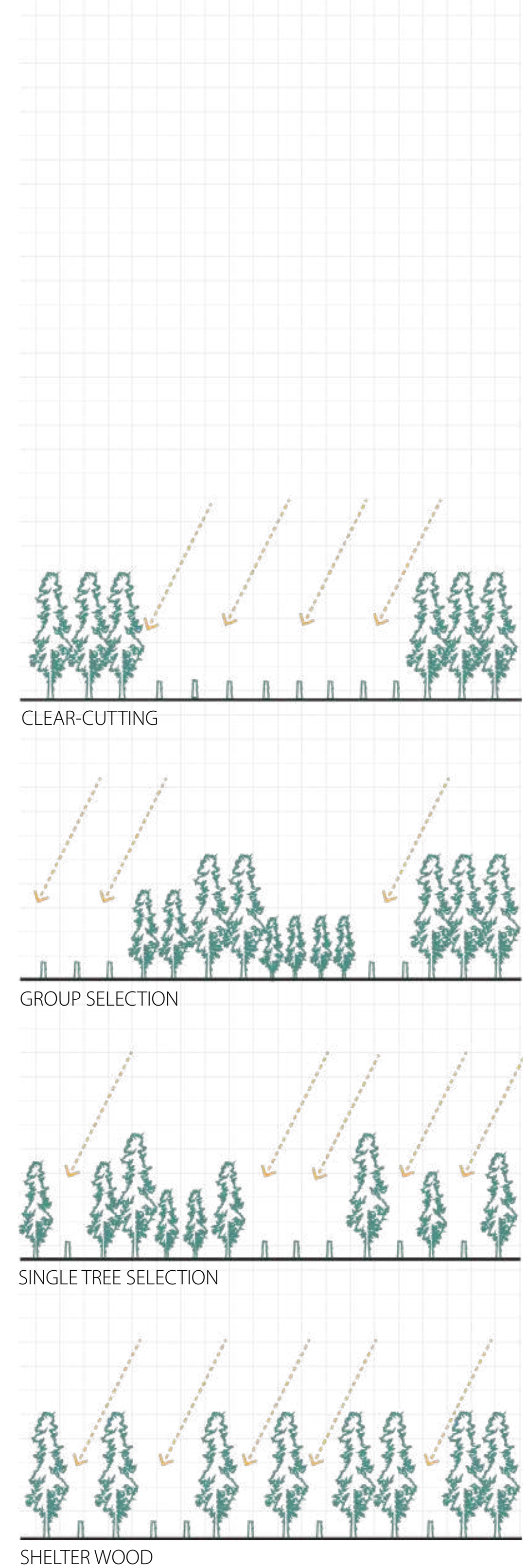


Figure 15.
Tree-Cutting strategies.
Illustrated by the author, on the bases of the diagram on page 469 of the book "Wooden Urbanism", (2019).

The harvest season is defined not by the time of ripening, as it is for agricultural products, but by considerations such as working conditions for workers, machinery, and animals, such as nesting birds, and the risk of harm to the remaining forest and collected wood (Ibid.) But we can consider that an optimal rotation for forest harvest could be between 35 and 70 years, depending on species and location, forests have a long life span in terms of human timelines (Verkerk et al., 2015).

However, to be able to harvest trees responsibly, several considerations must be made, such as the contribution to carbon sequestration and the space that is produced to allow for the planting of new trees. Studies demonstrate that sustainable tree harvest creates new forests, which, as they expand, absorb carbon more quickly than older forests.

By adapting harvesting methods, it could maximize carbon sequestration while still preserving and managing forest biodiversity.

However, even though the longest forest rotations are only a blink of an eye on any geological time scale -that is, the time scale for the replenishment of the earth's resources (rocks, minerals, and soils) through their harvesting rotations- forests have an impact on society and the environment. In light of this, timber can be defined as essentially sustainable (Ibid.).

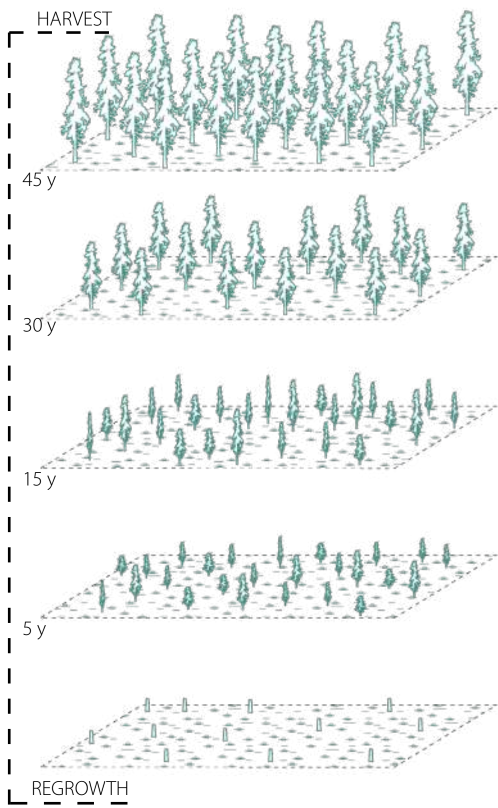


Figure 16.
Growth Stage Of A Harvested Tree Area.
Illustrated by the author.

Figure 17.
Machinery Harvest.
Image from Forest Research ,(2022).

PRODUCTION

To understand the production and consumption processes, we must talk about the anatomy of wood, its biology, and its supply chain.

According to an interview made for an investigation conducted by the studio Formafantasma to Pieter Baas, a Dutch botanist: «Wood anatomy is very simple, it's the microscopic structure of wood, and wood is of course the most crucial element of trees, shrubs, and lianas.[...]Understanding the biology of the tree requires an understanding of wood anatomy, which is aspect number one.

Number two is that the structure of the wood is related to how you can use wood in applications as building materials, so structure-property relations are also very important.

And the third aspect is that, like all expressions of plant life, it is species-specific, so woods are very diverse, and you can identify the plant that is in the plant group to which that piece of wood ever belonged with a piece of wood.[...]

Wood formation in the tree is very much dependent on the environmental conditions», the time, and space. So, in time, you have diverse weather conditions, in space, you have fertile soils or sandy soils, etc. All these factors affect wood structure so that[...] those correlations that made the tree formation in the past, we can use it for the future, and we can project all that climate change scenarios[...] onto wood responses in the future» (Formafantasma - Cambio, 2020).

After being cut, timber is taken from the forest to a sawmill, where it is subsequently processed to eliminate surface defects.

About half of it is recovered during processing, as shown in (Fig. 18), and the remaining dust, shavings, and fiber products are commonly utilized as biomass fuel or as fiber in engineered wood panel products with a market value (Ramage et al., 2017).

Timber naturally varies in its physical characteristics, even within samples of the same species. Because of that, each piece of dimensional timber must be strength graded under BS EN 14081 to guarantee that the construction timber materials can handle expected maximum loads when used as part of a structure in service. With the use of this grading system, a structural engineer can designate a specific strength class of wood and include its distinctive strength values (Ibid.).

According to the standard BS EN 14081-3, there are two forms of strength grading: visual strength grading (VSG) and machine strength grading (MSG) (Ibid.).

VSG regulates imperfections like knots on the surface of the wood and any fissures or associated issues that can develop as a result of drying (Ibid.).

On the other hand, by supplying individual wood lengths, MSG measures the stiffness and density characteristic values for the strength classes (Ibid.).

Additionally, the timber undergoes a visual inspection that takes into account any structural issues that the system is unable to detect automatically (Ibid.).

Then, according to the European Standard, BS EN 338, the timber is categorized as "C" (softwoods) or "D" (hardwoods) into several strength classifications, each of which is indicated by a number showing the value of bending strength in N/mm2, for example, "C14" (weakest) to "C50" (strongest).

Although EN 338 identifies a significant range of the most typical strength classes in timber, this list is not exhaustive (Ibid.).

Grading inspection is performed in the factory that processes timber, where the materials are cut to the specified lengths and dimensions specified by BS EN 336:2013.

Anyone who trades in construction timber products inside the European Union must provide "CE"-marked materials that list the product's specifications by the following European standards:

/ *Solid construction timber: EN 14081.*
/ *Glued-laminated timber: EN 14080.*
/ *Wall / Facade paneling made of solid wood: EN 14915.*
/ *Finger-jointed timber: EN 15497.*

Along with being processed into dimensional sawn timber, softwoods are used to create mass timber products, which are shown in the next chapter.

As one of the last steps, the material gets eco-labeled, which is meant to guarantee that items sold to consumers are not manufactured in an environmentally harmful way (Ibañez et al., 2019).

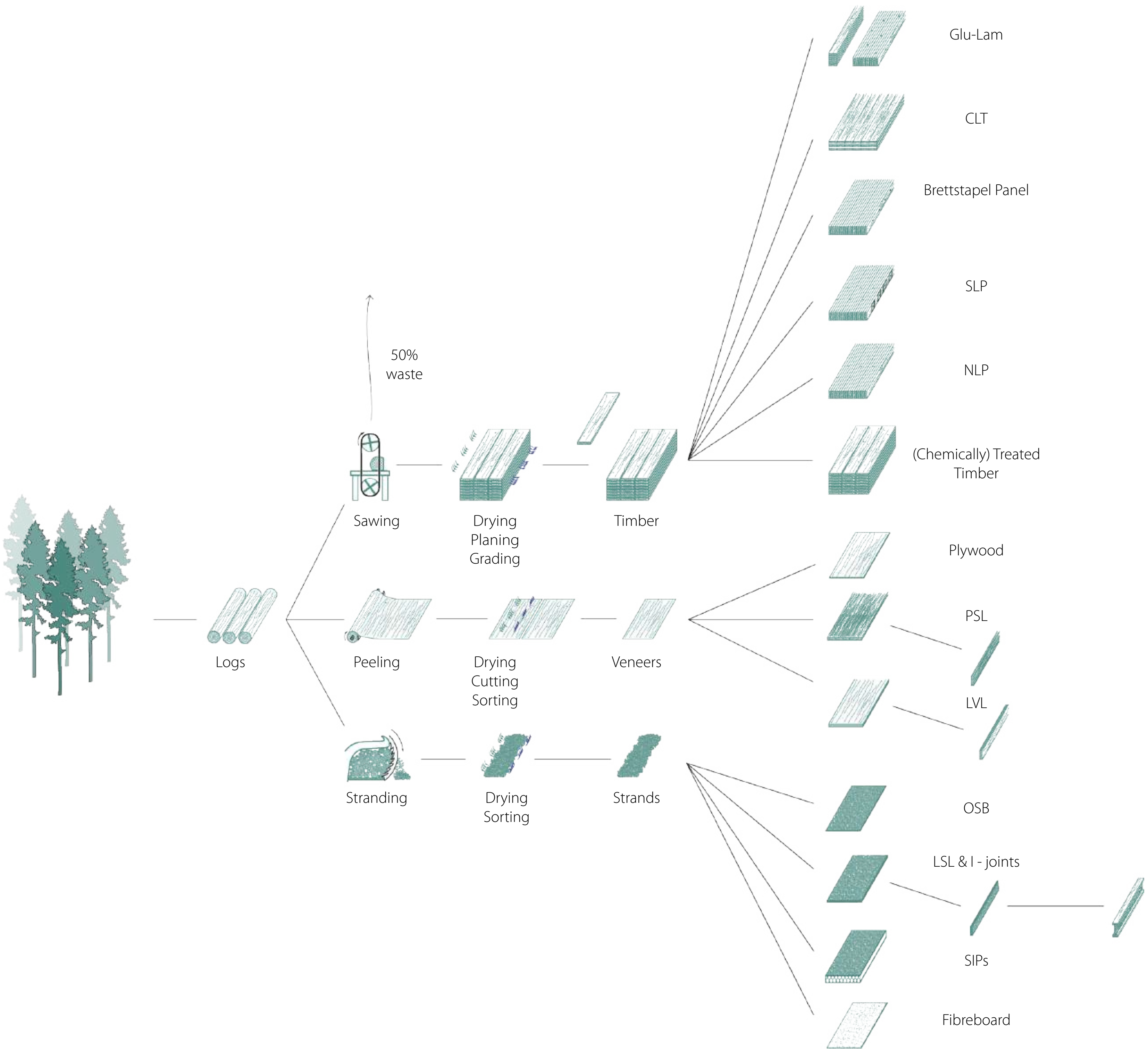


Figure 18.
The processing chain of engineered timber products.
Illustrated by the author, on the bases of the diagram of P.H.Fleming, (2017).

Wood / Making tree artificial

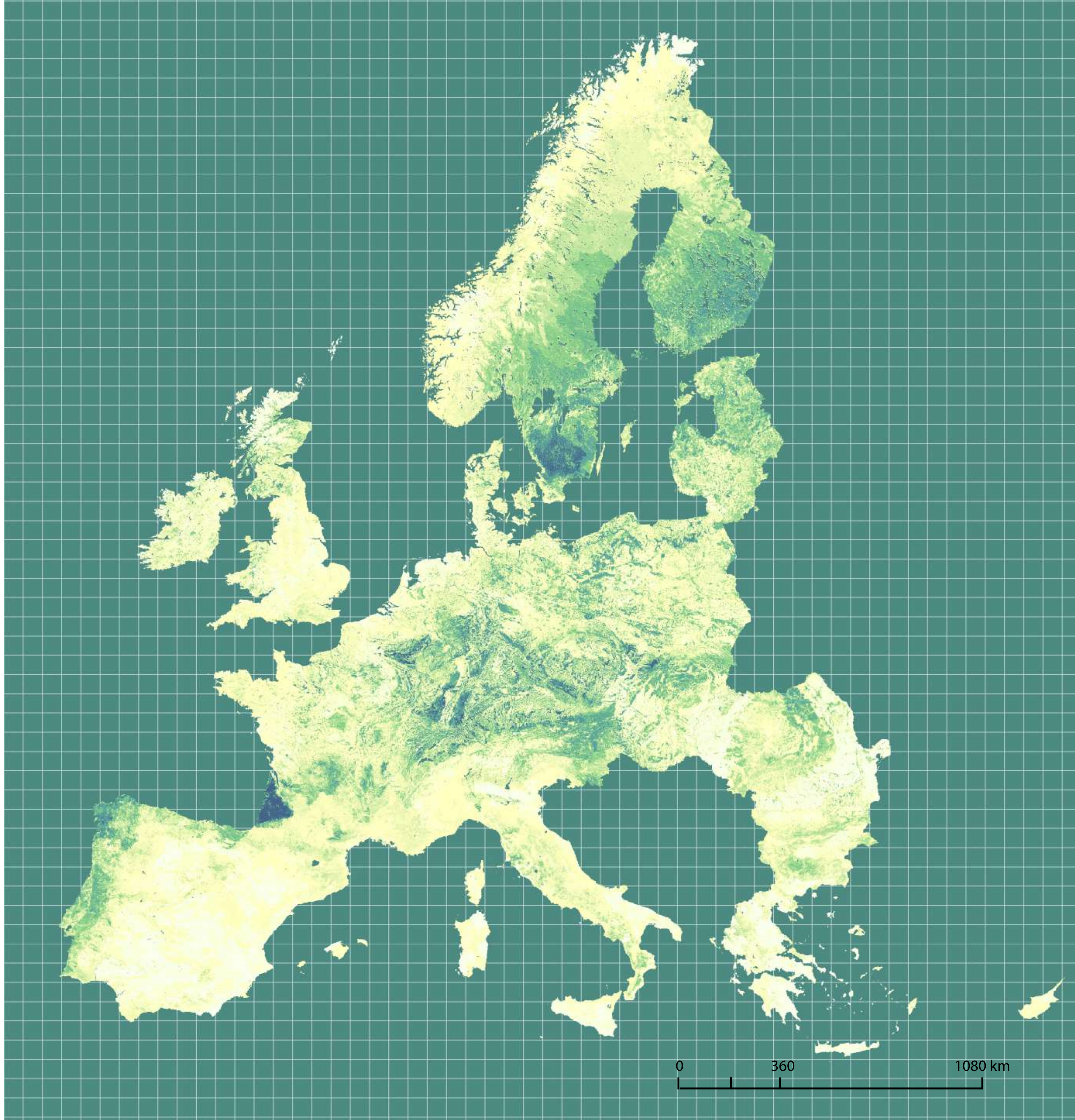


Figure 19.
Annual European wood production -in m³ per hectare of land from 2000 to 2010-.
Illustrated by the author, on the bases of the digram of Verkerk et al., (2015).
/ The production of timber in 29 European countries from 2000 to 2010 is shown in this map. Regions with poor timber production include the Norwegian coast, parts of England, Spain, Greece, northern and eastern Italy, and western Netherlands and Belgium. High levels of production were found in southern Sweden, SE Belgium, NE France, southern Germany, parts of the Czech Republic, Austria, and Switzerland, and northern Spain. The area with the highest production relative to the average was the SW coast of France (Verkerk et al., 2015).

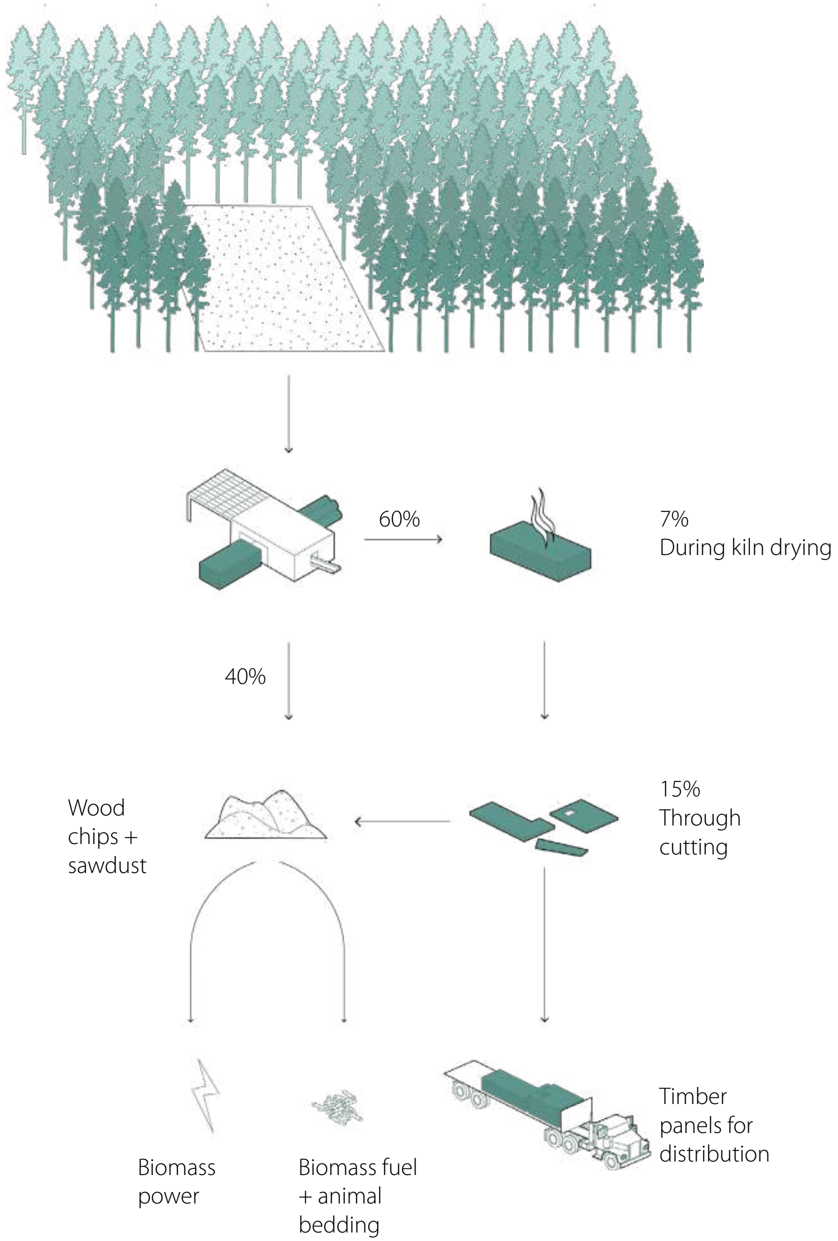


Figure 20.
The production of timber products is a closed loop process.
Illustrated by the author, on the bases of Waugh Thistleton Architects, (2015).
/ The main steps and effectiveness of the manufacturing process for engineered timber products. On this, almost zero waste is produced during production. The parts of the log that are not used for the product, the "waste" of the product, are later used as biomass power or fuel, where they are generally used by the factory itself.

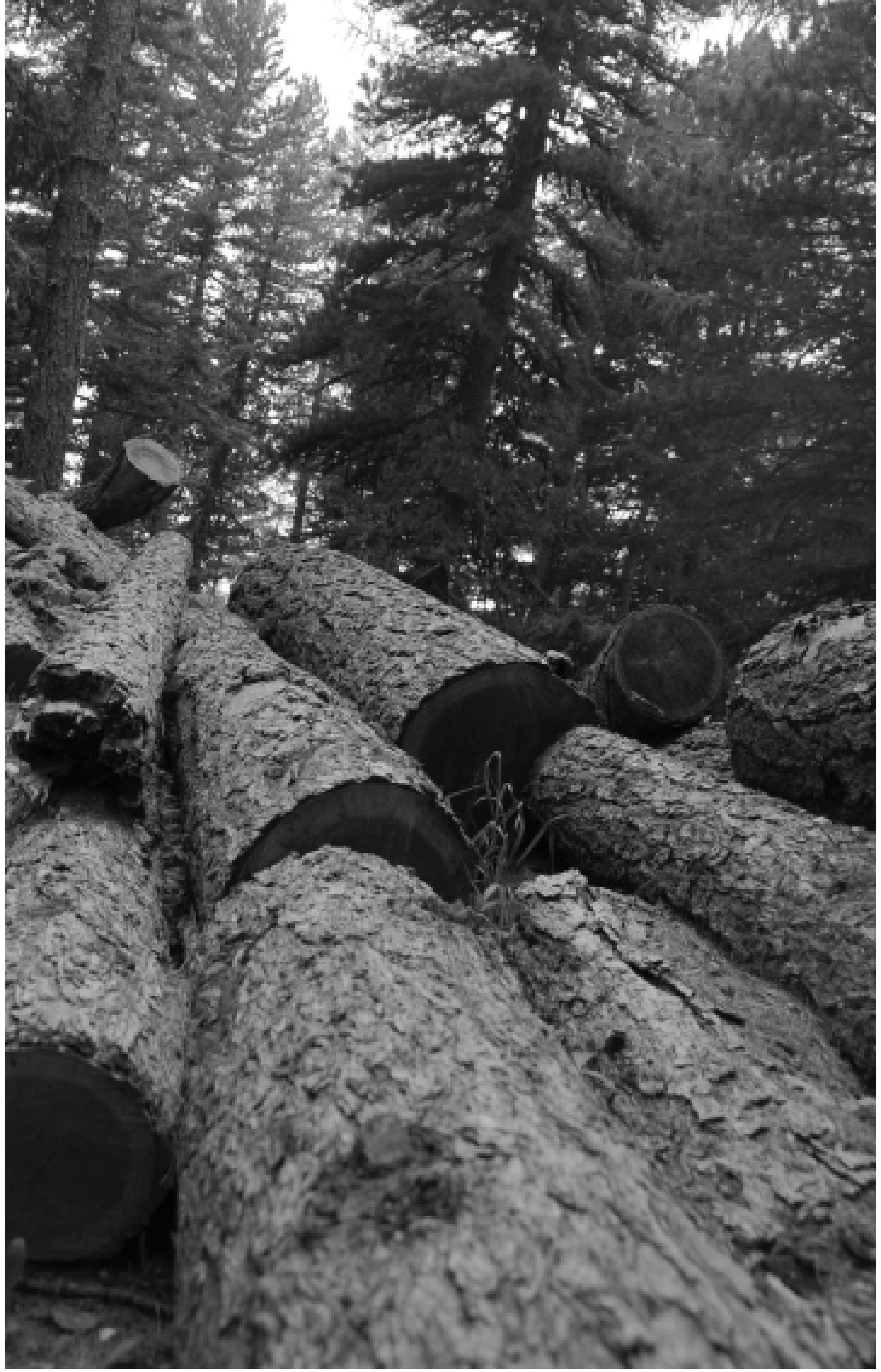


Figure 21.
Great Salbertrand Forest, Piedmont.
Image courtesy of F. Viani.

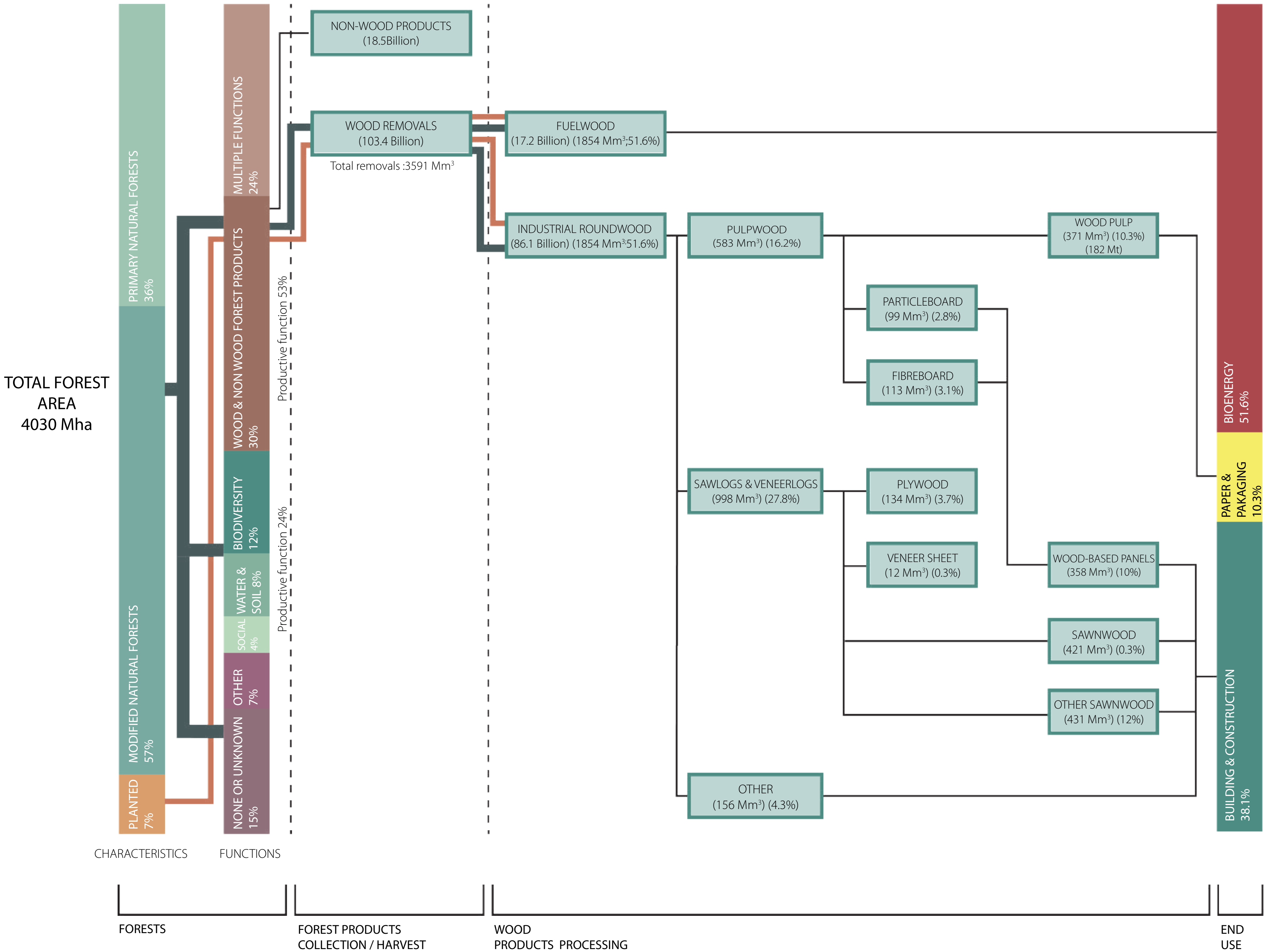


Figure 22.
Sankey map illustrating the global flow of wood, from forests to end-use. Illustrated by the author, data from FAO. Forestry data for ,(2010). Wood removal data, (2013).
/ The diagram presents the systems of wood processing, from forest supply to end-use. It highlights the importance of sustainable management and provides a comparison of wood use in construction with other uses. The graph is divided into three sections: source (forests), collection of raw materials, and manufacture of wood products. Primary natural forests make up just under 10% of the world's woods, but provide 35-40% of annual roundwood harvest. By 2030, it is predicted that planted forests would provide 80% of the world's annual wood harvests. (Ramage et al., 2017).

Figure 23.
Great Salbertrand Forest, Piedmont.
Image by the author.

Wood / Making tree artificial

Figure 24.
Wildernesse Restaurant, Duggan Morris Architects.
Image from Mark Hadden.

MASS TIMBER MATERIALS

The term "mass timber construction" refers to a group of framing designs that are frequently distinguished by the use of substantial engineered wood panels (WoodWorks, 2021).

In the past years it has been experiencing a rapid spread because of the many advantages it offers: from the speed of realization to the accuracy in the phase of cost prediction, effectiveness of energy performance, provides great thermal and acoustic insulation, and has verifiable health and well-being benefits. The timber structure also locks carbon within its fabric, an intrinsically sustainable and modern approach to construction that produces high quality, high performance buildings (Ibid.).

The use of mass timber products leads to the creation of lighter and higher quality structures in a faster time frame, which results in fewer foundations, fewer deliveries to the site, a cleaner and quieter construction process, and fewer employees. These panels can also handle both horizontal and vertical loads in a single project(Waugh Thistleton Architects, 2018).

It is also frequently observed in projects where various construction methods are integrated to improve and get bigger benefits that are typically not provided by one particular method of construction alone (WoodWorks, 2021).

These systems can be categorized into two large groups, the dry systems (non-glued) and wet systems (glued), where the non-glued ones, are composed by friction or use of dowels to join the pieces (Ibañez et al., 2019).

A mid-rise steel or concrete building, according to a research from the University of Canterbury, has about 1500 tonnes of net embodied carbon dioxide emissions, but the same building made of mass timber has a net sequestration of 610 tonnes of carbon dioxide, making this timber construction carbon positive even before the building is operational (Organschi et al., 2016).

When applied at larger scales of production, the mitigation of emissions, the absorption of CO_2 during the forest harvesting process, and the sequestration of CO_2 from the material make the production of timber have greater advantages.

The numerous difficulties that have prevented the wooden construction from infiltrating the urban typologies can therefore be handled.

Below are examples of the two categories mentioned above and their characteristics.

/
CROSS-LAMINATED TIMBER (CLT)

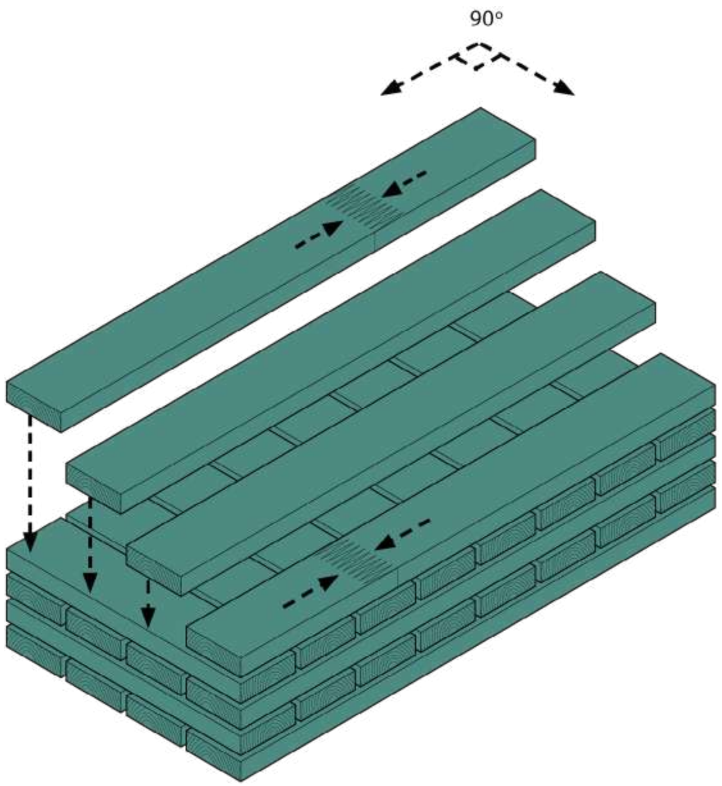


Figure 25.
Axonometric View of CLT System.
Illustrated by the author, on the bases of Waugh Thistleton Architects, (2015).

One of the most used products within the category of wet systems (glued) is the CLT which in English stands for "Cross-Laminated Timber", although in Italy its more often to called X-LAM.

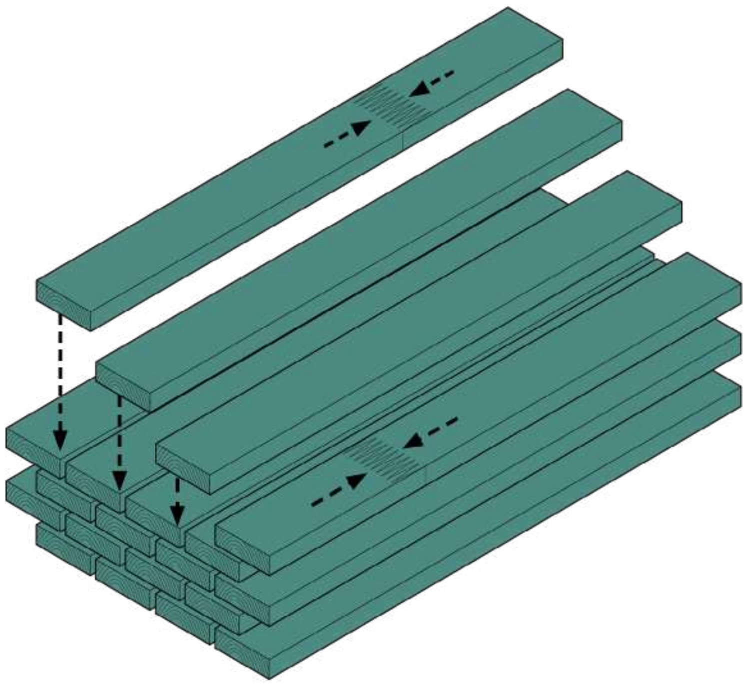
It consists of laminated timber arranged in cross layers, 90 degrees one to each other, as shown in (Fig.27), typically in odd numbers. A CLT panel's cross section is generally made up of three to nine layers of boards, and glued under pressure to form a single wooden element with exceptional load capacities in all directions. By alternating the orientation of the layers of wood, expansion and shrinkage in the plane of the panel is minimized. Also the manufacturer, the type of lumber used, the project's structural and architectural requirements, among others. All affect the lamination thickness. (WoodWorks, 2021).

Because of its easy of handling during construction and high level of prefabrication, CLT has shown its competitiveness in "medium and tall structures" in Europe (Waugh Thistleton Architects, 2018).

Figure 26.
CLT walls and ceiling in the five-story Catalyst in Spokane, WA.
Image from MGA | Michael Green Architecture, Ben Benschneider.

Figure 27.
Clt Building.
Image from Lewis Kahn, and illustrated by the author.

/
GLU-LAMINATED TIMBER (GLU-LAM)



GLUE

PUR, or polyurethane-based adhesives, or MUF, or less frequently, melamine-urea-formaldehyde-based adhesives, are generally used in Europe for mass timer production. PURs are popular because they don't contain formaldehyde or solvents, which ensures low toxicity and makes it easier to reuse or recycle them in the future. However, fire restrictions might affect the adhesive choice. (Waugh Thistleton Architects. 2018).

Figure 28.
Axonometric View of a GLU-LAM System.
Illustrated by the author.

Glue-laminated timber is a structural engineered wood product also within the category of wet systems (glued) that is typically used in applications for beams and columns, its stronger than steel and has more strength and stiffness than comparable sized dimensional lumber (WoodWorks, 2021).

The process of the making starts by cutting the wood, as shown in (Fig.30), the laminations are joined end to end to enable for large spans and are bonded with a long-lasting, moisture-resistant glue. The grains of the laminations run parallel with the length of the member to increase its strength (Ibid.).

Glu-Lam is available in conventional and customized sizes. According to APA (The Engineered Wood Association), depths range from 15 to 180 centimeters and widths from 15 to 70 cm. When ordered, components are trimmed to length they can exceed 30 meters. Glue-laminated technology allows almost any structural products to be manufactured in different sizes and shapes according to the requirements of different building projects (Ibid.).

Glu-Lam is well-known for its application to seek a combination of structural and aesthetic features as churches, higher education institutions, workplaces, and residences.

Glu-Lam can also be used behind the scenes as, floor beams, cantilevers, and other structural elements.

Figure 29.
Glu-lam Building
Photo from Andreas Muhs, and illustrated by the author.

Figure 30.
Ilogistics Center in Fischamend, Austria by Poppe-Prehal Architekten, and illustrated by the author.

/
DOWEL-LAMINATED TIMBER (DLT)

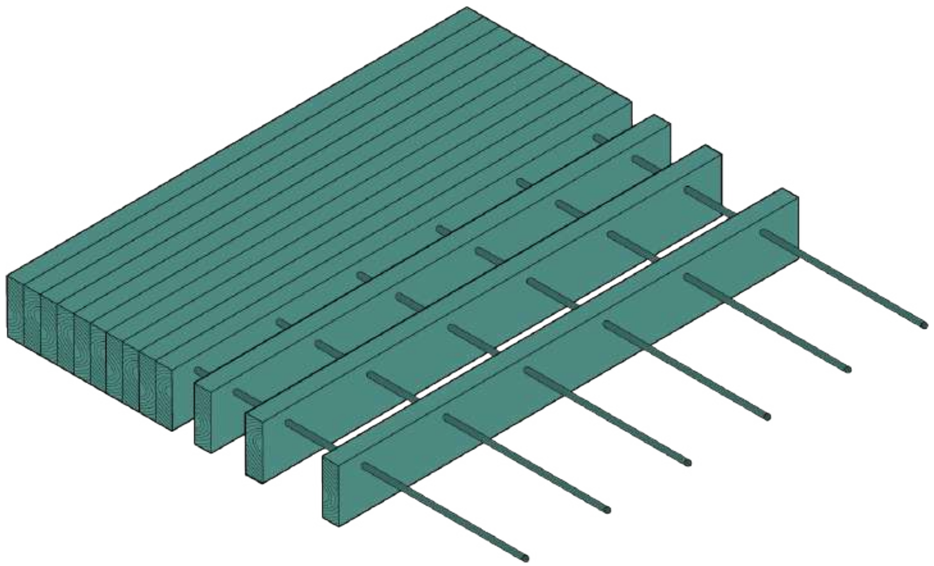


Figure 31.
Axonometric View of a DLT System.
Illustrated by the author.

On the other hand one the products within the category of dry systems (non-glued) is the DLT panels. They are constructed from solid sawn timber that is orientated on edge, but the particular thing, as shown in (Fig. 33) is that is friction-fit together using hardwood dowels (WoodWorks, 2021).

The friction fit offers dimensional stability while the dowels keep the boards together side by side. Each board is planed, making it possible to economically integrate a wide range of aesthetic profiles into the panel's bottom surface. To fulfill noise reduction goals and keep the wood exposed, an integrated acoustic profile can be created.

The all-wood construction of DLT laminations, which are commonly finger-jointed, makes it simple to cut with hand tools to make openings or other field adjustments. DLT panels are commonly used for floors and roofs (Ibid.).

Figure 32.
BOKA Powell, Dlt decking in The Soto,
building by Hixon Properties.
Photo from Structure Craft, and illustrated by the author.

Figure 33.
Dlt panels.
Photo from Patano Studio, and illustrated by the author.

Wood / Making tree artificial

/
NAIL-LAMINATED TIMBER (NLT)

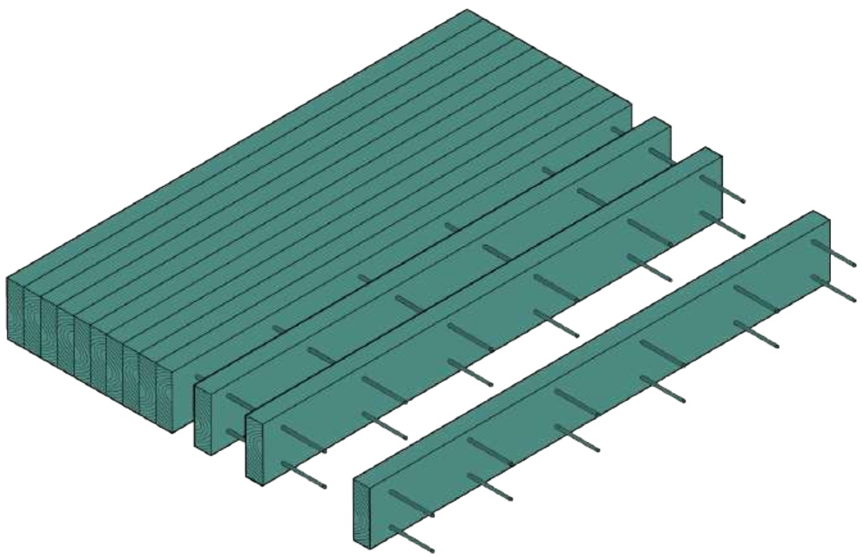


Figure 34.
Axonometric View of a NLT System.
Illustrated by the author.

Figure 35.
Brentwood Skytrain Station, Burnaby.
Image from Tae Ik Hwang, and illustrated by the author.

Figure 36.
NLT decking in the seven-story T3 Minneapolis.
Image from MGA | Michael Green Architecture, Ema Peter.

Another product within the category of dry systems is the NLT, which has been used for more over a century, but as part of the current mass timber movement, it is experiencing a rebirth (WoodWorks, 2021).

NLT unlike the more popular ones (Clt, Glu-Lam), is manufactured without the use of glue, as seen in the (Fig. 36) but is created by joining pieces of solid sawn dimensional timber (2 by 4, 2 by 6, etc.) with nails or screws to create larger structural panels.

It is usually prefabricated in panels 1 to 2.5 meters wide and 4 to 12 meters long and is commonly used for floors and ceilings, and less often for walls, lift shafts, and stairwells (Ibid.).

Wood / Making tree artificial

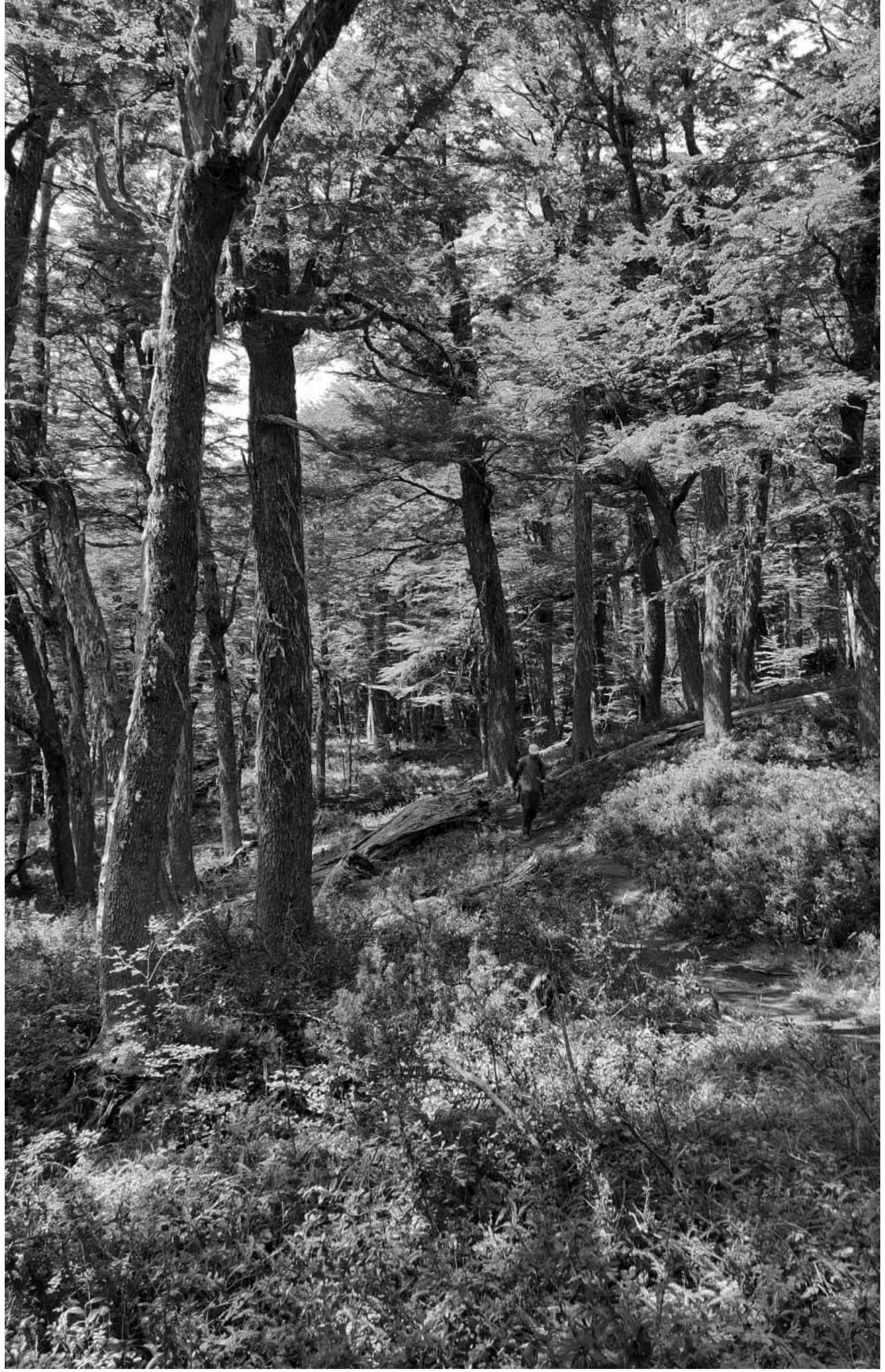


Figure 37.
Patagonian Forest, Argentina.
Image from the author.

/CARBON BENEFITS

CO_2 FORESTS

For mitigating greenhouse gas emissions, forests are crucial. This chapter examines the role of forests and trees with CO_2 emissions.

We will consider Baldo et al. (2005)'s book as a guide to approaching the subject since it describes the carbon cycle and CO_2 emissions.

With this in mind, there are two key themes that could emerge from the study of this subject: the sustainability of a forest and the method for calculating CO_2 emissions.

In these conditions, it is important to emphasize that the topics are quite complex. Nonetheless, this section of the study tries to give the required components for a proper framing of the problem.

It is first necessary to talk about the function of forests in relation to the carbon cycle in order to frame the issue (Fig. 38).

Carbon pool:
A reservoir of carbon. A system which has the capacity to accumulate or release carbon.

Carbon stock:
The absolute quantity of carbon held within a pool at a specified time. The units of measurement are mass.

Carbon flux:
Transfer of carbon from one carbon pool to another in units of measurement of mass per unit area and time. (e.g., t C ha -1 yr-1)

Carbon sink:
Any process or mechanism which removes agreenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. A given pool (reservoir) can be a sink for atmospheric carbon if, during a given time interval, more carbon is flowing into it than is flowing out.

Sequestration (uptake):
The process of increasing the carbon content of a carbon pool other than the atmosphere.

(IPCC, 2000).

Wood / Carbon benefit

As it is well known, the carbon cycle is the backbone of life on Earth. We are made of carbon, we eat carbon, and our civilizations are built on carbon. We need carbon (Riebeek & Simmon, 2011).

Forests are vital to the carbon cycle because they exchange 20 times as much carbon dioxide (CO_2) annually as is emitted by burning fossil fuels (Ibid.).

Forests are able to absorb CO_2 by using the solar energy they receive to transform water (absorbed through the tree's roots) and CO_2 (absorbed through the leaf) into sugar to make cell building blocks and oxygen, which is subsequently exhaled through the tree's leaves (Ibid.).

As trees grow, carbon is stored in the biomass. Approximately 50% of the dry matter of a plant is carbon.

To illustrate the potential this represents, consider that cellulose aggregates 1,500 glucose monosaccharide rings into polysaccharide molecular structures with 9,000 carbon atoms during the molecular sequestration of carbon in timber (Organschi, 2016).

In simple terms, the forest, like every other living species, "breaths". This means that CO_2 is released partly because of organisms in the soil or dead trees, where CO_2 will then be released when the wood is burned by natural causes or influenced by human activity (Ibid.).

However, as the biomass of the forest increases, more CO_2 is stored than is released. This indicates that maintaining and developing forests are crucial to the forest's ability to absorb carbon dioxide (Ibid.).

The total carbon sequestration potential of a forest system also is considerably affected by altering the frequency of sustainable timber harvests, according to a 2005 study by the Consortium for Research on Renewable Industrial Materials (CORRIM).

Forests can increase their life cycle total gross sequestration and emission mitigation from about 225 metric tons of carbon per hectare to almost 280 metric tons of carbon per hectare by increasing the frequency of harvesting cycles from a natural mortality rate of 120 years to a much more intensive harvesting rate of 45 years.

Over the years the carbon uptake in forests is estimated by taking into consideration changes in the biomass, which is where CO_2 is stored, as well as the number and variety of organisms within the forest as shown in (Fig. 39).

Foresters in order to measure wood volumes through time. They have devised, managed, and regulated methods for measuring wood carbon in forests which exclusively take into account the above-ground portion (MacDicken, 1997; Brown et al., 2001).

Returning to the subject of study, wood use is related to the environmental friendliness of forest activities and its contribution to the greenhouse effect[1].

To elaborate on this argument, the main factors that are determinant for analyzing the greenhouse effect could be said to be:

/ *Let's refer to Q as the raw material, whether it originates from a fossil or biological source, from which the energy needed to manufacture the timber will be produced.*

/ *The stock utilization requirement, let's call it G, i.e. how much wood is needed, this value can be expressed in tonnes per year.*

/ *The speed of the re-stock the raw material source, let's call it V, which in this case would be the time it takes for the tree to grow before it can be used. This parameter is evidenced in years.*

It should be noted that for this procedure to be considered sustainable, considering that the raw material is the only one used for this production, a stock of the size of the required quantity will be necessary in relation to the number of years it takes to replenish the total stock.

This consideration would be manifested as follows:

$Q = G*V$

A brief aside, this consideration can be seen in the sustainable management of forests.

The carbon cycle which is taken into consideration is highly complicated, as can be seen, and is really challenging to calculate accurately due to the determination of some of its constituent variables, such as the involvement of the atmosphere, ocean, and biosphere.

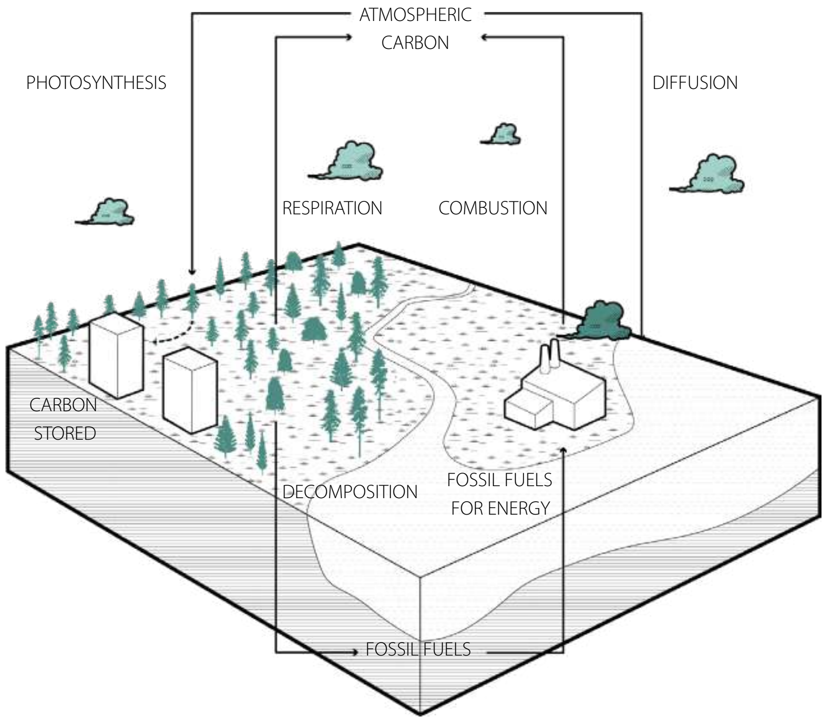
Therefore, if sustainability is believed to be characterized by keeping the atmospheric CO_2 concentration constant, all considerations must be based on the quantitative analysis of the balances taken into account.

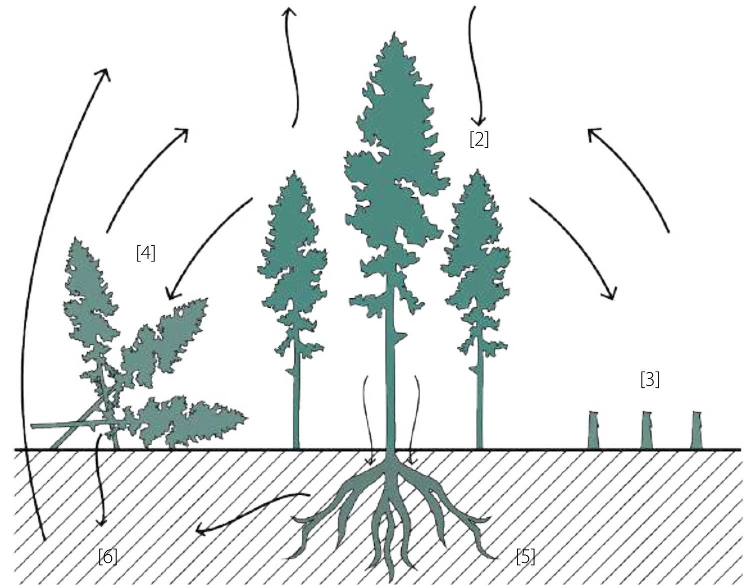
Therefore, it can be understood that compatibility is achieved when the carbon cycle factors are compatible with the time to supply the stock, and thus avoid unbalanced loading within the cycle.

Putting these concepts into perspective, we could intend to think that; fossil fuels could also be renewable, yes, but it would require a stock equivalent to millions of years consumed in a year.

This section can be concluded by stating that a forest is renewable as long as the same amount of trees used are planted as before.

[1]. The greenhouse effect is a process that greatly determines the temperature of the earth.





1. ATMOSPHERE / 2. ABOVE - GROUND CARBON: Tree trunk, branches, and leaves / 3. HARVEST PRODUCTS / 4. DEAD WOOD & LITTER / 5. ROOTS / 6. SOIL

Figure 38.
The Carbon Cycle.
Illustrated by the author, on the bases of Waugh Thistleton Architects, (2015).

Figure 39.
Pools and flows of carbon in forests (adapted from IPCC 2000; p.37).
Illustrated by the author, on the bases of Future Forests, (2003).

TO HAVE A REFERENCE OF ACTUAL DATA;

/ *81 percent of the carbon in the soil and 19 percent in plants make up the biosphere's total amount of carbon in the world. Approximately 31% of the carbon in all forests, is stored in biomass, and 69% of it is in the soil. In tropical forests, approximately 50 percent of the carbon is stored in the biomass and 50 percent in the soil (IPCC, 2000).*

/ *The amount of carbon stored in all of Europe's forests, except those in the Russian Federation, is believed to be 9.552 billion tonnes of carbon (t C), with a rise of 115.83 million tonnes of carbon every year. Meanwhile, the Russian Federation's forests are thought to store an extra 37 billion tonnes of carbon, with an increase of 440 million tonnes of carbon per year.*

/ *According to the FAO, over 1 billion hectares of forests globally are currently production forests, but only 70 to 100 million hectares of forest are fast-growing plantations. Converting more forestland to plantations could quickly increase carbon sequestration (Mendelsohn et al., 2012).*

/ *A 50-year-old conifer plantation may store 50 to 100 tonnes of carbon per hectare. However, over a much longer length of time, an old growth forest may store up to 250 tonnes of carbon per hectare (300 years or more) (Europanels, 2018).*

Figure 40.
Carbon accumulation potential from natural forests regrowth in potentially reforestable areas in Italian territory. Illustrated by the author, on the bases of GFW Data, Cook-Patton et al., (2020).
/ The rate of atmospheric carbon sequestration and aboveground living biomass storage by forests over the first 30 years of their natural regrowth is shown in (Fig. 41). This illustrate how it could be speculated that the distribution and amount of forest area found in this territory are part of the reason for the carbon sequestration being evenly dispersed throughout the Italian terrain.

Wood / Carbon benefit

Figure 41.
Roundwood, Austria.
Image from Waugh Thistleton Architects.

CO_2 MEASURE IN WOOD

The second matter that needs to be addressed in respect to carbon emissions from wood, as previously noted, has to do with carbon accounting methods.

Due to the wide variety of scientific ideas that exist in the scientific community, Life Cycle Assessment (LCA) studies on carbon emissions are frequently handled utilizing two alternative methods that may be summed up as follows:

/ *Carbon credit*
/ *Definition of the source of emission.*

The two methods already indicated are briefly described in the paragraphs that follow.

The first approach, known as "carbon credit", bases its calculation of carbon emissions mainly on the quantity of carbon absorbed during the tree's growth stage.

Lets temporarily put aside all the other aspects supply chain to concentrate just on the growth of the timber in order to make this notion more clear.

The carbon credit, which is measured in CO_2, can be thought of as beginning with the first second of a tree's development phase, from the planting of the tree in the ground. The carbon credit then rises in line with the tree's development until it reaches its equilibrium stage. It is important to note that the development stage needed to establish equilibrium differs based on the kind of tree. The balance between CO_2 absorption and breakdown is thought to be minor after equilibrium growth is achieved.

This makes it clear that when the tree is harvested in an appropriate manner, taking into account its growth time, there is a kind of "carbon credit" stored within it.

The carbon credit is trapped inside the material, as it is with all raw materials used to make energy, until combustion occurs and releases the CO_2, which is then released into the atmosphere. Last but not least, it is important to clarify that there is no increase in CO_2 emissions into the environment as a result of this burning process.

Let's use an example as simplification to comprehend this even more clearly.

Let's say a tree is planted on a plot of land where a tree was once harvested. Let's further assume that the tree reaches equilibrium growth and has so far stored 100 Kg of carbon dioxide.

Assuming also that there were no variations in CO_2 emissions during the whole process of this wood.

The tree, just after reaching equilibrium, is harvested to be used as a building material, say, in a wood panel. When the end of the life of this panel comes, the panel is recycled to create a new product. This wood is used for the creation of new energy after this recycled product has reached the end of its useful life. In the meantime, the 100 kg of CO_2 credit that this wood had is expelled into the atmosphere.

If a recycled product rather than a tree was used to make the construction material, then it may also be said that part of the process was changed. In this situation, the carbon credit would remain in the loop until the end of the life of the timber comes and would not be affected by the steps the wood took to being burnt.

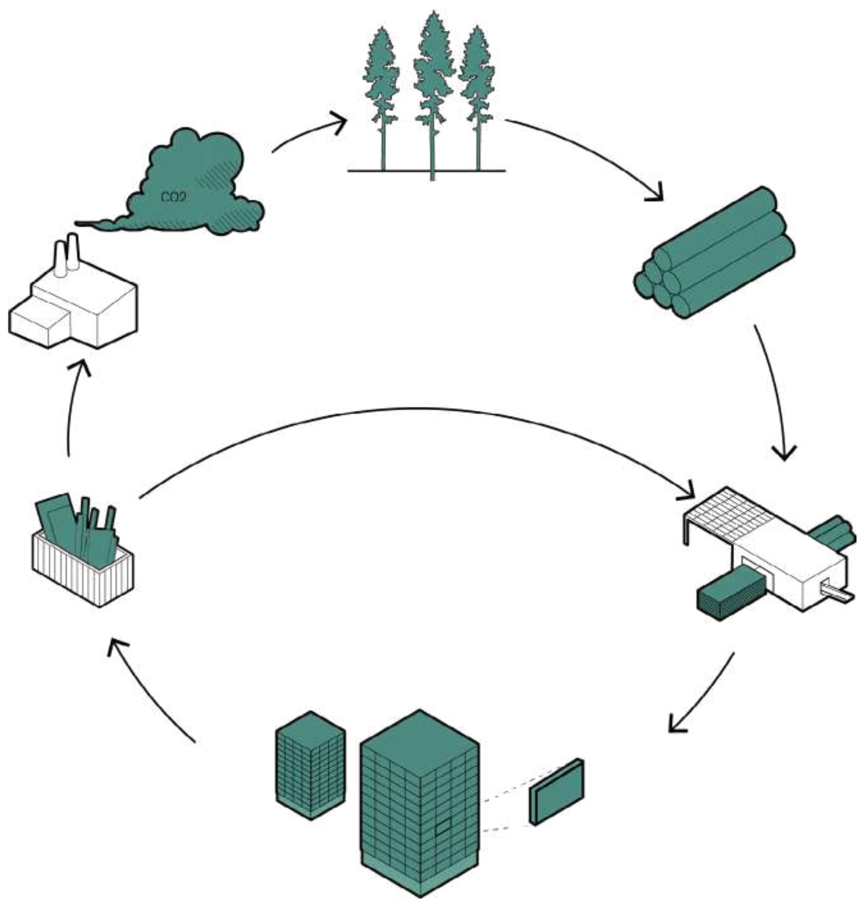


Figure 42.
Carbon cycle used in the production of wood. Taking into account that it offers a mass yield of 1:1
Illustrated by the author, on the bases of Waugh Thistleton Architects, (2015).

STAGE	DESCRIPTION	CO_2 EMISSIONS
[1]	Tree growth and CO_2 absorption	[-100 Kg]
[2]	Tree harvest	[0 Kg]
[3]	Log been manufactured	[0 Kg]
[4]	Material used for construction (panel)	[0 Kg]
[5]	First material recycle for a new product	[0 Kg]
[6]	Material burned for energy production	[100 Kg]
TOTAL CO_2 EMISSIONS		[0 Kg]

The table of (Fig. 43) shows how the carbon cycle in the production, recycling, and disposal of a manufactured wood product is balanced assuming that each operation has a 1:1 yield in terms of mass, the final balance leads to the conclusion that the whole cycle is CO_2 - neutral.

It is obvious that the numerical figures used in this example are merely intended to serve as a basic illustration for a better comprehension of the topic.

The system is actually much more complex because the fate of the product's waste is not always to be incinerated, where all the carbon is intended to be converted to CO_2. Instead, there is a possibility that the material could end up in a landfill, where the CO_2 would be converted to CH_4, which would have much more severe effects on the greenhouse effect.

For reviewing this study, the following considerations should be made:

/ *To account for the carbon dioxide that was absorbed during the manufacture process, the product must have a carbon credit that shows the value as negative.*

/ *For a true analysis, all process activities must be taken into consideration (e.g. transport, energy use, energy production, etc.).*

/ *In order to adhere to the standards of sustainable usage, this analysis must be evaluated while taking into account the balanced growth of trees.*

Figure 43.
Carbon cycle of a produced wood product.
Illustrated by the author.

On the other hand, when the CO_2 credit is not taken into consideration, the way of estimating carbon emissions would be through the source of CO_2 emissions.

Regardless of how much CO_2 storage a tree has, the analysis method starts with one that has already grown. The method begins with positive CO_2 emission levels, but it is crucial to specify whether the emissions are from fossil or biological sources by indicating where they are coming from. On the other hand, this study shouldn't account for the calculation of emissions that contribute to the greenhouse impact.

It could be stated that if the "credit" of the wood were ignored, the CO_2 issue will only exist at combustion.

By using this method to study the production of timber, it is possible to confirm that the only data presented regarding CO_2 is related to production activities like transportation and energy consumption.

The origin of the CO_2 that has been stored in the timber material and cannot be determined until it is burnt or disposed in a landfill.

To clarify these two methods of LCA's approach to carbon emissions, they will be confronted with an example.

Supposing there is a wood panel containing 10 units of CO_2 where the production process emits 100 units.

These two theories would be used in the prescribed sequence:

When taking into account the method where "credit" is taken into account (Fig. 44):

-10 (credit) + 100 (process) +10 (combustion) = 100; where these emissions contribute to the greenhouse effect, but it is not necessary to detail where it comes from.

When the "credit" is not taken into account (Fig. 45):

100 (process) +10 (combustion) = 110; where 10 units come from biological sources (wood), therefore only 100 units contribute to the greenhouse effect.

This example demonstrates how the outcomes of the two measures are similar.

However, by performing the calculation taking into account the "credit," it is possible to have a calculation that is more precise because, in the event that there is no combustion during the process, the contribution of the tree's growth is taken into account.

This is a very useful feature when considering the waste process of the material. Using the above situation as an example, let's assume:

/ *Each kilogram of wood used in the creation of a 4 kg wood panel contains 1 kg of carbon dioxide.*

/ *Each kilogram of panel that is burnt releases the equivalent quantity of CO_2.*

/ *For every kg of wood used in the manufacture, one kilogram of CO_2 was wasted.*

/ *The total amount of emission produced is equal to 10 kg of CO_2.*

Because the immobilized emissions from wood are not taken into account, it is evident that the overall CO_2 emissions in the second instance are different.

In order to correctly calculate carbon emissions, the following factors must be taken into account:

On the one hand, the utilization of a negative timber credit's CO_2 emission.

However, if the "credit" is not used, the source of the CO_2 emissions as well as the amount and final destination of the wood wastes produced throughout the entire system must be given.

In order to conclude this chapter, it is crucial to make it apparent that the two previously described qualities may be found in different circumstances.

While it is important to note that the species of the tree, or the type of wood, and how the forest from which it is extracted are necessary for an accurate calculation, the first aspect is based on the consideration of resource renewal and sustainable forest management, and the second aspect is based on the accounting of CO_2 emissions associated with a system.

It is clear that they should be utilized individually even if they were described as overlap.

Wood / Carbon benefit

TAKING INTO ACCOUNT THE CREDIT	CO_2 EMISSIONS
Wood credit	[-6 Kg]
Process	[10 Kg]
Panel combustion	[4 Kg]
TOTAL CO_2 EMISSIONS	[8 Kg]

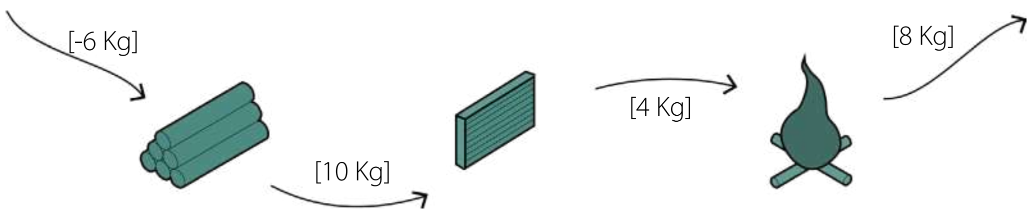
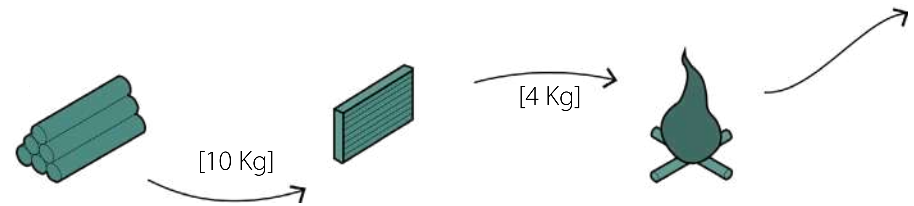


Figure 44.
Method of LCA's where "credit" is taken into account to calculate carbon emissions.
Illustrated by the author.

WITHOUT TAKING INTO ACCOUNT CREDIT	CO_2 EMISSIONS
Process	[10 Kg]
Panel combustion	[4 Kg]
TOTAL CO_2 EMISSIONS	[14 Kg]
Fossil source	[10 Kg]
Biological source	[4 Kg]



TO HAVE GENUINE DATA AS A REFERENCE;

"The combined effect of carbon storage and substitution means that 1m³ of wood stores 0.9 t CO_2 and substitutes 1.1 t CO_2 - a total of 2.0 t CO_2."
-Dr A Frühwald

Figure 45.
Method of LCA's where "credit" is taken into account to calculate carbon emissions.
Illustrated by the author.

/ WOOD IN CITIES: CASE STUDIES

In order to broaden the knowledge for the approach of timber solutions and strategies for an urban purpose, a selection of case studies with urban approaches are analyzed, The case studies were classified taking into account their urban scale (M , L, XL) and see how wood is used as the main response to become a key component of the urban regeneration project, as well as an optimal strategy in terms of sustainability.

/

Svartlamoen Housing, Trondheim Norway, 2005

/ ARCHITECT:
Brendeland & Kristoffersen Arkitekter AS

/ CROSS-LAMINATED TIMBER FABRICATOR:
Santner & Spiehs OEG, Tamsweg, Austria

/ CROSS-LAMINATED TIMBER PANELS:
Spruce (Picea abies)

/ WOOD CLADDING SUPPLIER:
Materialbanken [Alvdal Skurlag], Vingelen, Norway

/ PUBLIC PATERNS:
Municipallity of Trondheim, Norway

/ CLIENT:
Svartlamoen Commune

/ CONSTRUCTOR:
Stijern AS

/ SITE:
63°26'20.83"N, 10°25'25.33"E

/ FLOOR PLAN:
1 040 m^2

Figure 46.
Trondheim, Norway.
Illustrated by the author.

Figure 47.
Svartlamoen Housing, Trondheim.
Image from Ibañez et al., (2019).

M

L

XL

BACKGROUND

Svartlamoen neighborhood in Trondheim, Norway was abandoned in the 1970s but later became a affordable housing option for working classes. After being partially destroyed during WW2, young people moved in and fought against the city's plans for demolition, leading to the preservation of the unique vernacular housing. The neighborhood is now collectively owned by the residents and designated as an urban experimental ecological zone (Ibañez et al., 2019).

Figure 48.
Vernacular multy-story solid timber wharf buildings in Norway.
Image from the author.

Figure 49.
Vernacular multy-story solid timber wharf buildings in Norway.
Image courtesy of B.Strand.

Figure 50.
Project site.
Illustrated by the author.

Figures 51, 52 on the right.
Svartlamoen housing, rear facade.
Image from Jeroen Musch.

PROJECT

The design competition for "New Housing at Svartlamoen" was guided by three criteria: rentable, reasonably priced, and made of wood. The architects sought to challenge Norway's views on affordable housing by using CLT (Cross-Laminated Timber) as a solution. CLT provided more flexibility, reduced building costs, and demonstrated vertical building options with mass wood. The CLT panels were sourced from Austria, and the design aimed to preserve the existing urban morphology of the experimental urban commune of Svartlamoen. The design matched the scale of traditional masonry buildings while using wood instead, providing both an appropriate material language and necessary density for the neighborhood. The result was a reformulation of timber as an urban building material in Savartlamoen.

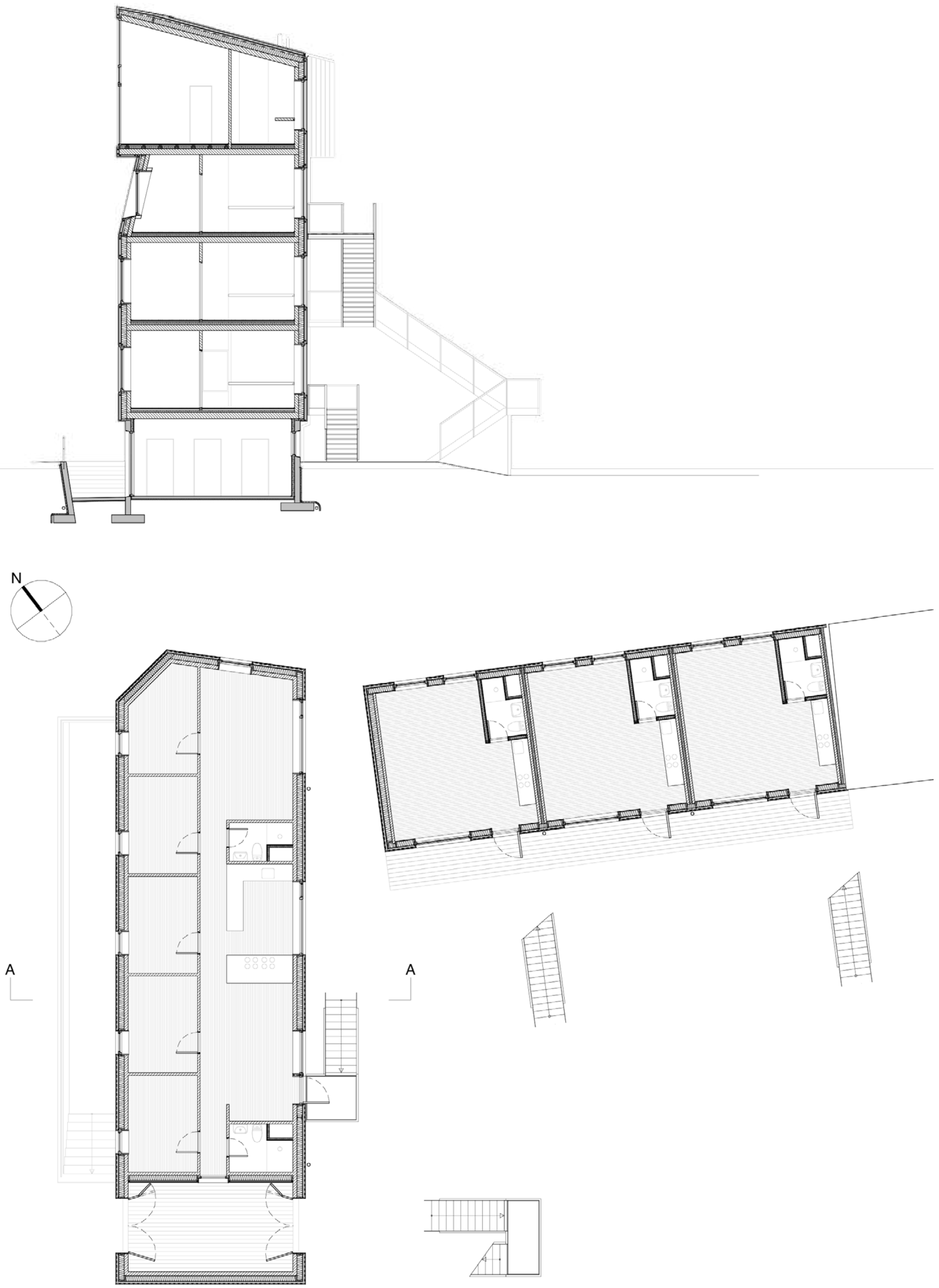


Figure 53.
Floorplan & Section.
Plans from Architect: Brendeland & Kristoffersen arkitekter AS.

Material layers from the outside in:

ROOF:
22 x 148 ore pine
22 x 73 ore pine
36 x 48 barges
Asphalt roofing
23 x 36 loops
22 mm roof rack
48 x 48 c / c 600, aeration
Wind barrier
48 x 198 c / c 600 rafters, mineral wool
Cross-laminated timber (spruce, pine, fit)

FLOOR SEPARATION:
21 x 70 Scots pine (Pinus sylvestris) floorboards
20 mm cement cheep-boards
48 x 98 on 80 mm heavy mineral wool
100 mm light mineral wool between feeders
Cross-laminated timber (spruce, pine, fit)

EXTERIOR WALL:
22 x 148 ore pine
22 x 73 ore pine
36 x 48 barges
23 x 36 loops
9 mm GU wind barrier
48 x 198 c / c 600 rafters, mineral wool
Cross-laminated timber (spruce, pine, fit)

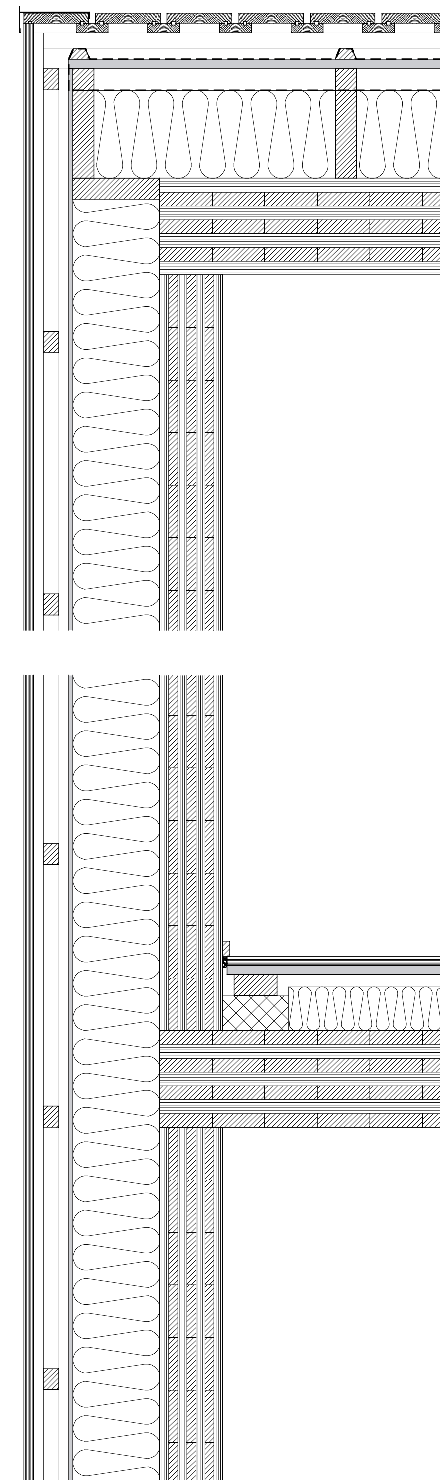


Figure 54.
Detail.
From Architect: Brendeland & Kristoffersen arkitekter AS.

/
ECO-FRIENDLY NEIGHBOURHOOD IN CHAÑARAL
Chile, 2017

/ ARCHITECT:
Juan Jose Ugarte
Andrés Sierra (CIM-UC)

/ CLIENT:
Ministry of Housing and
UC Center for Wood Innovation

/ SITE:
29°01’59.99”S, 71°25’59.99”W

/ PROJECT AREA:
18 702 m^2

Figure 55.
Chañaral, Chile.
Illustrated by the author.

Figure 56.
Eco-Friendly Neighbourhood in Chañaral.
Image from Ibañez et al., (2019).

M

L

XL

BACKGROUND

Given Chile's vast surface area, not all of its areas experience the same weather, ranging from a dry climate in the north to one with heavy rainfall in the south.

Chile stands out for its diverse climate as well as its significant forest reserves and wood industry.

With these qualities, one may assume that Chile would serve as a model for timber in the mass construction industry, but this is not the case. The majority of the wood is exported.

As a begin place, Chañaral in 2015 experienced a flood that severely devastated the region's infrastructure. A sizable portion of the population was forced to live in temporary housing as a result of being relocated (Ibañez et al., 2019).

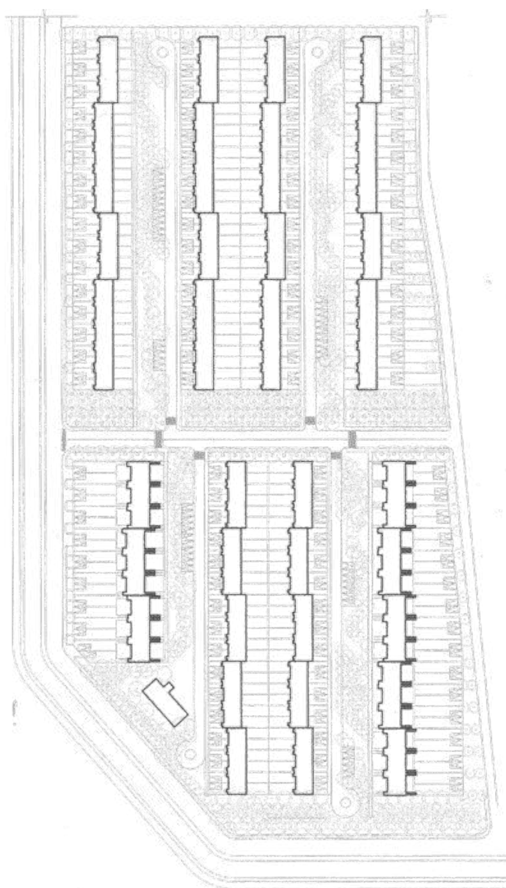


Figure 57.
Eco-Friendly Neighbourhood plan.
Image from Ibañez D. et al. (2019).

Figure 58.
Eco-Friendly Neighbourhood in Chañaral.
Illustrated by the author.

Figure 59.
Eco-Friendly Neighbourhood in Chañaral.
Image from Teresita Ugarte A.

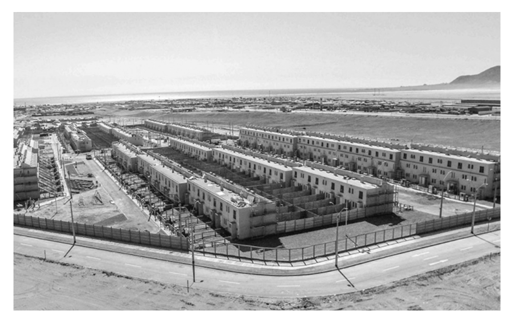


Figure 60.
Eco-Friendly Neighbourhood in Chañaral.
Image from Serviu Atacama.

PROJECT

The Ministry of Housing and the UC Center for Wood Innovation in Chile have proposed a new project aimed at building a sustainable, affordable and flexible housing community through the use of wood. The goal is to integrate processes such as energy generation, urban agriculture, and social amenities.

Using timber for the project allowed them to:

/ *Make the building process more effective while supporting the development of industrial capacity.*

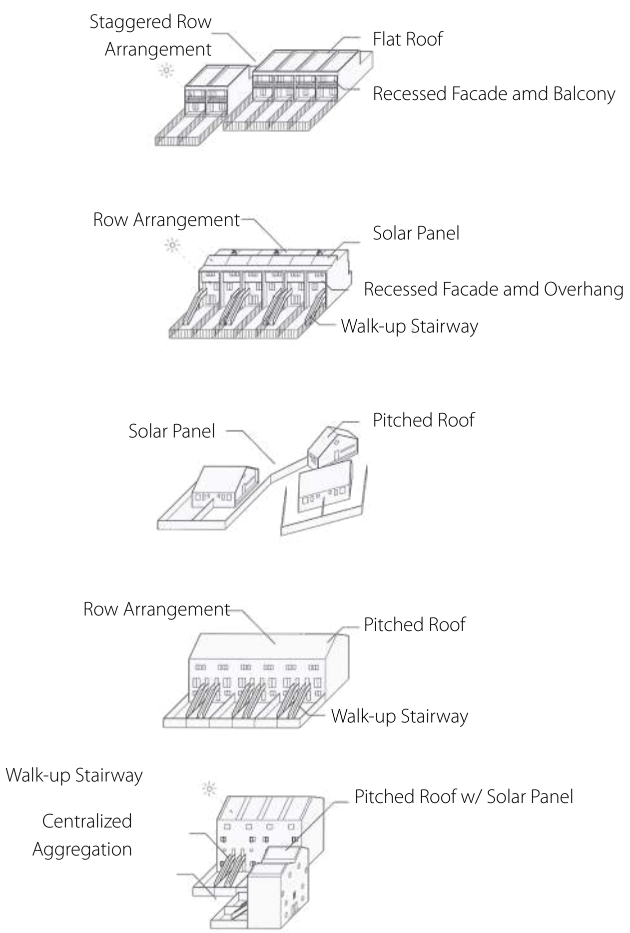
/ *Promote the undertaking as a potential housing option for low-income households across Chile.*

/ *The affordable price of manufacturing wood.*

/ *Energy efficiency, from the layout of the walls, enables the building's performance to be adjusted for the location.*

/ *Prefabrication and a flexible design approach allows interior modifications based on resident demands.*

/ *Considering its climatic and geographic characteristics, design flexibility for houses to be developed beyond the Chañaral region.*



The Chañaral model will be used as a model for seven additional projects to show how wood can coexist with urbanization and be adaptive of various climatic conditions.

Beyond these projects, the aim is to be able to extend urbanization; this model might also increase in height to accommodate housing with a maximum of six stories in response to very dense development.

Also, compared to a comparable concrete construction, the building of wooden housing uses around 67 percent less energy during its lifetime (Ibañez et al., 2019).

Moreover, this kind of urbanization may significantly reduce carbon emissions.

Figure 61.
Eco-Friendly Neighbourhood adaptations according to the different climate conditions.
Image from Ibañez et al., (2019).

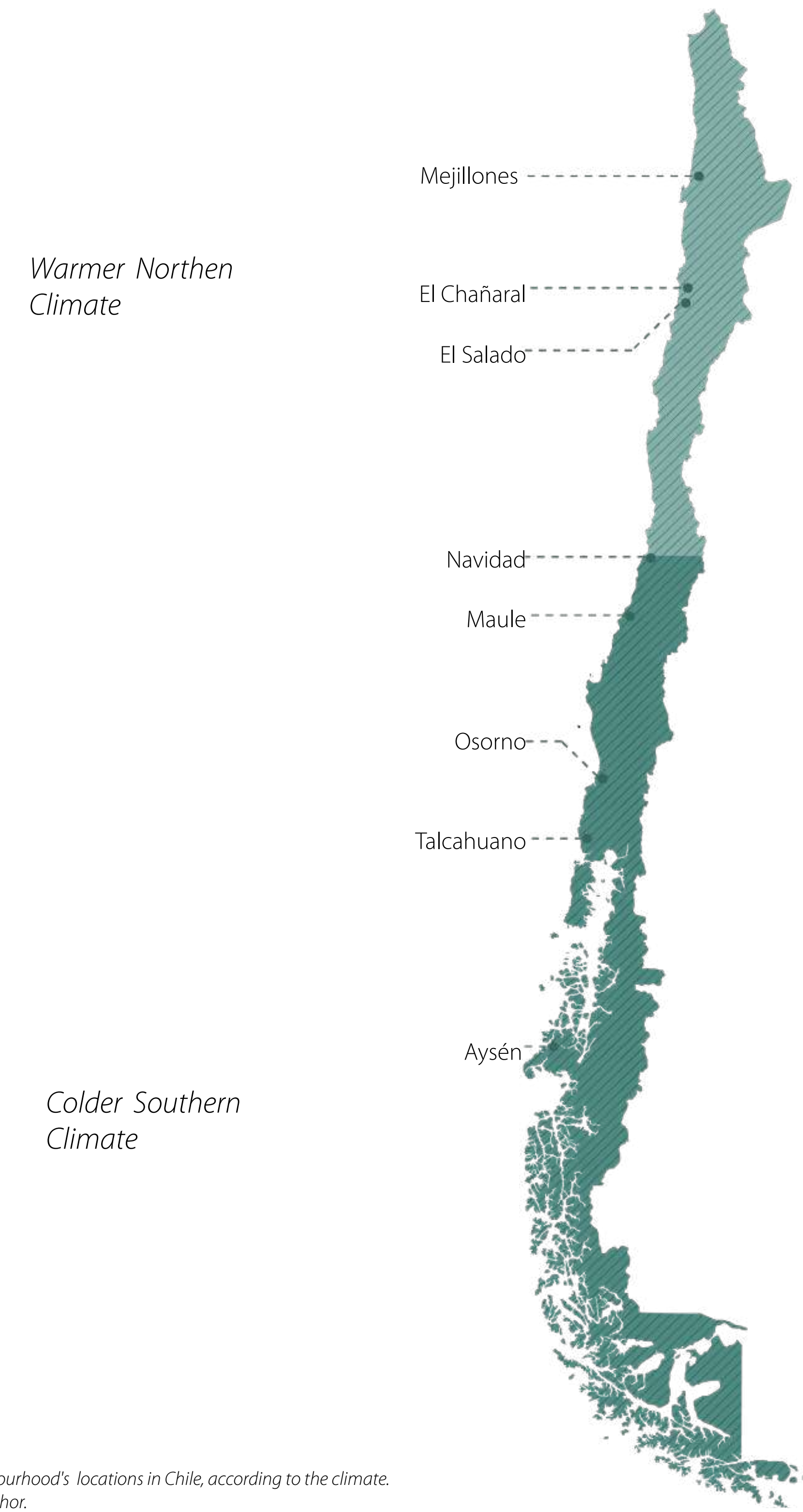
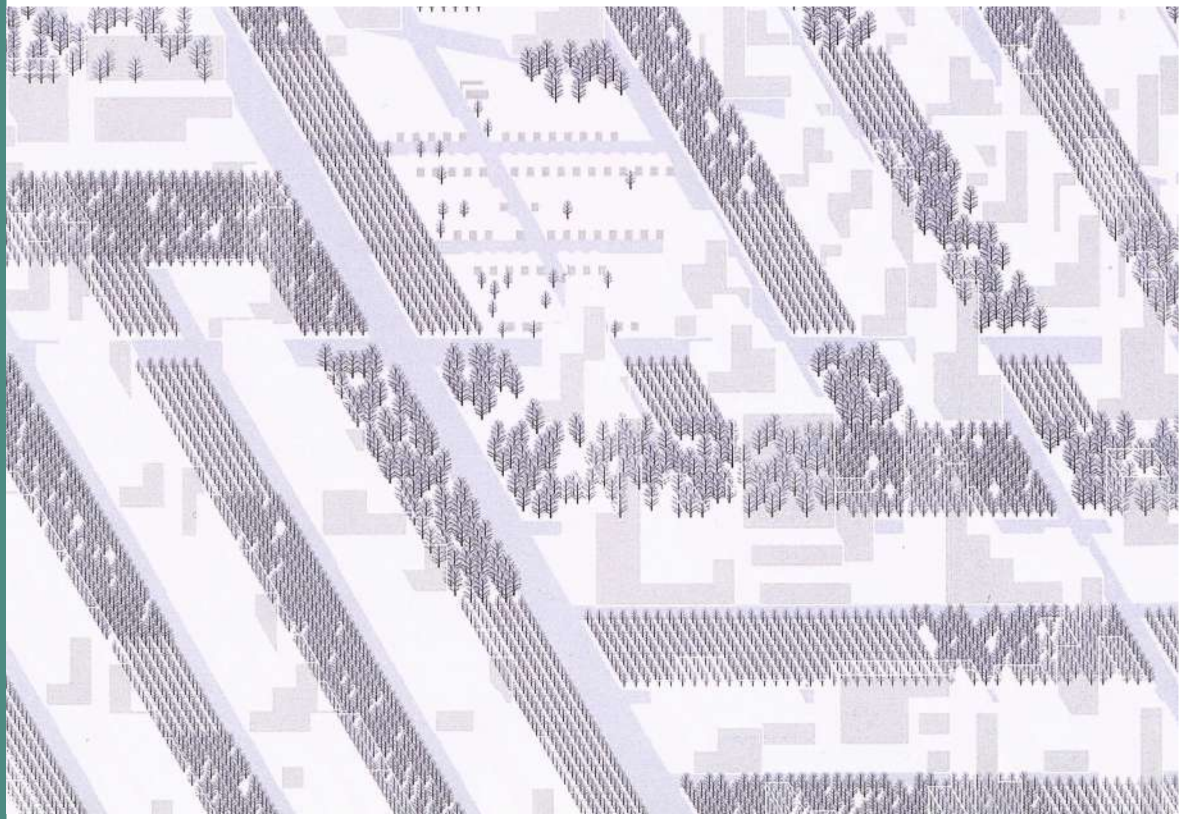


Figure 62.
Eco-Friendly Neighbourhood's locations in Chile, according to the climate.
Illustrated by the author.

/

NEW CORKTOWN, DETROIT
USA, 2016



/ ARCHITECT:
Albert Pope, joined by Jesus Vassallo, Gail Chen, Daniel Khuen, Chenyang Lyu, Peter Stone and Louis Wise

/ CLIENT:
Venice Biennale

/ SITE:
42°19'50"N, 83°03'50"O

/ PROJECT AREA:
20 Ha

Figure 63.
Corktown, Detroit, U.S.
Illustrated by the author.

Figure 64.
Corktown, Detroit, Project.
Image from Ibañez et al., (2019).

M

L

XL

BACKGROUND

Corktown is a neighborhood in Detroit that was the subject of a proposal to density the region; it is distinguished by being immediately connected to a major business center and by having the Detroit River, which serves as an international border. Corktown, among other things, once served as a home to many immigrants, but by 2016, it had lost 75% of its building stock, indicating that it had seen better day (Pope, 2020).

Corktown's deterioration was accelerated by the fact that it was cut off from the rest of the city and surrounded by highways. It is a neighborhood that, with the exception of a few recent constructions, has mostly been forgotten (Ibid.).

PROJECT

The concept imagines how the Corktown neighborhood would seem if it were redeveloped as a sustainable dense area that makes the most of its existing urban infrastructure.

High-density redevelopment will be done in response to the threats posed by climate change to the current and future residents of Corktown. To prevent the worst impacts of global warming, electricity demand per person must be reduced by 75% (Ibid.).

To accomplish such significant reductions is through extensive urban development designed at densities high enough to handle the transit system.

The most valuable resource for the new Corktown would be the current urban footprint.

The target density for Corktown would be 60 units per acre, which is equal to the bare minimum required for a reliable mass transportation system (10 times more than the typical US city).

This density is demonstrated as being reached by New Corktown over the course of five phases and fifty years.

At that period, the production of massive amounts of useful open space is balanced against dense building. Built on top of Detroit's current grid is a spine-based infrastructure that creates a contrasting system of density and open space (Ibid.).

High-density mass-timber building and open space carbon plantings are the two elements of the new paradigm that is being proposed for New Corktown. Large areas of open space are included into the project in the form of no-build zones, which are typically one block wide and six blocks long. The density of the high-rise timber building on other blocks is balanced out by these open space sections.

In accordance with this suggested structure, New Corktown views the city as a dynamic organism with its own temporal logic rather than a fixed composition (Ibid.).

The approach of the project intends to:

/ *Be able to adapt to the anticipated needs of society, economy, and environment.*

/ *Incorporate three cycles: the cycle of human habitation, the cycle of building renovation, and the cycle of multi-species tree planting (to serve as an urban forest and carbon sink for the area).*

/ *Add trees into their building cycles as a method of carbon sequestration and a supply of building materials. The material culture that New Corktown suggests is completely incorporated into the carbon cycle.*

/ *Create a network that re-directs urban development involves both human and non-human aspects.*

/ *Seeks to reestablish the ancient cycle of continuous obsolescence and renewal.*

Figure 65.
Corktown, Detroit, Project.
Image from Nash Baker.

Figure 66.
Corktown, Detroit, Project.
Image from Nash Baker.

Wood in cities / Cases of use of wood in urban context

2025

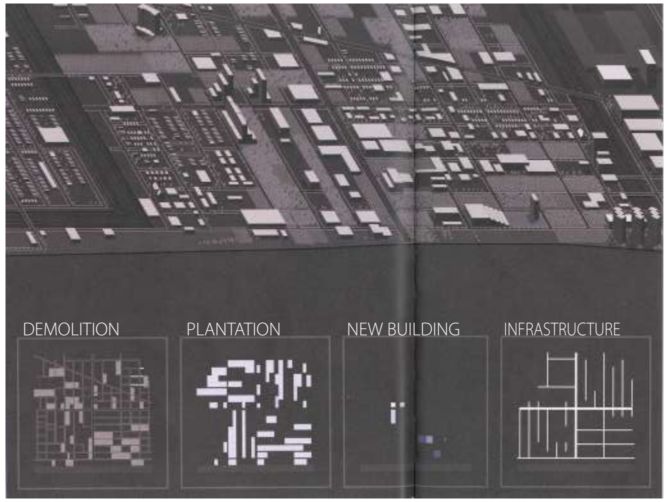


Figure 67.
Corktown, Detroit, U.S.
Image from Ibañez et al., 2019.
/ Planting thousands of trees will be the first step to reduce carbon emissions.
/ Redefine urban density in terms of the utilization of underutilized infrastructure.
/ Starting a carbon market to reduce per capita energy usage.

2035

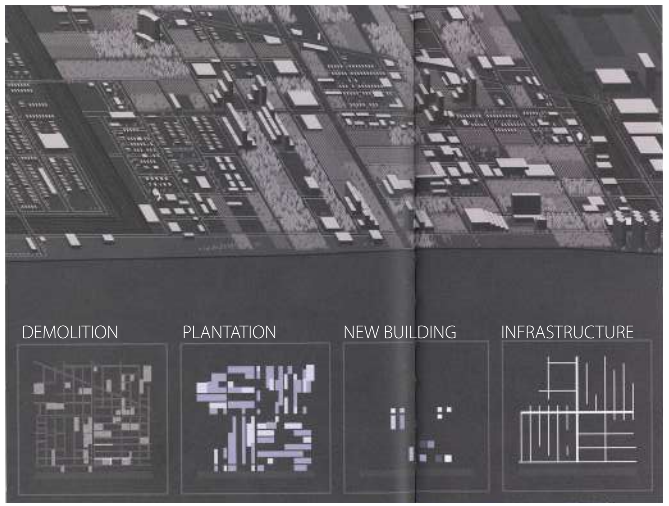


Figure 68.
Corktown, Detroit, U.S.
Image from Ibañez et al., 2019.
/ First mass timber housing blocks will be built around two stops of a new mass transit system.
/ Later, these fundamental choices would be expanded into more intricate block combinations.

2045

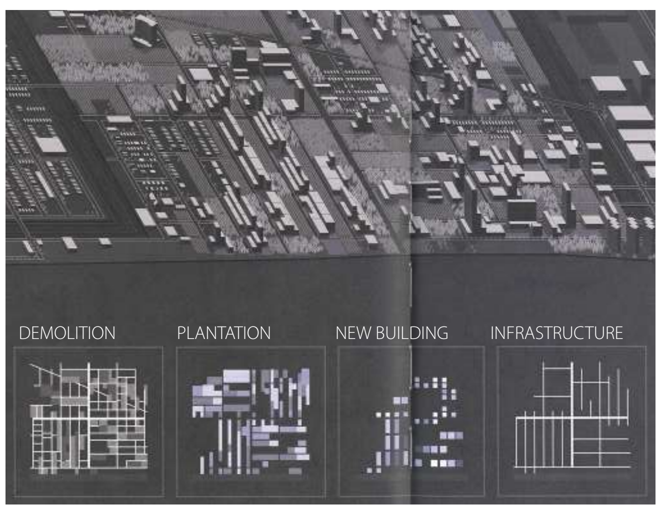


Figure 69.
Corktown, Detroit, U.S.
Image from Ibañez et al., 2019.
/ A new super-block is will start getting constructed prefabricated in CLT panel-based modules.
/ A structure with 40 stories will house a wide range of activities as well as additional public areas.

2055

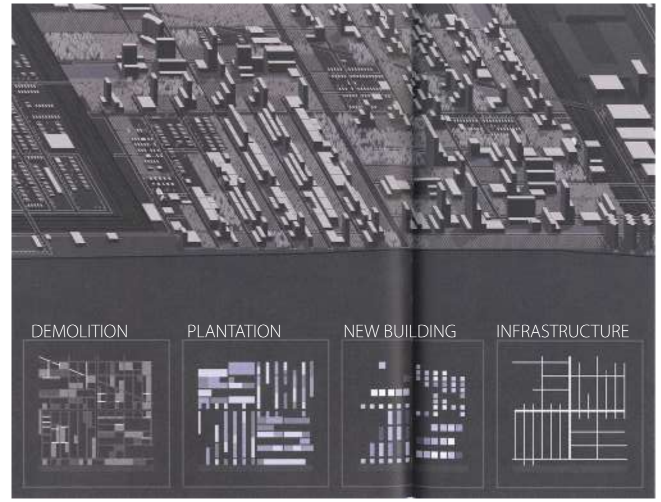


Figure 70.
Corktown, Detroit, U.S.
Image from Ibañez et al., 2019.
/ The completion of a new super-block will provide room for more planting areas and open areas.
/ Density will be close to 45 units per acre.

2065

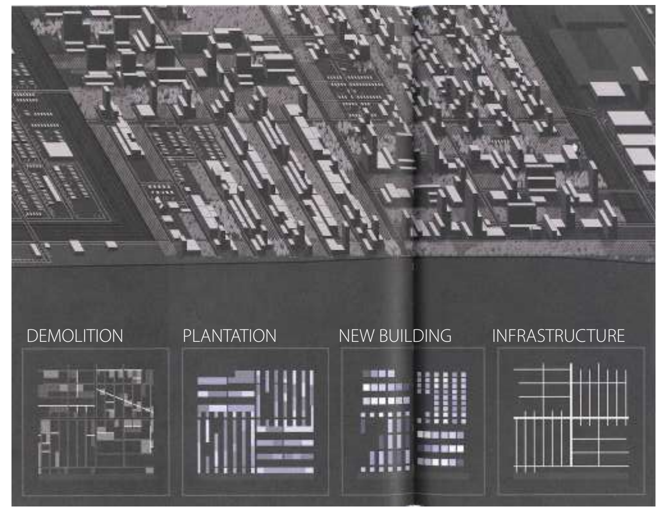


Figure 71.
Corktown, Detroit, U.S.
Image from Ibañez et al., 2019.
/ Corktown will experience a shift in urban density as tall timber structures and tree plantations reach maturity. This will lead to a new carbon-reducing culture and a reduction of emissions by over 75%.
/ In 50 years, the city will have completed its first building cycle, symbolized by the longevity of original buildings, and rapid demolitions will make room for new construction.

Wood in cities / Cases of use of wood in urban context

2 / Wood in urban green transformations: *Assesing timer sustainability*

/ MODEL PROPOSAL AND METHODOLOGY

As shown in the introduction, the purpose of this thesis is to explore the use of timber in construction and assess its sustainability through various proposed scenarios. The study focuses on the geographical availability of wood, including its quantity, type, and proximity, as well as its performance and carbon capabilities.

To this end, a hypothetical model of sustainable assesment for timber on a urban context has been developed. This model is not intended to be a project proposal, but rather a tool that opens a debate arround the actual sustainability of wood and provabliy gives a tool for planning.

The model evaluates sustainability based on two main factors: availability and carbon capability. Availability is defined as wood sourced within a radius of 500 km or less and from local production. The carbon capability of wood is determined by its great propierties to reduce emissions by storing CO_2 and its life cycle phases, including harvesting, production, transportation, use, and end-of-life, which all contribute to its carbon footprint.

The model was applied to the city of Torino as a case study. Torino was selected for this study due to its policies promoting ecological transition, readily available data, and its status as an intermediate European city. Additionally, the city was chosen because it serves as an archetype among the Urban Transformation Zones as classified by the vigent PRG of Torino. The assessment method was applied to a theoretical project for this archetype, and the results showed the potential for a carbon balance assessment at an urban scale. However, the current models in use did not provide a satisfactory answer to the research question.

/ TORINO AS A PILOT

We are all aware of the climate change issues, which has deadly repercussions for both humans and cities and has a direct impact on the economy, society, and, most importantly, the environment.

As can be seen, this is a factor that may be addressed to reduce the causes of climate change owing to the steps made by international agreements between nations, including, among other measures, the Conference of the Parties (COP).

It is important to keep in mind that its possible to deal with a significant portion of these issues through urban planning.

An overview of the urban level criteria that a city must meet in order to minimize greenhouse gas emissions and create a resilient system to adapt to future scenarios is clearly related to the study of Torino's climate challenges.

This makes it evident that developing a city through adaptation and mitigation because is a fundamental tool to handle climate change.

Note:
The main source for this section is the climate resilience plan for Torino 2030.

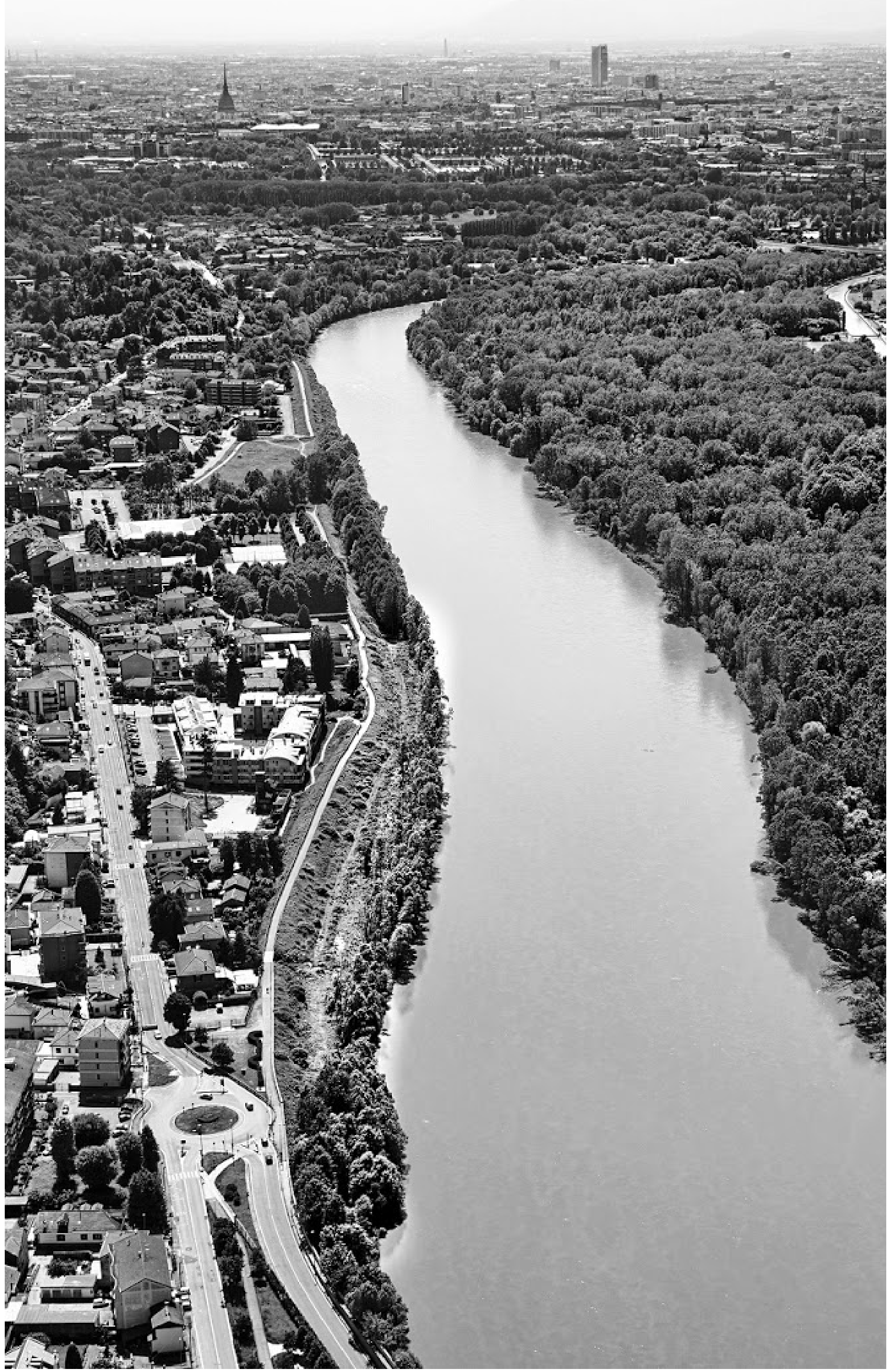


Figure 72.
Torino.
Image from Michele D'Ottavio.

THE CASE STUDY

The territory of Torino, capital of the Piedmont Region and Metropolitan City, is sorrounded by the Alps and consist of flat and hilly areas. The flat area is located at the left of the Po River (which flows from south to north) and the other to its right.

The flat part, which has an average altitude of 245 meters above sea level, is located immediately at the east of the mountainous offshoots of the Alpine chain, and it has three other rivers passing trough: the Stura di Lanzo, the Dora Riparia and the Sangone. The hilly area, in contrast, is influenced by streams and wetlands, rises up to 715 meters above sea level.

The city area extend westward toward the Alps and eastward toward the hills, are characterized by these features, giving them a distinctive identity and value that inspired Le Corbusier to refer to it as - "*The city with the most magnificent natural position in the world*."

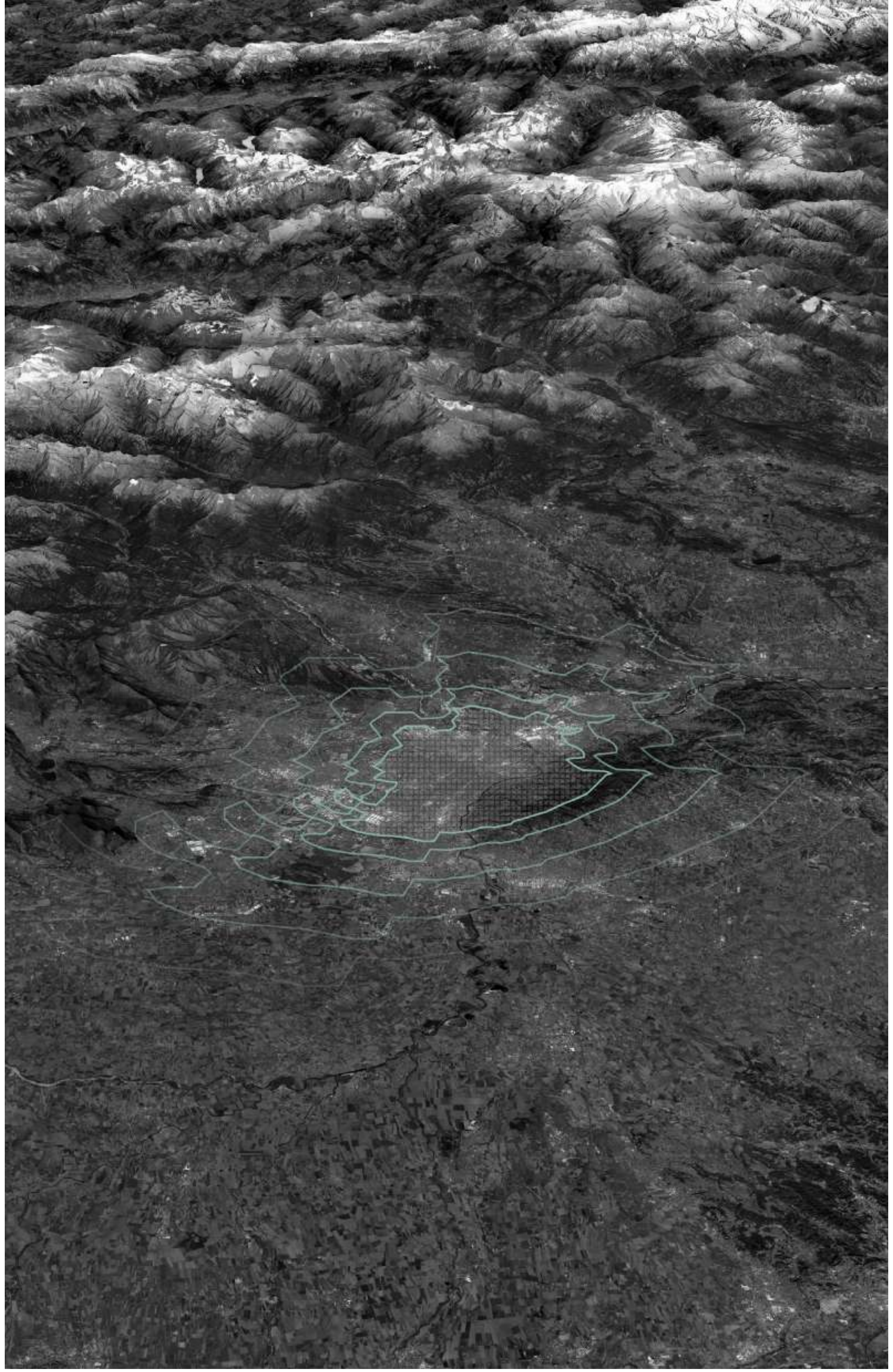


Figure 73.
Speculative aerial view of Torino.
Illustrated by the author.

TORINO'S CONTEXT DATA

(IMQ 2013 CMT survey data)

POPULATION
872,316 Number of inhabitants, Update 2019.

SURFACE AREA
130.17 km2, Update 2019.

POPULATION DENSITY
6,701 km2, Update 2019.

MAXIMUM TEMPERATURE *(ARPA station - Torino (Consolata) data from 19/12/2003 to 31/12/2019)*
39.40 °C, Update 2019.

AVERAGE TEMPERATURE *(ARPA station - Torino (Consolata) data from 19/12/2003 to 31/12/2019)*
14.62 °C, Update 2019.

MINIMUM TEMPERATURE *(ARPA station - Torino (Consolata) data from 19/12/2003 to 31/12/2019)*
-10.2 °C, Update 2019.

ENERGY CONSUMPTION *(Data from the TAPE 2017 update - excluding industrial consumption)*
11,387,765 MWh/year, Update 2019.

REDUCTION IN CO2 EMISSIONS
-33 % compared with 1991, Update 2017.

GREEN INDEXES *(Data from green print 2019)*
(37 % sup. , Update 2019) - (55 m_2 / resident, Update 2018)

WATER CONSUMPTION *(SMAT website data - City of Torino)*
189 L/resident, Update 2011.

JOURNEYS *("MobilitAria" report data 2019 - Metropolitan City of Torino)*

/ *Average length of journey 10.1 Km, Update 2016-2017*
/ *Average time dedicated to mobility on weekdays 57 min/day.*
/ *Average mobility rate 90.2 %*
/ *Average weekday entrances to city 245,300 journeys/day, Update 2011.*

Figure 74.
Torino.
Image from Fabio Lamanna.

Wood in urban green transformation: Assesing timer sustainability study / The case study

The effects of climate change are already being felt in cities across Europe, including rising temperatures, fluctuations in precipitation, water shortages, and a rise in sea levels. A survey of 196 European cities found that 81% have already experienced extreme heat, which is expected to be the major impact in the next 30 years. 71% of cities also anticipate more severe water scarcity.

The primary cause of this global warming is believed to be human activity, according to the Intergovernmental Panel on Climate Change (IPCC).

The impact of climate change can have far-reaching effects, including changing the physical form of cities, contributing to economic inequality and poverty, and affecting people's well-being. To address this, the United Nations included climate change as a goal in its 2030 Sustainable Development Agenda.

Signs of climate change in Torino include unusual weather patterns and increased storm events, as well as anomalies in the changing of seasons leading to extended periods of low and high rainfall and poor air quality. It is important to implement measures to protect people's health and wellbeing and to ensure their ability to live in harmony with their city and surroundings (Fig. 75).

The main strategies adapted in the urban planning (Castán Broto et al., 2021) consist of three aspects:

Mitigation:
/ All actions taken to reduce concentrations of greenhouse gas released into the atmosphere.

Adaptation:
/ A set of actions taken to anticipate the adverse consequences of climate change, to prevent or minimize potential damage or to exploit the opportunities that could arise from it.

Resilience:
/ The ability of a social or environmental system to absorb alterations while maintaining the same basic structure and modes of operation; the ability to self organize and adapt to stress and change.

(*Climate resilience plan for Torino 2030).*

In a similar way to ther cities in Europe, also Torino is dealing with Cliimate Chance through urban planning and experiments a set of strategies and plans that aim at revise the actual General Plan (PRG, 2022).

Figure 75.
Torino.
Image from Valerio Minato

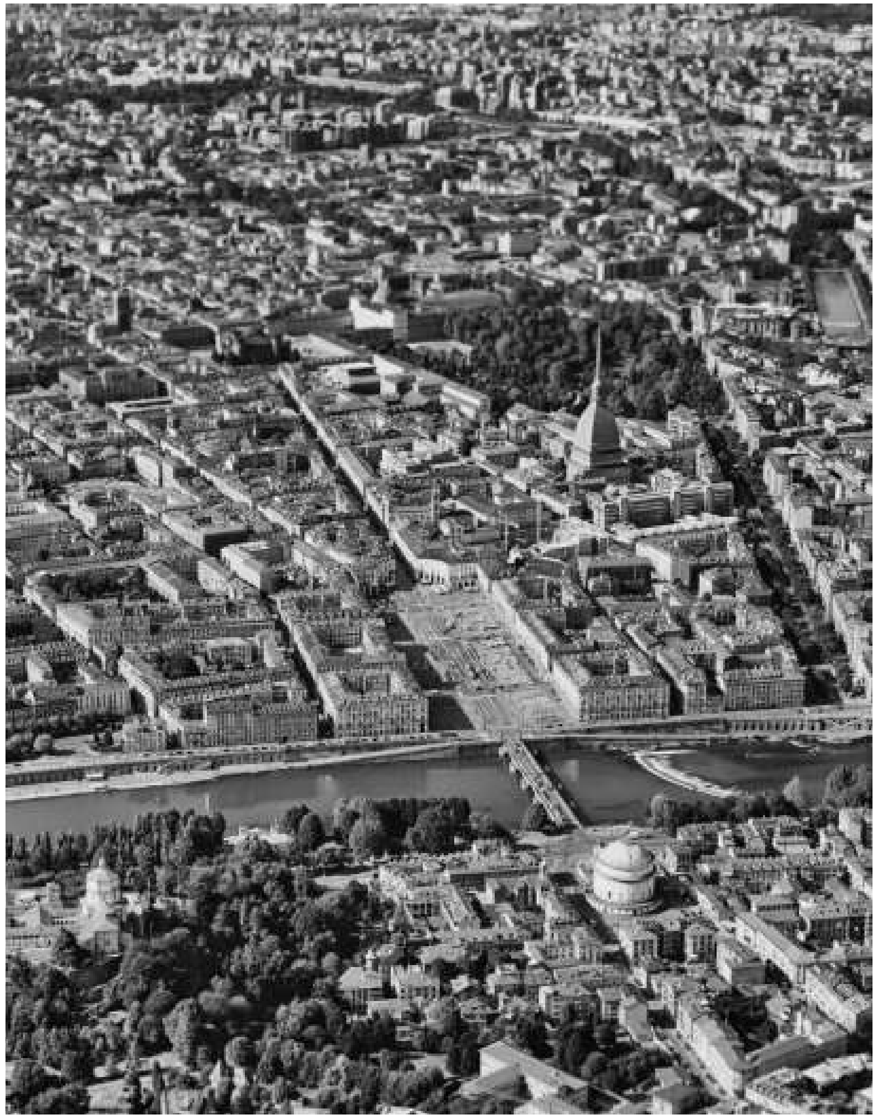


Figure 76.
Torino.
Image from Michele D'Ottavio.

Wood in urban green transformation: Assesing timer sustainability study / The case study

PLANNING INITIATIVES FOR A GREENER TORINO

BACKGROUND OF THE PRG

«*The revision of Torino's PRG*[1] *has the ambitious intention of promoting an idea of a city in which it is possible to combine an increase in GDP (Gross Domestic Product) with an increase in GDW (Gross Domestic Wellbeing). Hypothesising, therefore, a forward-looking city capable of building its future by putting the well-being of its citizens first, focusing on the quality of life and the urban environment, so as to generate widespread prosperity in an area rich in social, economic and environmental opportunities* [...] *In order for the city to be able to adapt to changing needs, it is important to have lean and flexible tools that keep pace with change and facilitate innovation.*[...] *(It is necessary to develop and promote the vocations of the city, its citizens by building on the past to create the future.*

Torino has the chance to regenerate itself starting from its environmental, historical architectural and landscape heritage.[...] ***Supporting and enhancing the role of Torino, recognised by the European Commission, among the 'strong innovators'.).***[...]

In the revision of the PRG, it was decided to focus on a few stringent structural parameters that would guarantee settlement flexibility, in compliance with high quality standards of services spread throughout the territory, as well as in the protection and promotion of landscape-environmental features.

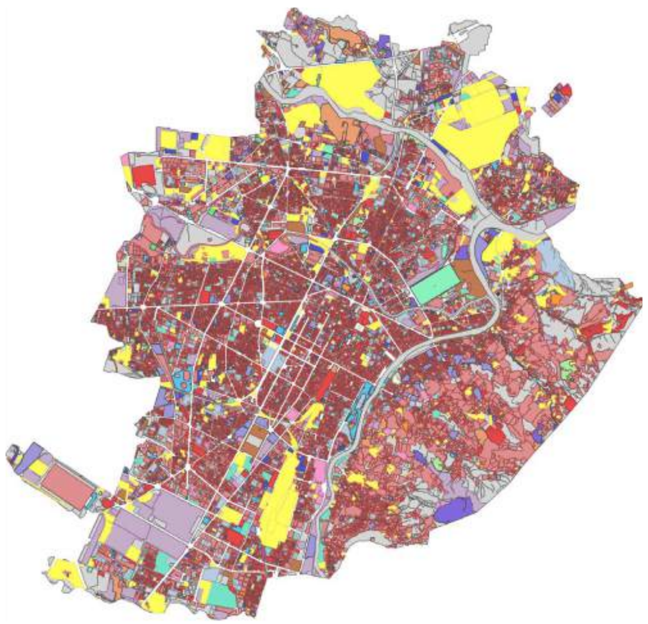
Reproposing, in an urban planning key, the brilliant intuition of Ludwig Mies Van Der Rohe, "Less is More", as the foundation of a new Urbanism that addresses the complexity, not with a heavy, redundant and overly detailed regulatory framework, but focusing on the result that can be achieved with an urban planning vision that pursues clear objectives. [...]

The sustainable and resilient city that is intended to be realised must include a quality of living through the connection of neighborhoods, the valorisation of identities and of inequalities, the widespread promotion of cultural sites, neighbourhood services common goods, digital services, meeting places, crafts, innovative and environmentally compatible productive activities.[...The formation or redevelopment of pedestrian spaces, safeguarding proximity services as an essential element for the vitality of neighborhoods.

The redesigning of abandoned areas must be thought of as the city's opportunity to recover unused spaces, where environmental quality and urban space can be promoted urban space to be transformed into incubators of innovative social, economic and productive ideas.».

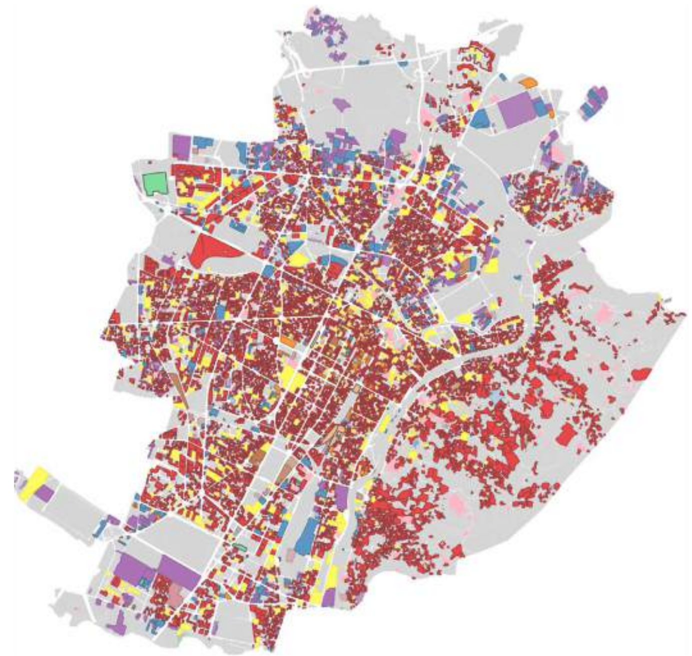
(A. Iaria, Assessore Urbanistica Edilizia LLPP e Patrimonio.2020)

[1]The Torino PRG (1995) has been designed by Vittorio Gregotti, Pierluigi Cerri, Augusto Cagnardi.



- Workshops for Arts and Crafts
- Solar Panels
- Warehouses and Storage Areas
- General Shops
- Progressions and Reformers
- Residence - Castles and Palaces of Eminent Artistic or Historical Value
- Hotels - Pensions and Residences
- Urban Areas
- Libraries - Museums - Galleries
- Boxes or Parking Spaces
- Buildings for Worship
- Nursing Homes and Hospitals
- Colleges - Convents Boarding schools Shelters - Orphanages - Hospices Convents - Seminaries and Barracks
- Productive Buildings in an Accentuated Level of Degradation.
- Sports Facilities
- Productive
- Buildings Awaiting Category
- Offices and Public Buildings - Offices and Private Studios
- Schools and Scientific Laboratories
- Stations for Land, Sea and Air Transport Services
- Theatres, Cinematographs - Concert Halls
- Closed and Open Roofs
- Unclassified Areas
- Credit, Exchange and Insurance Institutes

Figure 77, 78, 79.
left; Classifications According to The Main Categories.
Top right; Classifications According to Territorial Data Base by Cells.
Bottom right; Classifications According to Tari Data.
Illustrated by the author, on the bases of the current PRG Data (2022). / Data from the BDT (Territorial Database) which was used to gather data for the analysis of land use and building evolution in Torino city. Urban cells were traced, which are the minimum homogeneous units to represent the municipal area, by examining the settlement unit of the building and the block unit of the conventional zoning. The map of Torino was represented at a scale of 1:1000 to display the collected data. The study of urban cells also included examination of current land use, green spaces, services, land consumption and public property. In the future, the data of electricity, water, gas and district heating services, as well as TARI and cadastral geometries, can be combined with the BDT uses of the urban cells to provide an option to register uses and characteristics.



- Agricultural
- Transports
- Administrative
- Prison
- Commercial
- Industrial
- Places of Worship
- Military
- Residential
- Recreational
- Pullic Services
- Receptive
- Not Known
- Not Classified

- Recreational Activities
- Commerce
- Restaurants
- Services Sector
- Productive
- Transport
- Public Administration Offices
- Kiosks in general
- Colleges - Convicts - Dormitories - Cohabitation - Barracks - Prisons
- Craft Shops
- Fuel Stations
- Warehouses And depots
- Public and Private Parking Lots
- Special Waste
- Not Classified
- Healh
- Places and Areas used for Worship
- Residential
- Hotels - Guesthouses - B&B
- Public and Private Schools - Kindergartens - Nurseries

The regulatory plan of 1959 was still in effect in Turin at the end of the 1990s, but due to changes in the city's structure and population growth, it was evident that the goals outlined in the plan were no longer practical. This was partly due to the construction of buildings on hillsides and the expansion of the urban network away from industrial areas.

To address these challenges, a new preliminary plan was put into effect in 1995, which provided a new vision for the city. The Passante Ferroviario, C. Marche, and Po axes were designated as the primary development areas, and an additional 154 areas of radical transformation were identified using a simplified methodology. These areas corresponded to abandoned production sites and were designated as Urban Transformation Zones (ZUT).

The Areas to be Transformed for Services (ATS), which corresponded to the former service areas of the 1959 plan, also needed to be updated. The 1995 plan reduced building capacity in these areas to prevent losing important constraints, but still provided for the development of services within the urban tissue. The plan also identified areas with similar uses and morphologies, assigning them homogeneous urban and building parameters.

For the first time, the 1995 plan took into consideration the problem of climate change, taking into account natural resources and other factors. Some of these issues, such as the refurbishment of the Spina Centrale and the re-classification of the historic center, have already been addressed. This shows that Turin is undergoing a transition that goes beyond what the 1995 plan prescribed.

The current plan classifies spatial transformations into four categories based on local characteristics: general guidelines and consolidated tissue, areas of urban transformation, areas of services and mobility, and environmental protection. The primary urban transformation areas were analyzed to define the plan areas of Turin, and were studied on the basis of the PRG provisions.

The Norme Urbanistico Edilizie di Attuazione (NUEA) of the General Regulatory Plan classifies ZUT's as areas for which radical urban restructuring and new planting are planned, and the ATS's as areas for the development of services within the urban tissue. The 1995 plan specified these locations to provide for the development of new green spaces and to integrate the existing services in the city.

To gather information for the revision of the plan, it was prepared a lists all the areas with their urbanistic parameters, implementation status, approved executive urban planning instruments, territorial surface, and urban planning standards. This information makes it possible to know the conditions of each area, their territorial consistency, and the comparison between the PRG provisions and their degree of development.

	[ZUT]	[ATS]	[TOTAL]
Implemented	[87]	[57]	[144]
In process of Impl.	[12]	[3]	[15]
Not Implemented	[113]	[86]	[199]
TOTAL	[212]	[146]	[358]

(*) For ZUT not implemented, the theoretical data of the data sheets.

Figure 80.
State of Implementation of the ZUT and ATS areas.
Illustrated by the author, on the bases of the current PRG Data (2022).

state of impl. ZUT	N* ZUT	TOT. ST m²	TOT. SLP m²	TOTAL PUBLIC SERVICE
	[87]	[5 720 640]	[3 438 445]	[3 135 709]
	[12]	[754 074]	[536 481]	[492 118]
	[133]	[4 022 319]	[2 016 210]	[2 056 132]
TOT.	[212]	[10 497 033]	[5 018 136]	[5 683 959]

(*) For ZUT not implemented, the theoretical data of the data sheets.

Figure 81.
Summary of the state of implementation of ZUT .
Illustrated by the author, on the bases of the current PRG Data (2022).

	ZUT &ATS	TOT ST m²	TOT SLP m²	USE DESTINATION (m²) RESIvDENCE	ASPI/TERITIARY	PRODUCT/ EUROTORINO	N* HABITANTS SETTLED/ TO BE SETTLED	TOTAL PUBLIC SERVICE
	[144]	[6 564 680]	[3 707 077]	[1 711 755]	[985 373]	[1 009 943]	[50 346]	[3 755 438]
	[15]	[766 716]	[569 802]	[19 845]	[216 073]	[133 884]	[6 466]	[501 785]
	[199]	[4 928 289]	[2 227 603]	[755 613]	[811 550]	[660 440]	[22 224]	[2 780 908]
	[358]	[12 259 685]	[6 504 482]	[2 687 213]	[2 012 998]	[1 804 268]	[79 036]	[7 038 131]

(*) For ZUT and ATS not implemented, the theoretical data of the data sheets.

Figure 82.
Summary of the state of implementation of ZUT & ATS, showing the m².
Illustrated by the author, on the bases of the current PRG Data (2022).

The "State of Implementation of the PRG of ZUT and ATS" also allows for the location and extension of these areas on the territory to be known, as well as their relationship with the surrounding urban tissue and the relative articulation of the interventions foreseen in the Plan.

The reported data show that the settlement capacity achieved for the implemented ZUT's and ATS's is currently around 50 346 residents, while the theoretical settlement capacity that can still be settled for the non-implemented ZUT's and ATS's and those under preliminary investigation is 28690 inhabitants (assuming transformation hypotheses in relation to the functional mixes envisaged in the regulatory data sheets) (calculated on the basis of the conventional figure of 34 square per capita) (Fig. 82).

Among the key, unalterable definitions identified in the Regional Standard Building Regulations theres one of how to calculate the realizable area based on the available land and land areas, which is therefore a substantial element in determining the actual building capacity.

10 497 033 m^2 corresponding to a total SLP of 6 018 136 m^2, calculated by applying the buildability indexes indicated in the PRG regulations, the majority of which vary from 0,5 to 0,7 m^2/m^2 of TS, which can be raised to 0,8 m^2/m^2. In the case of the ZUT, it can be seen in the following graph that there are 87 in the condition of the ZUT, those that are in transition are 12 and those that have not If it is intended to provide for the construction capacity obtained from parks, those with an index of 0,7 m^2/m^2 of ST.(Fig. 81)

Approximately 50% (5,720,640 m^2) of the Land Area expected by the present PRG has been applied, resulting in a total SLP of 3 438 445 m^2 out of a total anticipated SLP of 6 018 136 m^2, as shown in the table below.

The data shown in (Fig. 82) shows the relation of the state of implementation of the ZUT. The total area calculated for those that will be put into practice is 5 683 959 m^2.

In the last 25 years of the plan the urban areas of urban transformation implemented adapted to public services turn out to be approximately to 3 135 709 square meters, that is equivalent to 55 % of the territorial surface of all the transformed ZUT, at the same time the work made for an SLP of 1 470 223 square meters, or a settlement capacity of 43 242 people, interventions have been made.

958 273 square meters of SLP were used for interventions connected to ASPI and Tertiary activities, whereas 1 009 493 square meters were used for productive/utility activities and other activities.

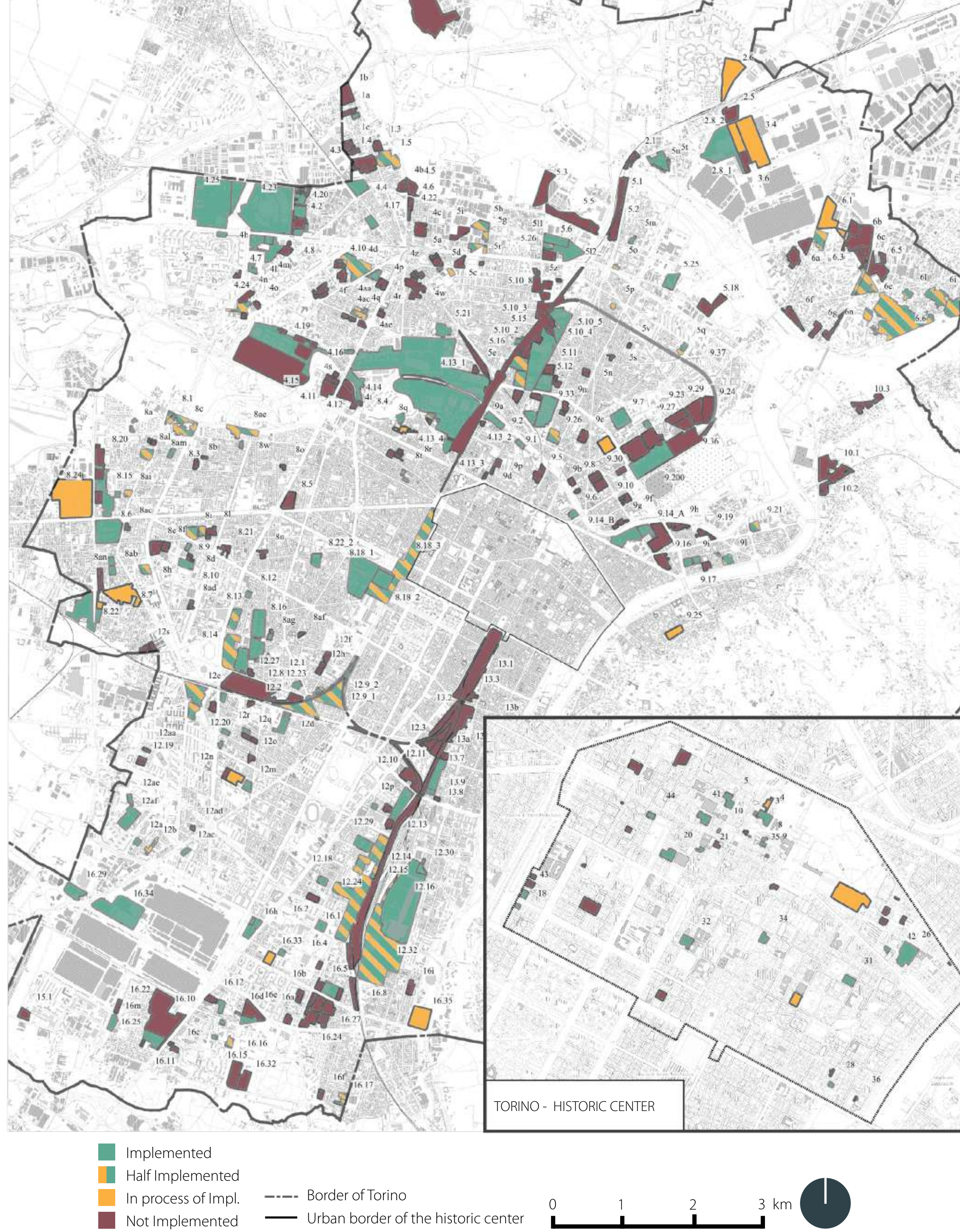


Figure 83.
Map of Torino showing the Implementation status of the Zut and Ats according to the PRG (2022). Illustrated by the author, on the bases of the Tavola n.1 of the current PRG (2022).

In addition, as already indicated, one of the primary objectives of the PRG was to reform the Spina Centrale, which required the replacement of important city components associated to the burying of the railway and some of its surroundings impacted by the huge industrial facilities abandoned in the late 1980s.

As shown in (Fig.85), the Spina Centrale is composed by four sections which represent about 20% of the city's transformation areas and occupy nearly two million square meters of land. The "Spina Central" transformation zones that have already been put into practice are summarized below here, along with the respective intended usage and population density.

The residential zones demonstrate that they are considered at roughly 50% of the total amount of the use-destinations. The table also demonstrates that approximately 16 000 people have been set up.

SPINA IMPLEMENTED		TOT	TOT	USE DESTINATION (m²)			N*	TOTAL
N*	NOMINATION	ST m²	SLP m²	RESIDENCE	ASPI/ TERITIARY	PRODUCT/ EUROTORINO	HABITANTS SETTLED/ TO BE SETTLED	PUBLIC SERVICE
[4.13/1]	SPINA 3 - PRIU	[1 002 956]	[585 542]	[344 406]	[93 038]	[985 373]	[10 130]	[638 451]
[4.13/3]	SPINA 3 - METEC	[14 515]	[7 304]	[5 844]	[1 460]	[-]	[172]	[8 370]
[4.13/4]	SPINA 3 - TREVISO.	[8 835]	[3 523]	[2 818]	[705]	[-]	[83]	[4 067]
[5.10/1]	SPINA 4 - PRIU	[150 021]	[6 504 482]	[77 323]	[9 777]	[-]	[2.274]	[92 612]
[5.10/5]	SPINA 4 - GONDRAND METALLURGICA PIAMONTESE	[59 337]	[35 592]	[24 914]	[10 678]	[-]	[733]	[38 729]
[8.18/1]	SPINA 2 - PRIN	[172 451]	[109 332]	[32 162]	[27 080]	[50 090]	[946]	[99 077]
[8.18/2]	SPINA 2 - LE NUOVE	[41 690]	[25 014]	[-]	[5 003]	[20 011]	[-]	[28 349]
[8.18/3]	SPINA 2 - PORTA SUSA	[178 951]	[103 262]	[-]	[103 262]	[-]	[-]	[112 251]
[12.9/1]	SPINA 1 - PRIU.	[139 416]	[78 153]	[48 844]	[29 309]	[-]	[1.437]	[88 889]
[12.9/2]	SPINA 1 - FS	[625 150]	[9 375]	[4 687]	[4 688]	[-]	[138]	[12 935]
TOTAL		[1 793 322]	[1 044 197]	[540.998]	[285.000]	[218.199]	[15.912]	[1.1123.730]

Figure 84.
Summary of the implemented Spina areas .
Illustrated by the author, on the bases of the PRG Data (2022).

Figure 85, 86.
Savigliano Spina 3 transformation.
Images from the current PRG (2022).

As shown in (Fig. 89), the ZUT's that have not yet been transformed generate a SLP of 2 016 210 square meters on a land area of 4 022 319 square meters. For these ZUT's, In the PRG a functional mix hypotheses have been made that are compatible with the forecasts indicated in the individual regulatory sheets of the current PRG.

Based on this hypothetical facts, the proposed residential area is approximately 609 052 square meters, which corresponds to a hypothetical settlement capacity of 18 000 people (applying the conventional data of 34 square meters per inhabitant).

The (Fig. 87) shows how only 18 % of the planned land area of the Spina Centrale has not yet been transformed, where the data with respect to the SLP is about 129 779 square meters, among others.

SPINE NON IMPLEMENTED		TOT	TOT	USE DESTINATION (m_2)			N*	TOTAL
N*	NOMINATION	ST m²	SLP m²	RESIDENCE	ASPI/ TERITIARY	PRODUCT/ EUROTORINO	HABITANTS SETTLED/ TO BE SETTLED	PUBLIC SERVICE
[4.13/2]	SPINA 3 - ODDONE	[143 067]	[49 647]	[29 788]	[9 929]	[9 929]	[876]	[66 404]
[4.13/5]	SPINA 3 - PIANEZZA	[2 191]	[1 169]	[935]	[234]	[-]	[28]	[1 386]
[5.10/2]	SPINA 4 - DOCKS DORA	[23 963]	[14 227]	[1 423]	[12 804]	[-]	[42]	[16 174]
[5.10/3]	SPINA 4 - FS1	[111 005]	[44 561]	[15 596]	[28 965]	[-]	[459]	[56 840]
[5.10/4]	SPINA 4 - FS2	[5 760]	[3 299]	[2 639]	[660]	[-]	[78]	[3 620]
[5.10/6]	SPINA 4 - LAURO ROSSI	[8 005]	[4 309]	[3 447]	[862]	[-]	[101]	[4 825]
[5.10/8]	SPINA 4 - BREGLIO	[39 481]	[12 567]	[10 054]	[2 513]	[-]	[296]	[17 299]
TOTAL		[333 472]	[129 779]	[63 882]	[55 967]	[9 929]	[1.879]	[166 549]

(*) For ZUT not implemented, the theoretical data of the data sheets.

	N*	TOT ST m²	TOT SLP m²	USE DESTINATION (m_2) RESIDENCE	ASPI/TERITIARY	PRODUCT/ EUROTORINO	N* HABITANTS SETTLED/ TO BE SETTLED	TOTAL PUBLIC SERVICE
ZUT IN PROCESS OF IMPL.	[12]	[754 074]	[563 481]	[214 907]	[214 690]	[133 884]	[16 321]	[492 118]

In order to illustrate the ST, SLP, and functional mixtures anticipated as well as the shares of public service needs to be acquired by the City, the data on the transformation areas that have not yet been implemented and the areas which are in process of transformation are merged (Fig. 90).

Therefore, as of right now, there are 125 untransformed ZUT's in relation to the two lists (under and not implemented), totaling 2 579 691 square meters of SLP, of which 823 959 square meters of residence (32% of the total SLP), having 24 234 residents.

Summing up, for the purpose of this research the necessary data are:

/ *Number of Zut non impl., 133*
/ *Tot ST m², 4 022 319*
/ *Tot SLP m², 2 016 210*

/ *Number of Zut in process impl., 12*
/ *Tot ST m², 754 074*
/ *Tot SLP m², 583 481*

	N*	TOT ST m²	TOT SLP m²	USE DESTINATION (m_2) RESIDENCE	ASPI/TERITIARY	PRODUCT/ EUROTORINO	N* HABITANTS SETTLED/ TO BE SETTLED	TOTAL PUBLIC SERVICE
ZUT NOT IMPL.	[113]	[4 022 319]	[2 016 210]	[609 052]	[753 323]	[653 835]	[17 913]	[2 056 132]

(*) For ZUT not implemented, the theoretical data of the data sheets.

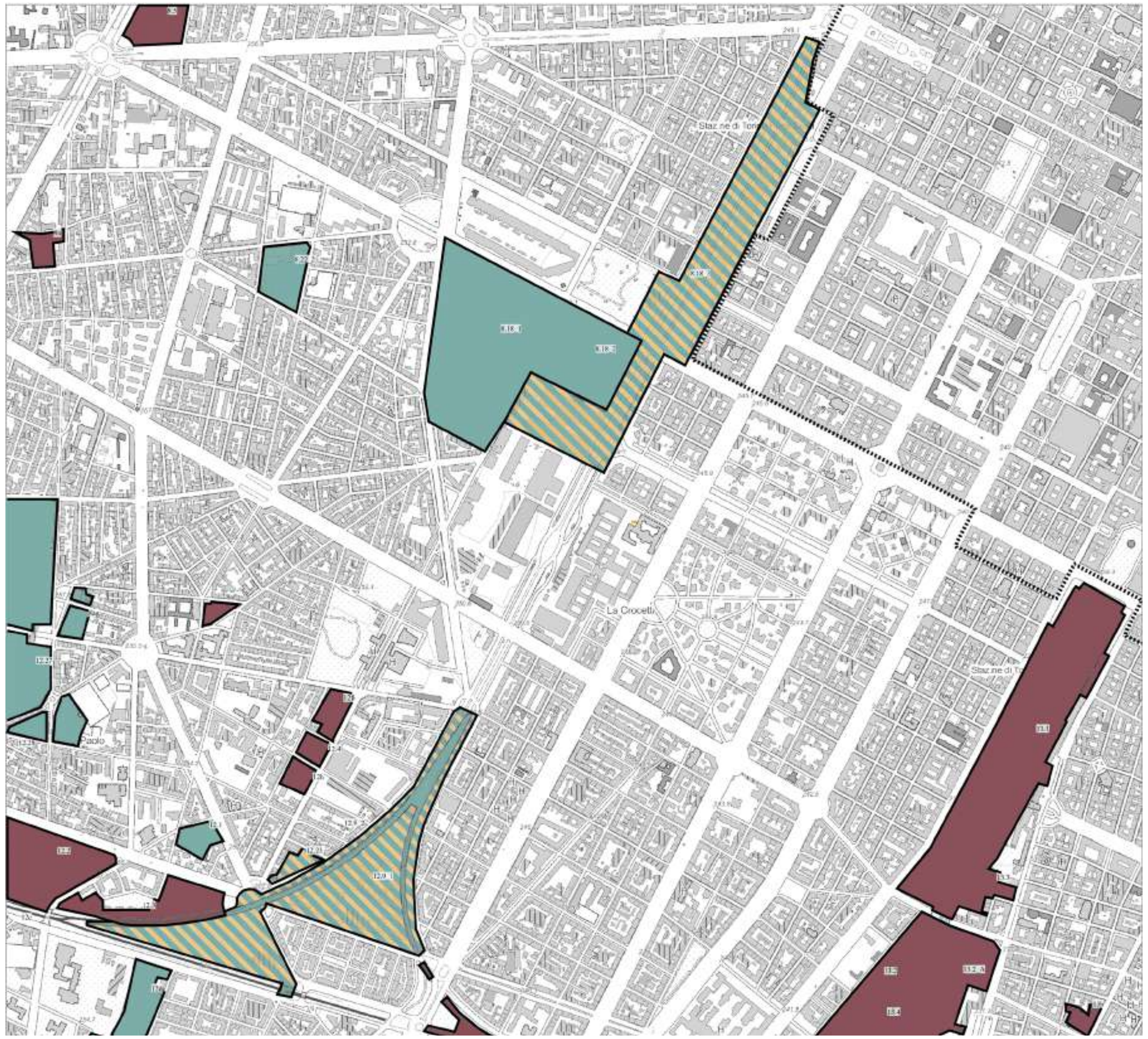
	N*	TOT ST m²	TOT SLP m²	USE DESTINATION (m_2) RESIDENCE	ASPI/TERITIARY	PRODUCT/ EUROTORINO	N* HABITANTS SETTLED/ TO BE SETTLED	TOTAL PUBLIC SERVICE
ZUT NOT IMPL. / IN PROCESS OF IMPL.	[125]	[4 776 393]	[2 579 691]	[823 959]	[968 013]	[787 720]	[24 234]	[2 548 250]

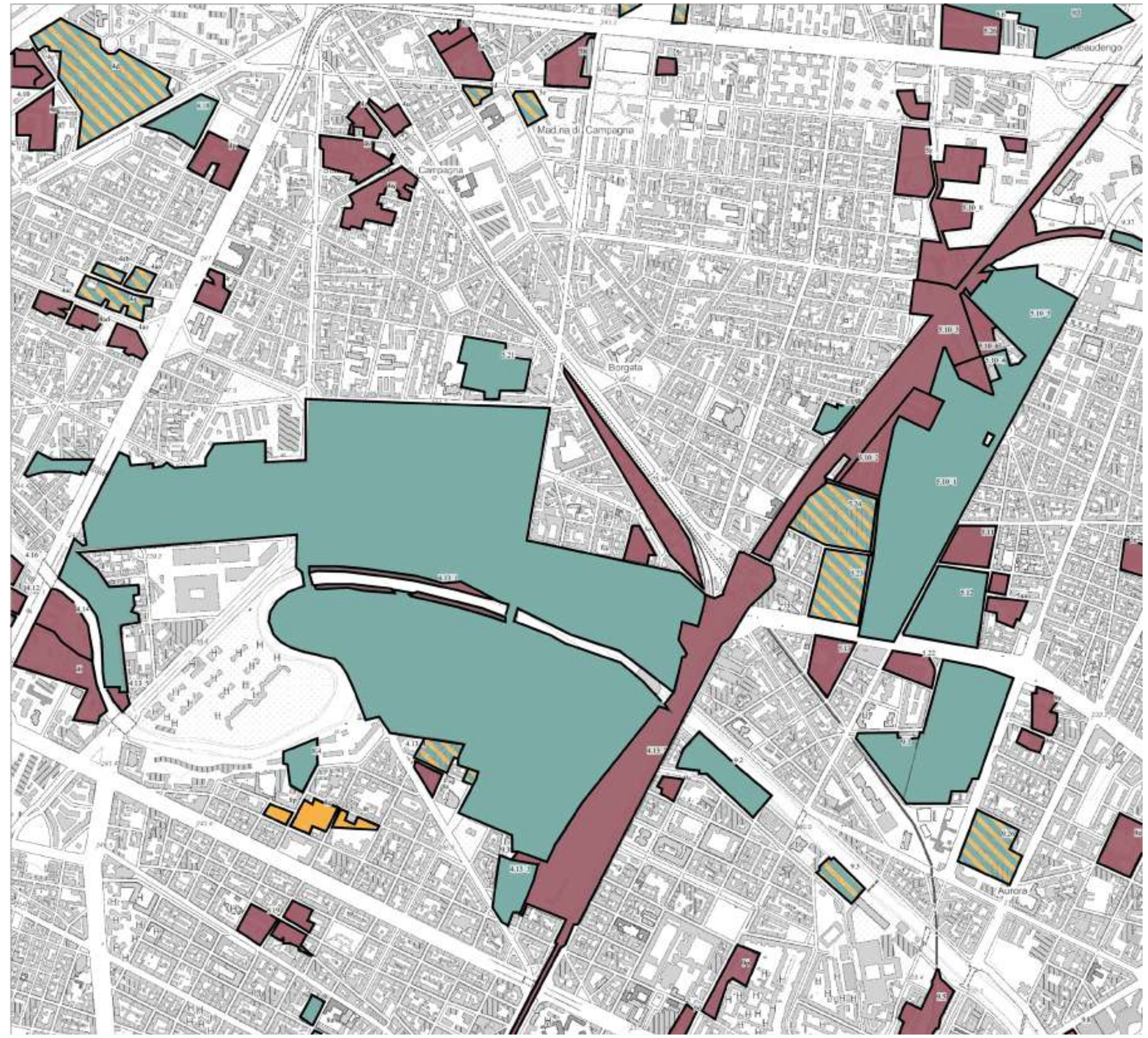
Top left, Figure 87.
Summary of the non-implemented Spina areas.
Illustrated by the author, on the bases of the current PRG Data (2022).

Bottom left, Figure 88.
Summary of the areas in process of implementation of the ZUT areas.
Illustrated by the author, on the bases of the current PRG Data (2022).

Top right, Figure 89.
.Summary of the non-implementated ZUT areas.
Illustrated by the author, on the bases of the current PRG Data (2022).

Bottom right, Figure 90.
Summary of the areas non-implementated and in process of implementation of the ZUT areas.
Illustrated by the author, on the bases of the current PRG Data (2022).





Wood in urban green transformation: Assesing
timer sustainability study / Planning initiatives
for a greener Torino

Implemented
Half Implemented
In process of Impl.
Not Implemented

0 0,25 0,5 km

Figure 91, 92.
Maps of Torino showing the Implementation status of the Zut and Ats
according to the Extract Areas of Spina 1, 2 and Extract Areas of Spina 3,4.
Illustrated by the author, on the bases of the Tavola n. 2 and n. 3 of the current PRG (2022).

PLANNING INITIATIVES

Several years ago, Torino started implementing its climate change strategy, focusing on mitigation techniques to lower local emissions of gases contributing to climate change, such as energy efficiency, conservation, and renewable energy production. As a model for other Italian cities, Torino prioritizes sustainable urban development for improved quality of life according to European standards. Mitigation involves reducing greenhouse gas emissions through methods like carbon sequestration, sustainable forestry, reforestation, and efficient production procedures.

In 2009, Torino joined the Covenant of Mayors and adopted its Turin Energy Action Plan (TAPE) in 2010, aiming to decrease CO_2 emissions by 30% by 2020 compared to 1991 levels. The first TAPE report showed a 22% reduction in CO_2 emissions by 2014, while the second report showed the city exceeded its goal with a 33% decrease by 2017. The city's commitment to combatting climate change is evident in these substantial results.

The highest decreases in CO_2 emissions were seen in the municipal (-62%) and residential (-47%) sectors, while the transport sector saw an overall decrease of 27%. Improved energy efficiency in the tertiary sector also contributed to maintaining constant CO_2 emissions despite an increase in services and distribution.

Adaptation measures are becoming necessary in Torino as the effects of climate change become more apparent, such as actions to reduce damage from extreme weather events, especially for vulnerable cities.

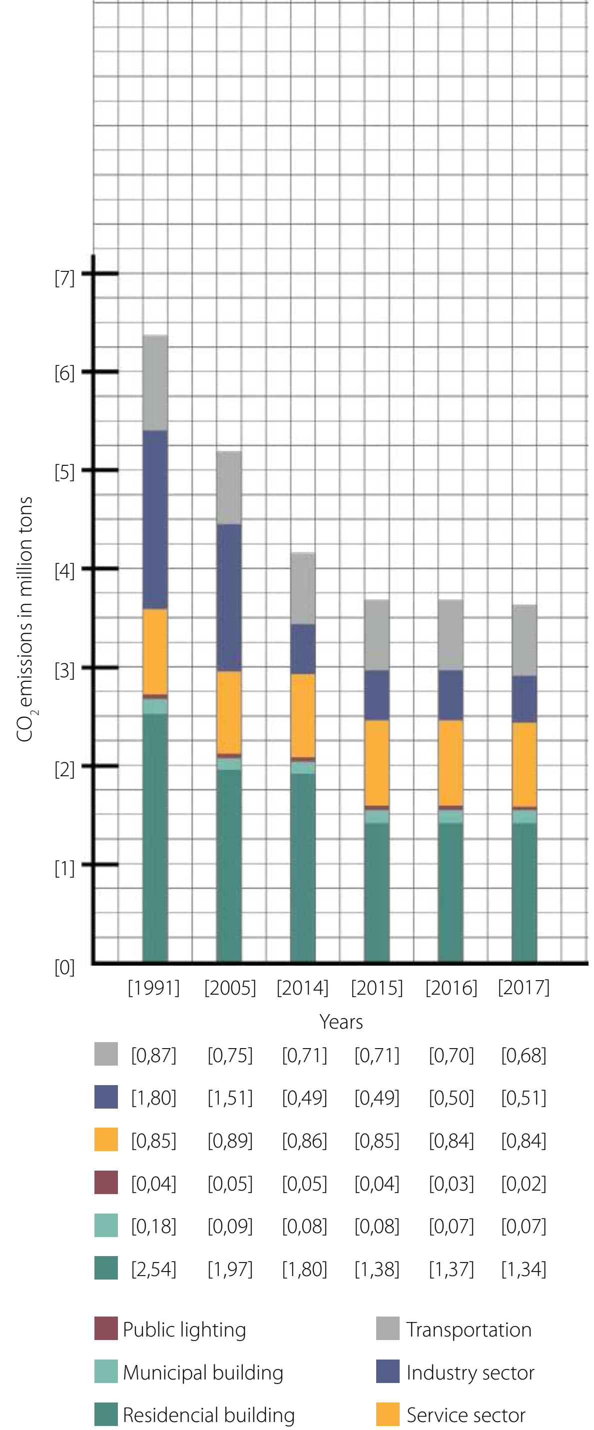


Figure 93.
Comparison of CO_2 emissions inventories of the City of Torino by type of emission source. Illustrated by the author, on the bases of the climate resilience plan for Torino 2030.

This measures vary in terms of their time frame, with some being short-term, such as those for natural disasters such as landslides, fires, and floods, and others being long-term. Adaptation not only prepares a city for the future but also positively impacts urbanization by improving the quality of life and safety for citizens. This leads to increased sustainability and a strengthened sense of identity, and can result in an increase in visitors.

In 2019, Torino joined the new Covenant of Mayors for Climate and Energy, which builds on previous initiatives by incorporating both mitigation and adaptation measures and requires its member cities to reduce CO_2 emissions by 40% by 2030. To effectively address climate change, it's crucial to integrate both mitigation and adaptation measures in public space design. For example, an urban park can lower CO_2 emissions while providing relief from heatwaves and improving thermal comfort for citizens.

The strategic plan -"Torino 2030; Sustainable and Resilient", (2019)- reflects the city's goal of being sustainable and resilient by 2030.

This plan places sustainability at its core, with adaptation to climate change as a key component. The environmental pillars of the plan include: climate resilience, green infrastructure and nature-based solutions, a modernized transportation system, electric and shared mobility, safe roads, circular economy, reduced waste, material recovery and recycling.

Wood in urban green transformation: Assesing timer sustainability study / Planning initiatives for a greener Torino

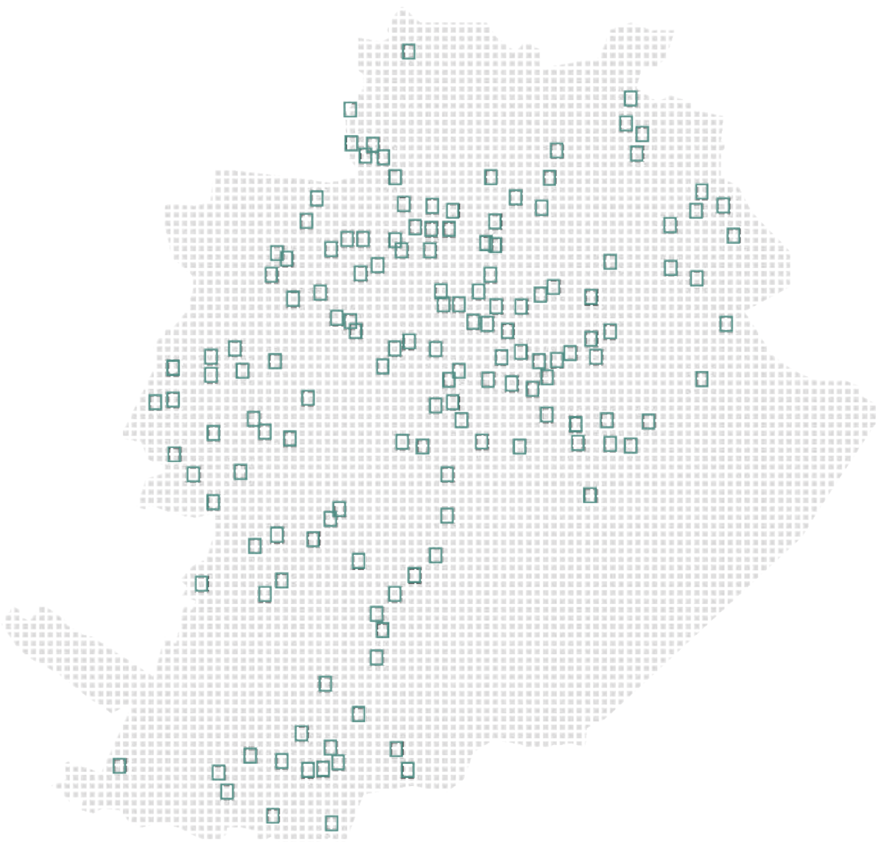


Figure 94.
Representation of the greener transition for ZUT's.
Illustrated by the author.

Wood in urban green transformation:
Assesing timer sustainability study / Urban Transformation Zones and Archetipic interventions

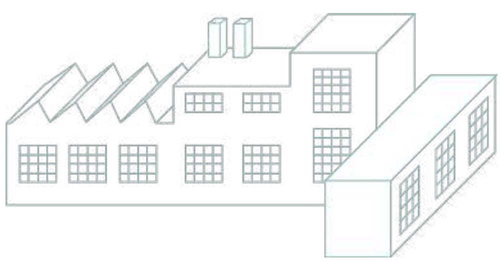
URBAN TRANSFORMATION ZONES AND ARCHETIPIC INTERVENTIONS

To explore to which extend timber may be sustainable in urban transformations we have chosen the case of Torino, Italy.

According to the map showing the implementation status of the ZUT areas mentioned in the PRG. (Fig. 91, 92) Torino has 4 022 319 m^2 non implemented area and 754 074 m^2 which are categorized as in process of implementation.

Considering the planning initiative proposed for the city and since is not possible to consider the entire transformations areas because of their complexity we decided to focus on the ZUT areas, since this are in the city, an available data and a very concrete example.

This type of information may be decided per typology, more specifically we focus on the followed archetype:



Archetype: an abandoned factory with a close by building that allows possible expansions.

For testing the actual sustainability of the use of the wood we chose a pilot project developed during the curse of Final Design Unit D | ADAPTIVE TO RESIST + MITIGATE (2020-21) and we tried to analyze its sustainability and scalability.

The goal is not designing a timber city, but to explore a method for assesing to which extend timber may be sustainable in a city like Torino.

The following project is a hypothetical sample created mostly from mass timber materials where it will then be used to account for the balance of carbon emissions associated with the life cycle of the building, in which the biogenic component will be assessed, i.e. the wood's ability to absorb CO2, so that it can then be examined whether or not the emissions can be lost, or increased, or even how this material ends enhanced in a recycling process.

These end of life scenarios are the ones that, according to this analysis, could define whether wood would be considered sustainable.

This analysis would have as a priority to see what happens in terms of the end of life senarios, specificlly in thewaste tratment and the final disposal (C3 + C4) scenarios within the studied model, according to the end of life cycle of the building.

Figure 95.
Archetype Torino.
Illustrated by the author.

Therefore, the accounting of scenarios C3 and C4 is intended to be analysed according to a series of possible scenarios for the management of the useful life of the material.

For this purpose, five different scenarios were chosen;

/ Scenario **A**; *100% scenario, in which 100% of the waste (generated in the phases that characterise the life cycle of the timber) is destined for disposal in* landfills.

/ Scenario **B**; *Scenario* 70-30%*, in which 70% of the waste (generated in the phases that characterise the lifecycle of the timber) undergoes recovery processes and the remaining 30% is destined for disposal in* landfills.

/ Scenario **C**; *Scenario* 50-50%*, in which 50% of the waste (generated in the phases that characterise the lifecycle of the timber) undergoes recovery processes and the remaining 50% is destined for disposal in* landfills.

/ Scenario **D**; Incineration *for energy recovery scenario, the Stored biogenic carbon is released into the atmosphere.*

/ Scenario **E**; Reuse *scenario, the timber used for the building is still in good condition and is able to be used for its intended purpose, the service life of the material is extended without undergoing any major alterations. Or the timber materials used in the building are saved and reused in other construction projects.*

Furthermore, it will help to assess how much wood would be required in the city of Torino according to its transformation zones witch are sill not in implantation phase as a method to track and obtain the carbon flow from forests to urbanization.

Considering that this model will be used as a guide for the different urban areas of the city that exhibit the same morphological and transformation characteristics, it simultaneously serves as a prototypical urban condition to test the city's capacity to sequester carbon.

This is done by identifying the forest and applying the mass timber model in the city in order to create a critical mass of carbon sequestration within the urban area.

The integration of mass timber architecture on Torino will provide in the future to not only increase the demand of products as timber, but will generate more harvesting patterns and produce a valuable carbon sequestration product stock and a carbon sink city.

A SAMPLE PROJECT

The project aimed to revitalize one of the ZUT areas, the ***5.13*** as clasified as a non-implementeed area in the current PRG (2022) , its context implies an important and nearly abandoned train station in the city that serves as a main international entrance for visitors. The project consisted of two phases and six steps. The first phase involved recognizing and preserving five existing buildings with historical or structural value. The second phase involved proposing a geometric composition that considered the context and reinterpreted it as an envelope that creates different spatialities and serves as a green platform. This envelope is both a compositional and tectonic element, and it is the starting point for a greener Torino.

The timber structure applied in the main buildingconsists in the use of Glulam beams and columns. The beams connect to the columns along the building's perimeter and support the timber floor panels. The columns vary in cross-section depending on the floor they are on. The walls and floor panels consist on cross-laminated timber (CLT) panels, the wall with thicknesses of 15 cm for internal walls and 30 cm for external walls.

Note:
The details of the project are shown within the Annex.

Figure 96.
ZUT area 5.13 actual site.
Image from Google Maps.

Wood in urban green transformation: Assesing timer sustainability study / A sample project

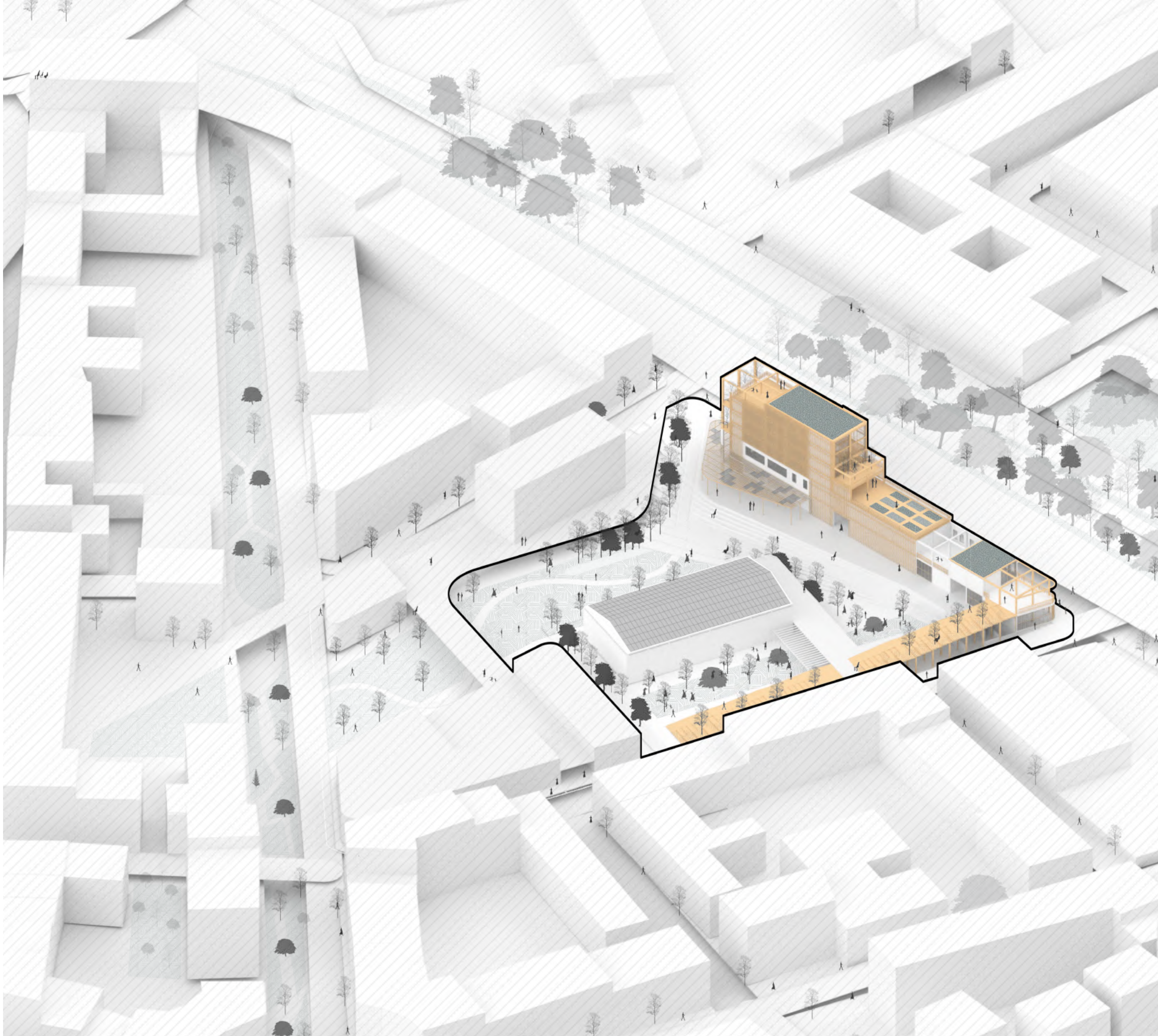


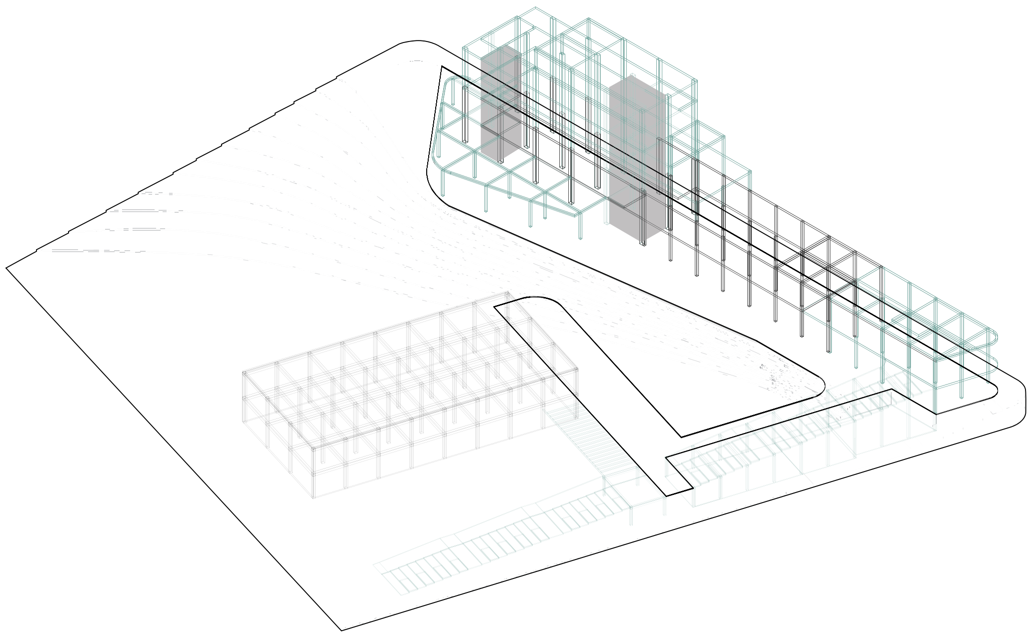
Figure 97.
Axonometric View, ZUT Transformed.
Illustrated by the author.

GENERAL STRUCTURE

For the timber structural components of the main building, a network of Glulam beams extend along the building, connecting to Glulam columns along the building, connecting to Glulam columns algong the perimeter of the module.The beams and columns support the timber floor panels.

The columns used vary in cross-section according to their application on the different floors, i.e. the columns on the third floor have a rectangular cross-section of 40.60 cm, while the last three floors of the main building have columns of 30 cm. 30 cm square cross-section.

As far as the walls are concerned, CLT panels of varying dimensions were used, with 15 cm thick panels for the internal walls and 30 cm thick panels for the external walls.



Stairs structure - CONCRETE

Columns - REINFORCED CONCRETE

Grid base (2nd floor) - STEEL

Slabs and walls - CLT

Columns and beams - GLULAM

Figure 98.
Structural Axonometric.
Illustrated by the author.

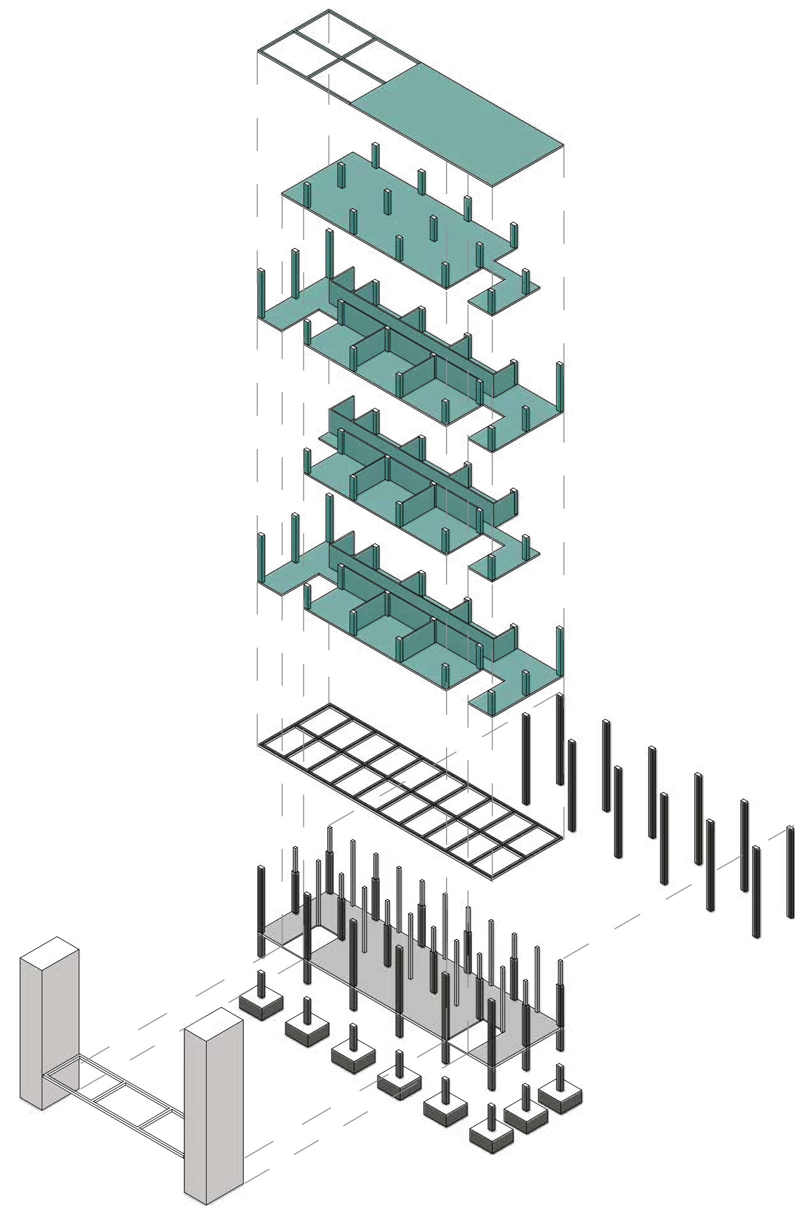
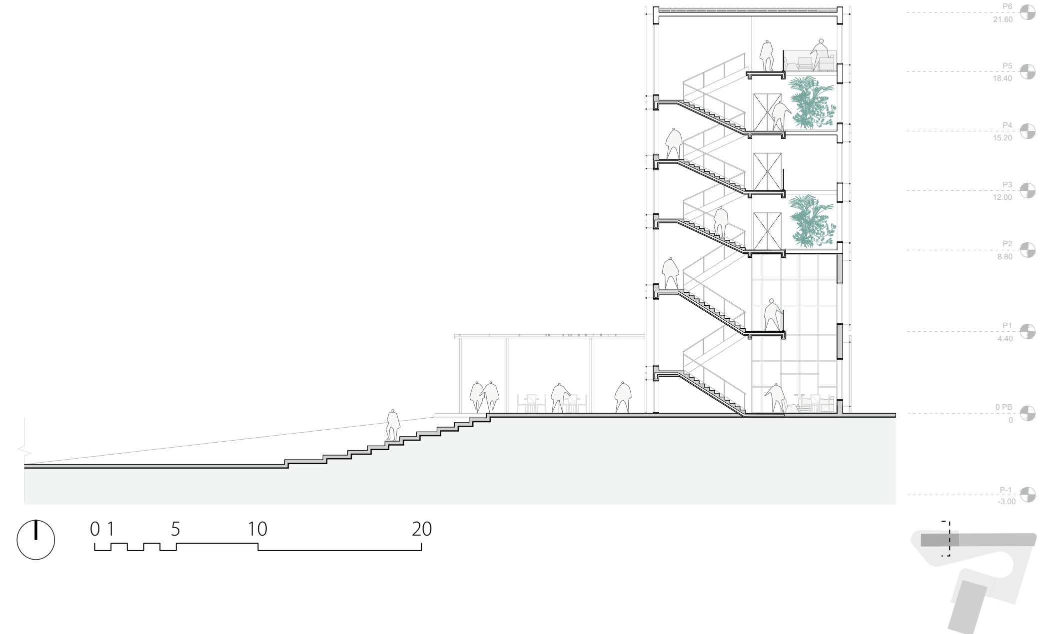
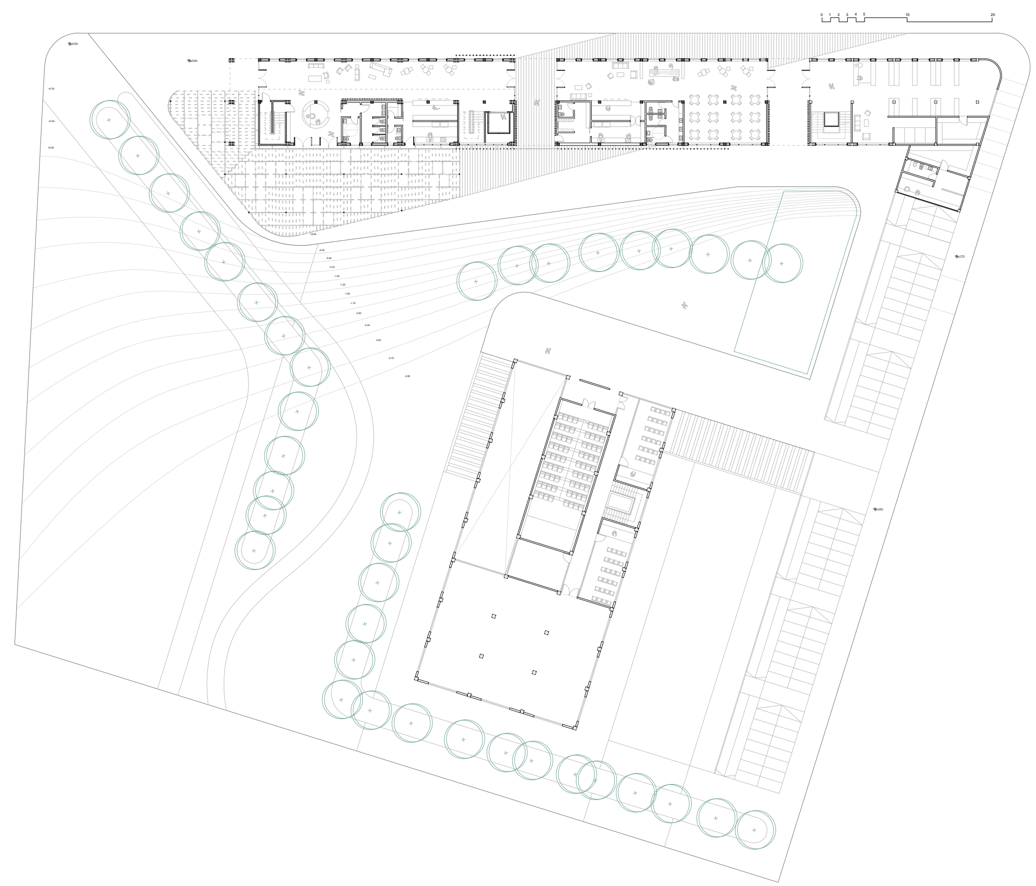


Figure 99.
Axonometric Structural Exploded View.
Illustrated by the author.

PROSPECTS

Facades, Figure 100, 101.
Section, Figure102.
Bottom left, Figure 103.
GROUNGFLOOR 0.00m.
Illustrated by the author.





DETAILS SECTIONS

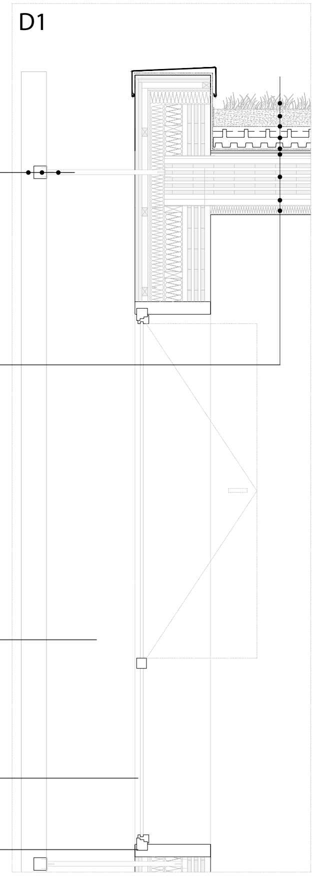
wooden structure
horizontal wooden structure
steel supports

Selected vegetation
DAKU ROOF SOIL 2 [80 mm]
DAKU STABILFILTER SFE [1,30 mm]
DAKU FSD 20 [82 mm]
Waterproof anti-root covering
Impact insulation layer
CLT slab
Sealing
Sound insulation layer

Side-hang window system

Glass

Wooden frame

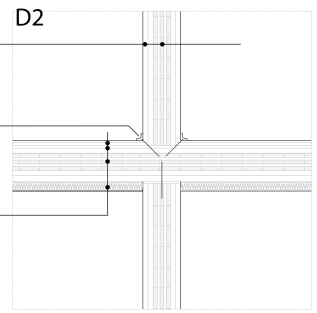


Window system & green roof
1.20

CLT slab
Internal cladding

Screws

Flooring
Impact insulation layer
CLT slab
Sound insulation layer

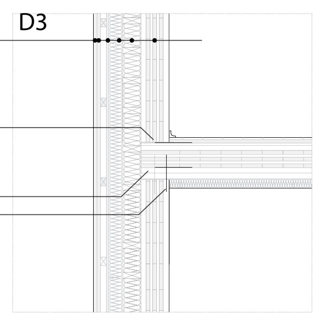


Internal wall to floor
1.20

Cladding
Vertical battens
Wind protection layer
Thermal insulation
Vcapour retarder
CLTpanel

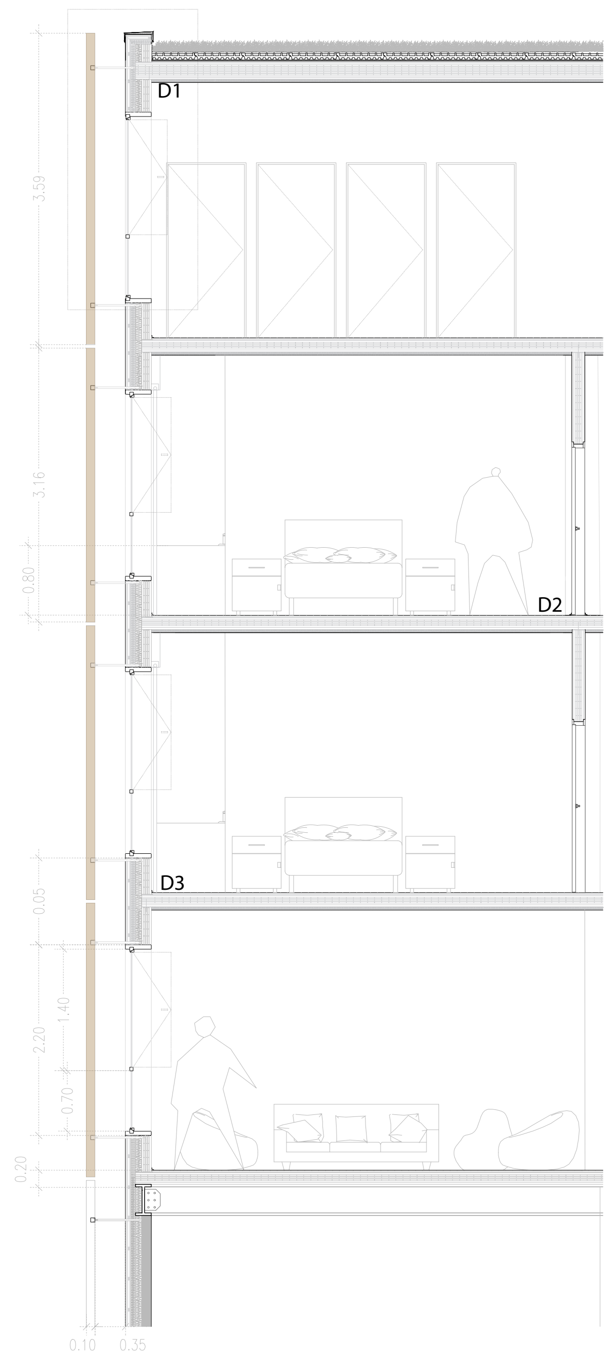
Sealing

Sealing
Screw



External wall to floor
1.20

CROSS SECTION



SOUTH FACADE

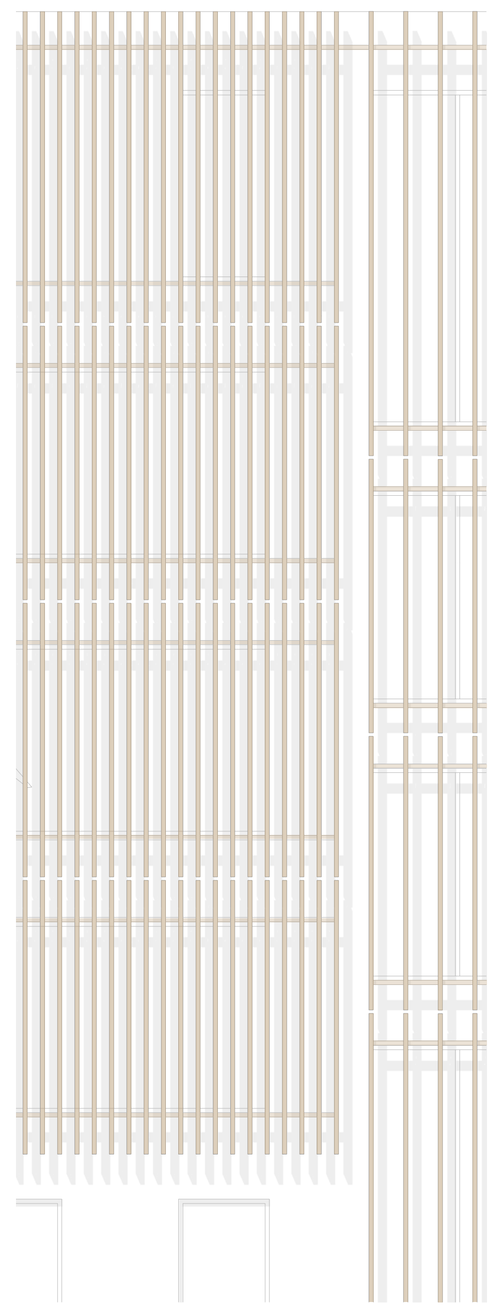


Figure 104, 105, 106.
Details.
Illustrated by the author.

*Figure 107.
Axonometric View of the Main Building
Illustrated by the author.*

/ MODEL

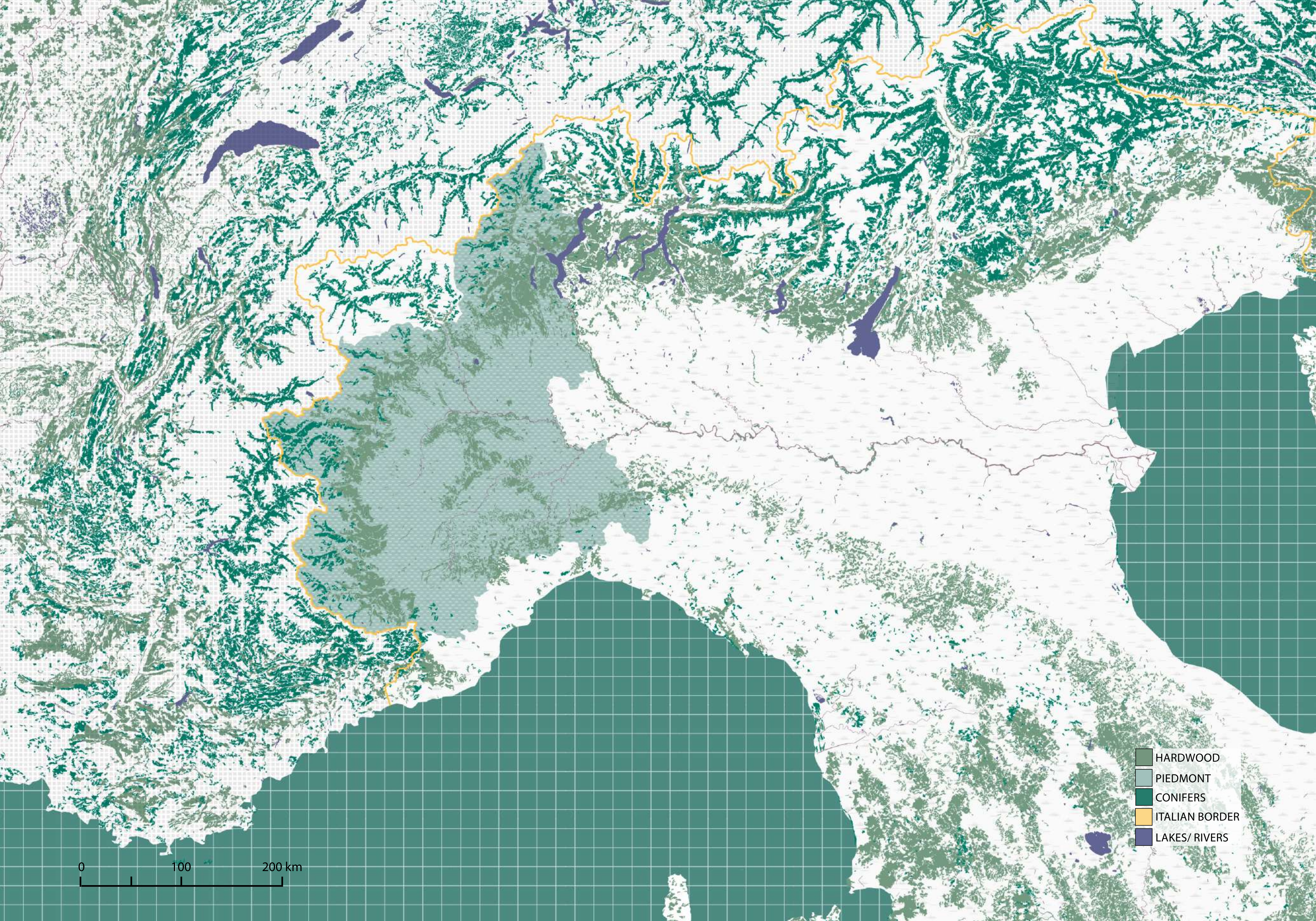
WOOD SUSTAINABLE AVAILABILITY

It is based on the fact that sustainability is the main objective facing urban planners and professionals for the development and planning of cities, and knowing that timber is the only building material which can be defined as essentially sustainable.

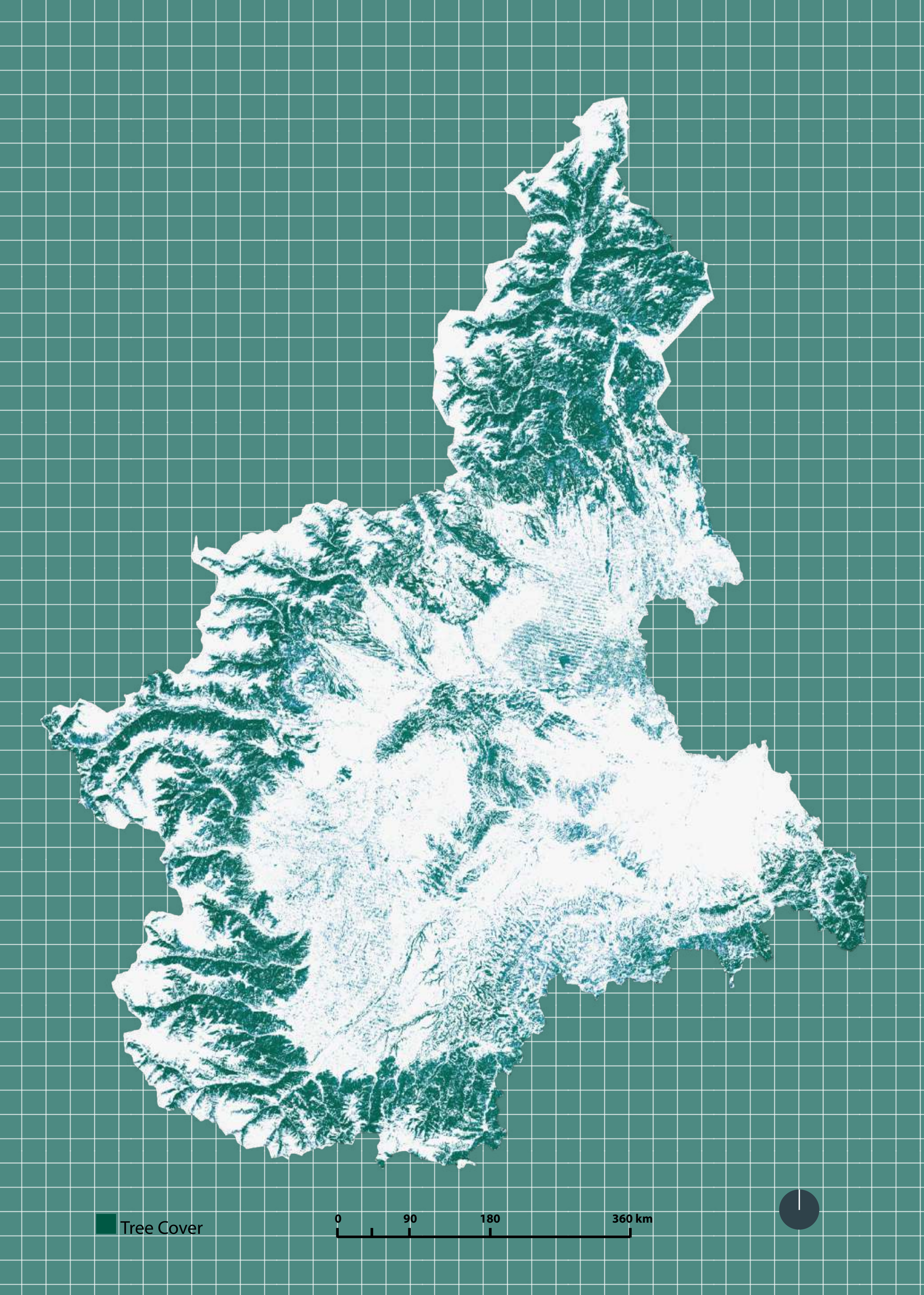
To understand to which extend Torino's transition plans may be implemented throughout the choice of a material, and more specifically, we assume for a supply chain not far more than 500 km.

The following pages explore the actual wood availability for the city of Torino according to the thesis, and 4 factories in the Italian territory will be analyzed, which differ in terms of their location in Italy, scale of production wood harvesting, and the space they use for wood production.

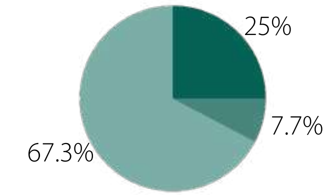
Model / Wood sustainable availability

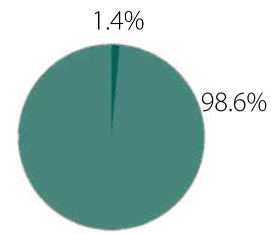


HARDWOOD
PIEDMONT
CONIFERS
ITALIAN BORDER
LAKES/ RIVERS
0
100
200 km



WOOD IN PIEDMONT TERRITORY





The Global Forest Watch organization reported in 2010 that 33% of Piedmont's total area, or 632 kha, was covered by natural forests. In 2021, the area declined by 663ha to a total of 631,337ha.

These forests have an impact on the global economy through the constant supply of wood for construction, energy production, and paper production.

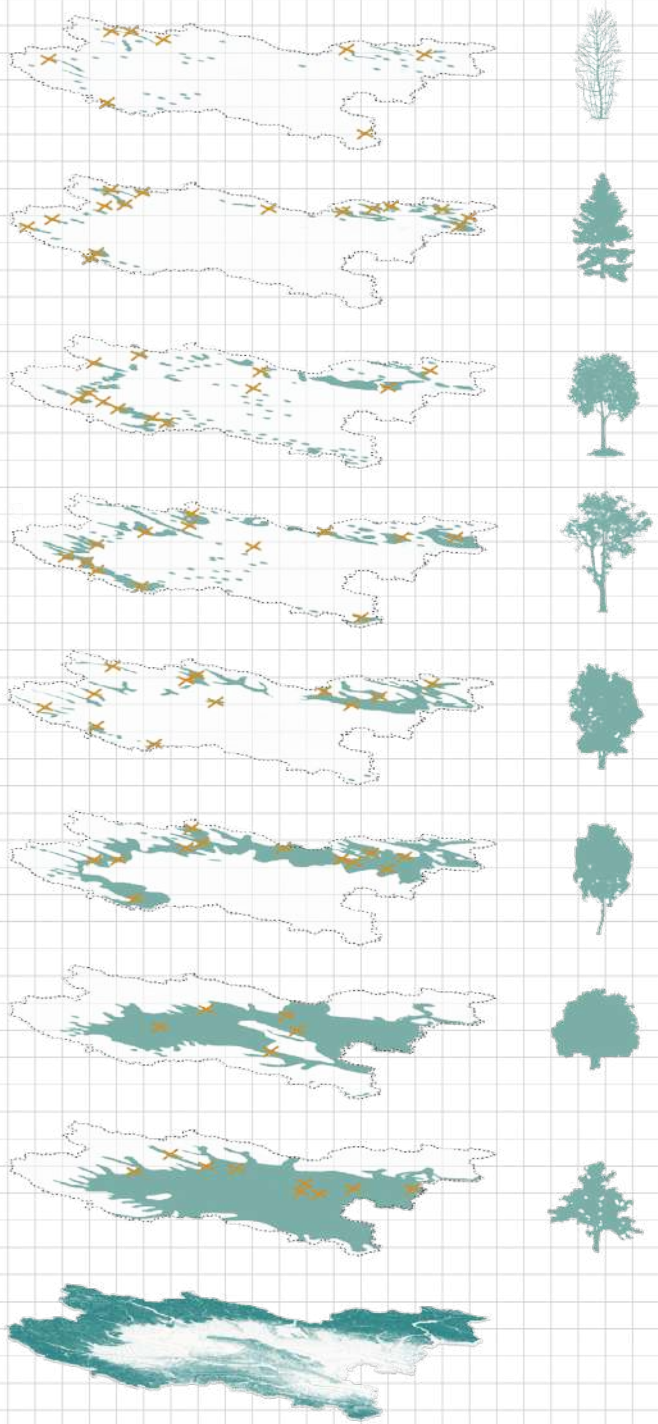
The mapping of tree plantations was done by Transparent World with the help of Global Forest Watch using satellite imagery.

In Piedmont, the top two regions represent 54% of all tree cover. Global Forest Watch has assessed the forest situation in Italy, and Cuneo had the largest forest area (227kha), followed by Torino (217kha), Verbano-Cusio-Ossola (199kha), Alessandria (81.4kha), and Vercelli (72.9kha) in fifth place.

Figure 108, on the left.
Display of Tree Cover over Piedmont territory.
Illustrated by the author, on the bases of GFW Data, (2022)

Figure 109.
Tree cover in Piedmont, Italy(2010).
Illustrated by the author, on the bases of GFW Data, (2022).

Figure 110.
Plantations in Piemonte, Italy.
Illustrated by the author, on the bases of GFW Data, (2022).



SPECKLED ALDER
Alnus incana (L.) Moench
Deciduous

EUROPEAN SILVER FIRE
Abies alba Miller
Coniferous

SWEET CHESTNUT
Castanea sativa Miller
Deciduous

EUROPEAN BEECH
Fagus sylvatica L
Deciduous

SYCAMORE MAPLE
Acer pseudoplatanus L
Deciduous

SILVER BIRCH
Betula pendula Roth
Deciduous

COMMON HORNBEAM
Carpinus betulus L
Deciduous

EUROPEAN ALDER
Alnus glutinosa (L.) Gaertner
Deciduous

Significant populations

Main tree species in Piedmont, which reproduce in groups as well as spontaneously.

Model / Wood sustainable availability

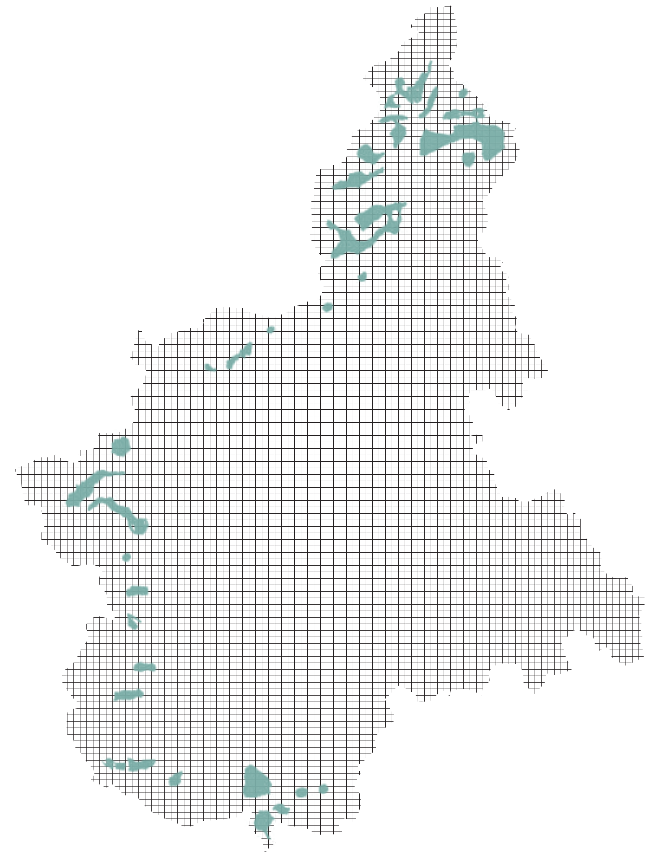


Figure 111.
Maps of The Main Forest Areas In Piedmont.
Illustrated by the author, on the bases of Alberi e Arbusti - Guida alle specie spontanee del Piemonte, (2002).

Figure 112.
European Silver Fire, Coniferouss in Piedmont, Italy.
Illustrated by the author, on the bases of Alberi e Arbusti - Guida alle specie spontanee del Piemonte, (2002).

Figure 113.
Turkey Oak.
Image from Botanica forestale vol. 2, (1997).

Figure 114.
Spruce tree.
Image from INFC, (2015).

WOOD IN ITALIAN TERRITORY

More than 11 million hectares, or 36.7% of the country's surface, were expected to be covered by trees according to the third Italian national forest inventory (INFC, 2015), up about 20% in the last decade, and the total projected volume for all trees in Italian forests exceeds 1.5 billion cubic meters, with an average value per hectare of 165.4 cubic meters.

According to information obtained by the Global Forest Watch organization, it is known that in 2010, Italy had 8.03Mha of natural forest, accounting for more than 31% of its land area. It lost 24.8 hectares of natural forest by 2021.

As of 2010, the top six regions in Italy accounted for 51% of total tree cover. Tuscany had the most tree cover (1.09Mha) compared to the national average of 472kha. And according to the regions, the Global Forest Watch has measured the position of the forests in Italy.

As seen in (Fig. 115) Tuscany has the greatest forest area (1.09 Mha), followed by Piedmont (827 Kha), Sardinia (823 Kha), Trentino Alto-Adige (755 Kha), and Calabria (686 Kha), which is fifth in terms of forest area.

In relation to what concise part of planting trees around Italy, either various planting type as native species or introduced species, thanks to Spatial Database of Planted Trees (SDPT) It is known that the highest percentage of plantation comes from the different types of timber (wood fiber) represented at the national level, which is an average of 2.46 Mha equal to 8.2% of the surface.

Only the 18% of the forest area is managed on the basis of a forest management plan (INFC, 2015).

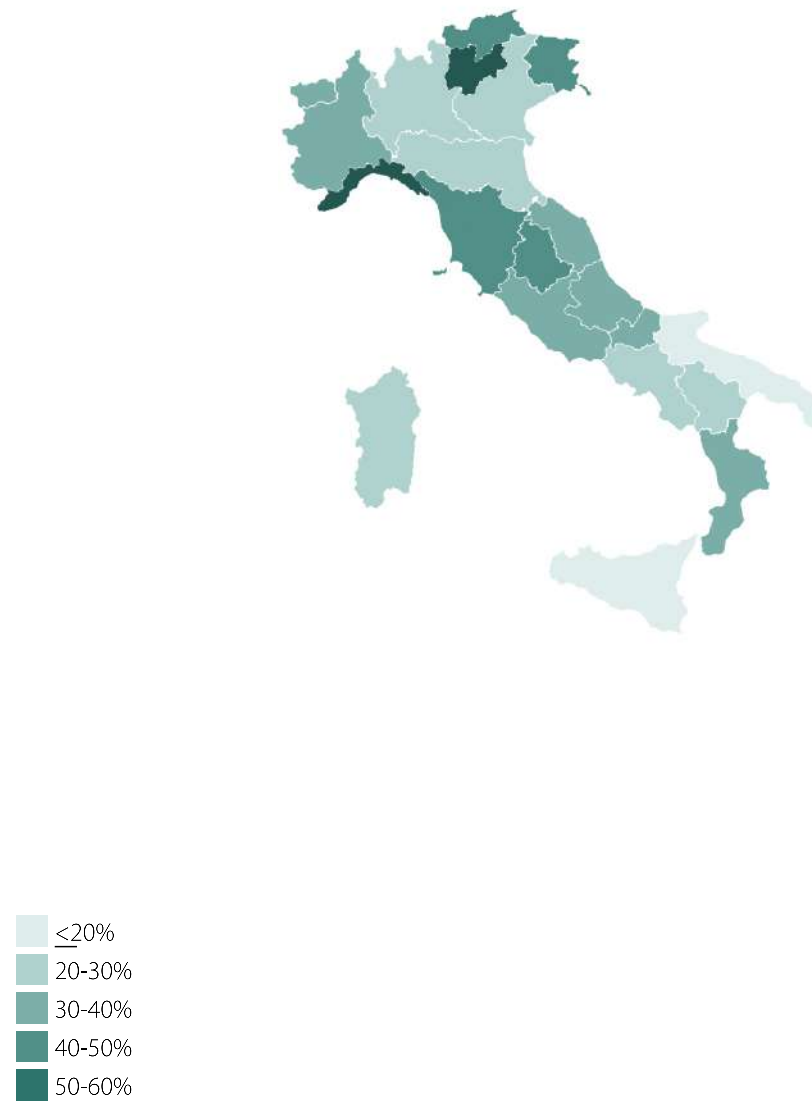


Figure 115.
Italian regions by Forest Cover (%).
Illustrated by the author,on the bases of INFC, (2015).

Tree species richness is a key element of forest biodiversity, from the ecosystem level to the regional and national one. It is a prerequisite for having forests in different environmental conditions, diversified for ecology and more suitable for the provision of the ecosystem services that are important to human well-being.

INFC2015 has measured woody individuals of near 180 species in the Italian territory, for a total volume of 1.5 billion cubic meters. Four species make 50% of the wood in forests, three broadleaves and one conifer: beech (Fagus sylvatica L.), spruce (Picea abies K.), chestnut (Castanea sativa Mill.) and Turkey oak (Quercus cerris L. where it is mainly present in the Apennine Mountains. Compared to other oaks, Turkey oak is less valued because of its tendency to crack, its lower technological quality, and its lower durability) With the following additional seven species, 75% of the wood in forests is made by eleven species: European larch (Larix decidua L.) Downy Oak (Quercus pubescens Willd.), European hophornbeam (Ostrya carpinifolia L.), Holm Oak (Quercus ilex L.), Fir (Abies alba Mill.), Black Pine (Pinus nigra Arn.), Scots Pine (Pinus sylvestris L.).

The so-called tall trees forest, temporarily unstocked regions, plantations for the production of wood and other forested land are all included in this (short trees forests, sparse forests and shrubs). The first three groups account for 82.2% of all the woody land and 30.2% of all of Italy.

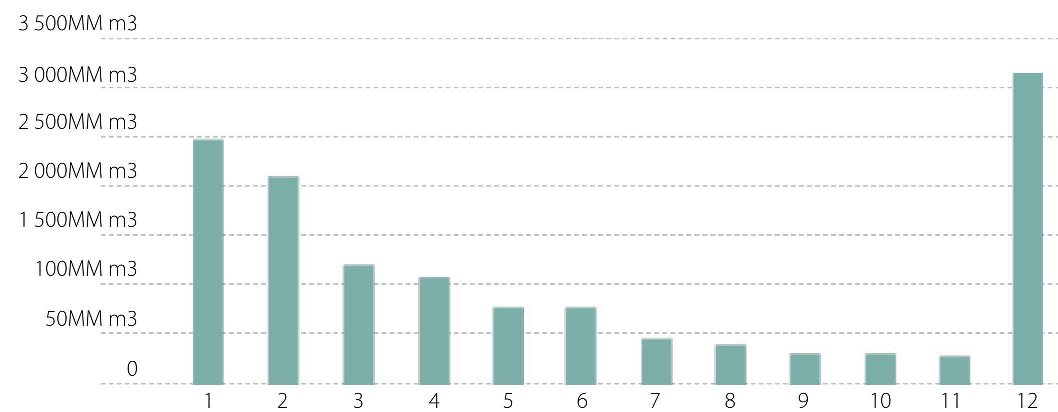
With respective contributions of 10.4%, 9.8%, and 8.7% of the total volume, Tuscany, Piedmont, and Lombardi make up the regions that contribute the most to the entire volume of Italian forests.

Italian Forest's above-ground biomass in relation to the CO_2 according to INFC, 2015 stats, contains more than 539 million tons of organic carbon, while deadwood has close to 30 million tons.

They hold more than 569 million tons of carbon in total, with various locations contributing varied amounts of fixed organic carbon. Living woody species store an average of 59.4 tons in a hectare of forest, but deadwood only holds 3.3 tons.

Between 2001 and 2021Forests in Italy emitted 6.59MtCO_2e/year and removed -55.4MtCO2e/year.

The wood biomass that is taller than 50 centimeters is what INFC classifies as aboveground biomass. In forests, deadwood can be found in on broken dead trees that are still standing, or dead trees that are lying on the ground, or stumps that are the last surviving pieces of trees that have been naturally broken or cut for sylvicultural purposes.



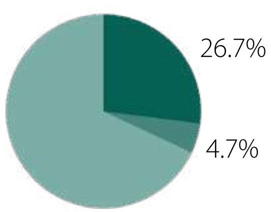
1. BEECH / *Fagus sylvatica L.*
2. NORWAY SPRUCE **/** *Picea abies K.*
3. SWEET CHESTNUT / *Castanea sativa Mill.*
4. TURKEY OAK **/** *Quercus cerris L.*
5. LARCH **/** *Larix decidua L.*
6. DOUNY OAK **/** *Quercus pubescens Willd.*
7. EUROPEAN HOP-HOMBEAN **/** *Ostrya carpinifolia L.*
8. EVERGREEN OAK **/** *Quercus ilex L.*
9. EUROPEAN SILVER FIR **/** *Abies alba Mill.*
10. BLACK PINE / *Pinus nigra Arn.*
11. SCOTS PINE / *Pinus sylvestris L.*
12. OTHER SPECIES

Figure 116.
Growing stock volume of the main tree species in Italy.
Illustrated by the author, on the bases of INFC, (2015).

(Fig. 117) Shows different locations on the Italian territory. As of 2010, 27% of Italy was natural forest cover.

Within the tree planting category according to the SDPT, it allows capturing the number of trees, whether native or not, or trees that were planted by the natural itself or within a "tree farm" area.

Except for the Alpine areas, where pure coniferous forests predominate, Italy's forest area primarily made up of pure broadleaved forests. Pure conifers and mixed woods make up slightly over 10% of the total. In some woodland areas, the presence of broadleaves is considerably more obvious. (Gen. D. Davide De Laurentis, 2021).



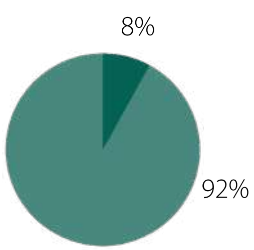


Figure 117.
Display of Tree Cover in Italy land (2010).
Illustrated by the author, on the bases of GFW Data, (2022).

Figure 118.
Display of Plantations forests over Italy land (2010).
Illustrated by the author, on the bases of GFW Data,(2022).

Figure 119.
Display of Tree Cover over Italian territory.
Illustrated by the author, on the bases of GFW Data, (2022).

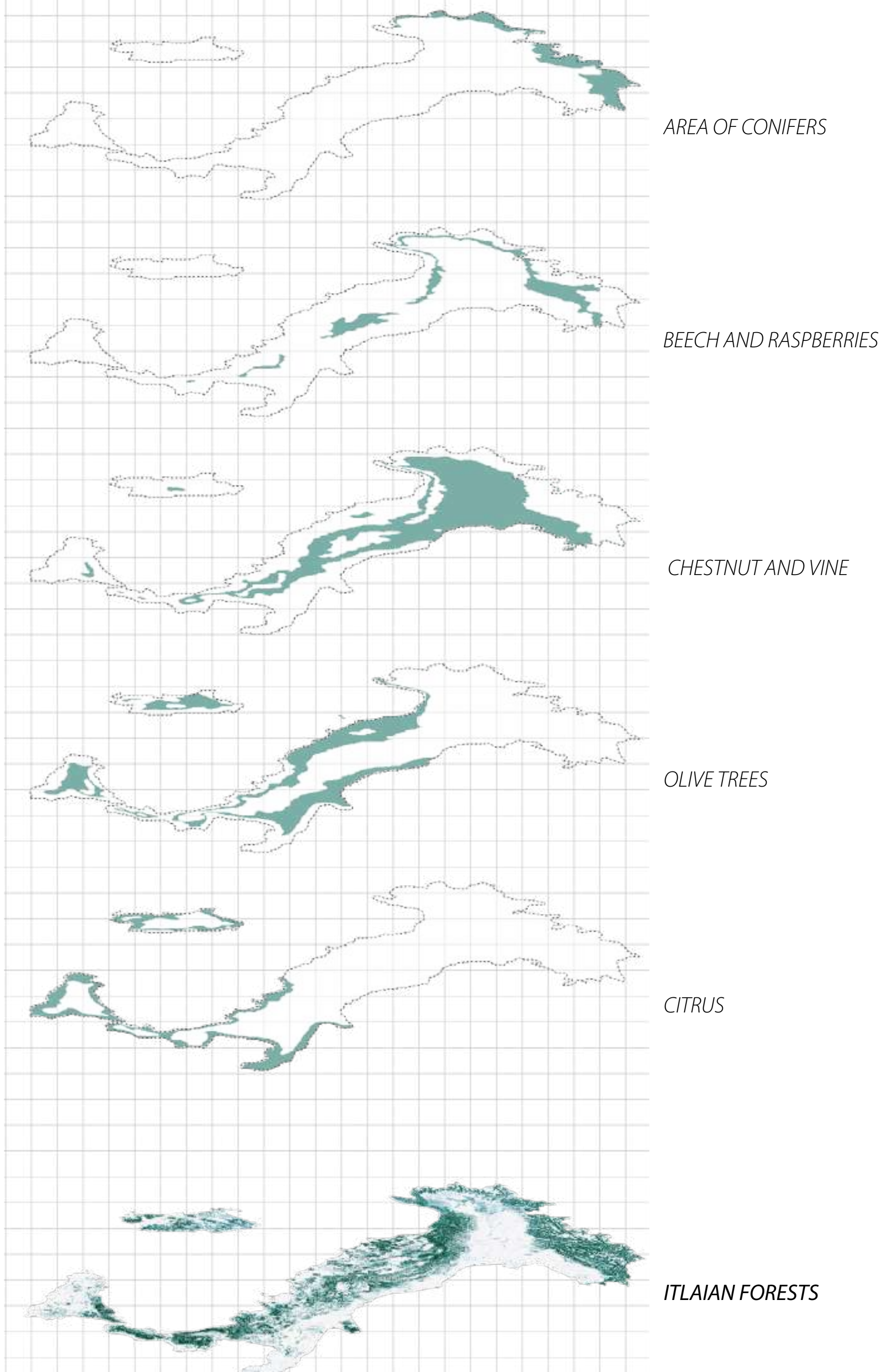


Figure 120.
Maps of The Main Forest Areas In Italy.
Illustrated by the author, on the bases of INFC, (2015).

Figure 121.
Maps of The Main Conifer Forest Areas in Italy.
Illustrated by the author, on the bases of INFC, (2015).

Model / Wood sustainable availability

Figure 122.
European Forest.
Image from Formafantasma - Cambio, (2020).

Model / Wood sustainable availability

Figure 123.
A log loader picks up a load of timber from a truck in a scaling and sorting area at Columbia Vista Corp, (2014).

POSSIBLE SUPPLIERS

According to (FAO, 2008) the production an consumption of wood-based panels in Europe estimate an amount of 104 million m^3, and in 2030 a total of 129 million m^3 . Also the information obtained from FAO Global Forest Resources Assessment Database shows that Italy has manage to sustain an annual net growth of forest of 1 424 million m^3.

The impact of wood production from both territorial and spatial point is shown on the map below.

Both the distance from the forest to the factory and the distance from the factory where the timber was processed to the construction site are shown in the study.

Italy displays the main timber producers in central and northern of their territory which also make us see how the infrastructure is in Italy, i.e. the roads and highways, which, in one way or another, they are the connectors for the distribution.

Model / Wood sustainable availability

ROUTE FROM THE MAIN FACTORIES TO TORINO

MAIN STREETS

LIMIT OF ITALIAN TERRITORY

▲ COMPANY: Mozzone Building System
FACTORY LOCATION: Via Torino, 272, 12038 Savigliano CN
DISTANCE: 52,5 km

▮ COMPANY: AB Legno - Bevilacqua Adriano Srl
FACTORY LOCATION: Via G. Bianchi, 68 - 21049 Tradate (VA)
DISTANCE: 147 km

● COMPANY: Xlam Dolomiti
FACTORY LOCATION: Viale Venezia, 35, 38050 Castelnuovo TN
DISTANCE: 399 km

⬣ COMPANY: Artuso Legnami s.r.l.
FACTORY LOCATION: Via Edificio, 19/2, 31030 Caselle TV
DISTANCE: 407 km

✸ COMPANY: Timber Lab s.r.l.
FACTORY LOCATION: Via del Molino, 42, 52010 Corsalone AR
DISTANCE: 466 km

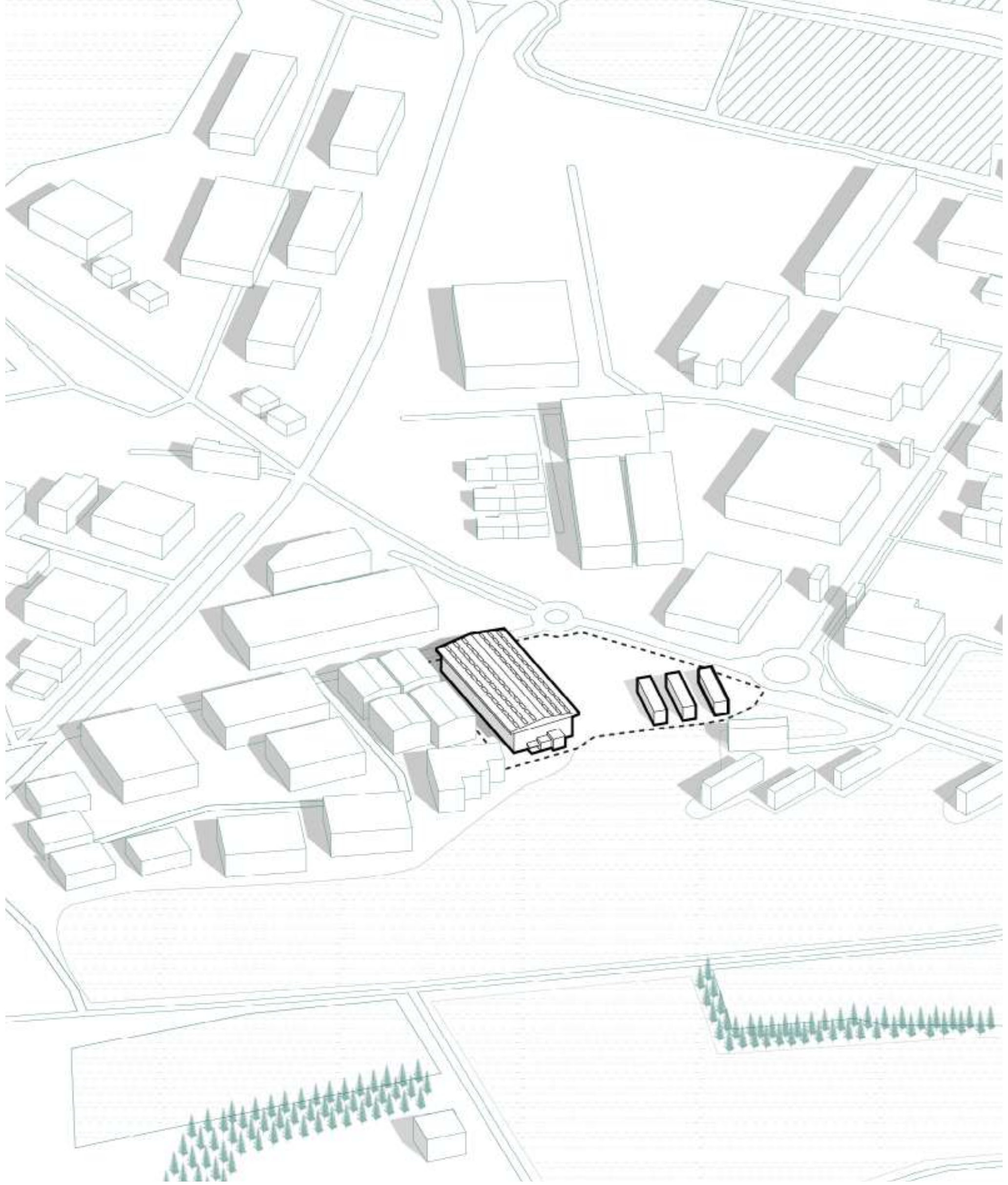
⬟ COMPANY: La Cost - Costantini Case in Legno
FACTORY LOCATION: Via Torgianese, 42, 06084 Bettona PG
DISTANCE: 560 km

◆ COMPANY: Biolam Italia SL
FACTORY LOCATION: Via della Giuliana, 44, 00195 Roma
DISTANCE: 671 km

■ PRODUCER OF STANDARD TIMBER MATERIALS FOR CONSTRUCTION

● TORINO

Figure 124.
Timber producers in Italian Territory.
Illustrated by the author.
/ The majority of the companies are spread over northern Italian area. This is due to the spatial location in relation to the distance from the forests where the wood is harvested. According to a number of factories that were examined, some of the wood is supplied from forests in mountainous regions, and a significant portion is obtained from other European forests outside of Italian territory, always in similar regions with the same geographical and climatic characteristics.



I.C.L.A. LEGNAMI

/ Factory Area: Alpignano
/ Plot Area of the Establishment: 0.8 Ha
/ Fabrication Area: 1 380 m^2
/ Factory Space: 6 120 m^3
/ Area of Material Collection: 0.23 Ha
/ Production Scale: National
/ Type Of Wood They Work With: Abete

Figure 125.
Axonometric view of the factory and its spatial environment.
Illustrated by the author.

Figure 126.
Distance between the wood-source forest and the factory.
Illustrated by the author.

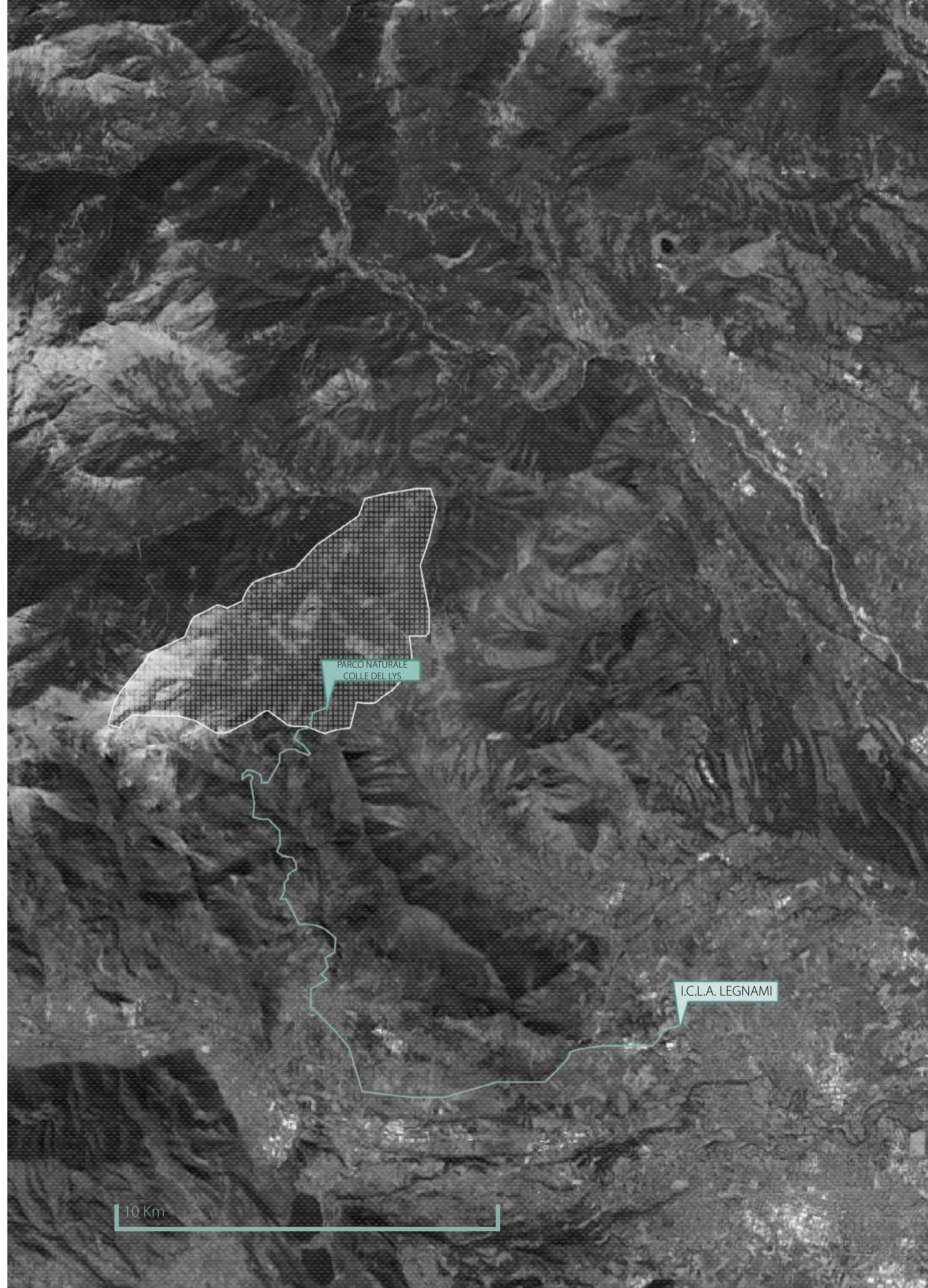
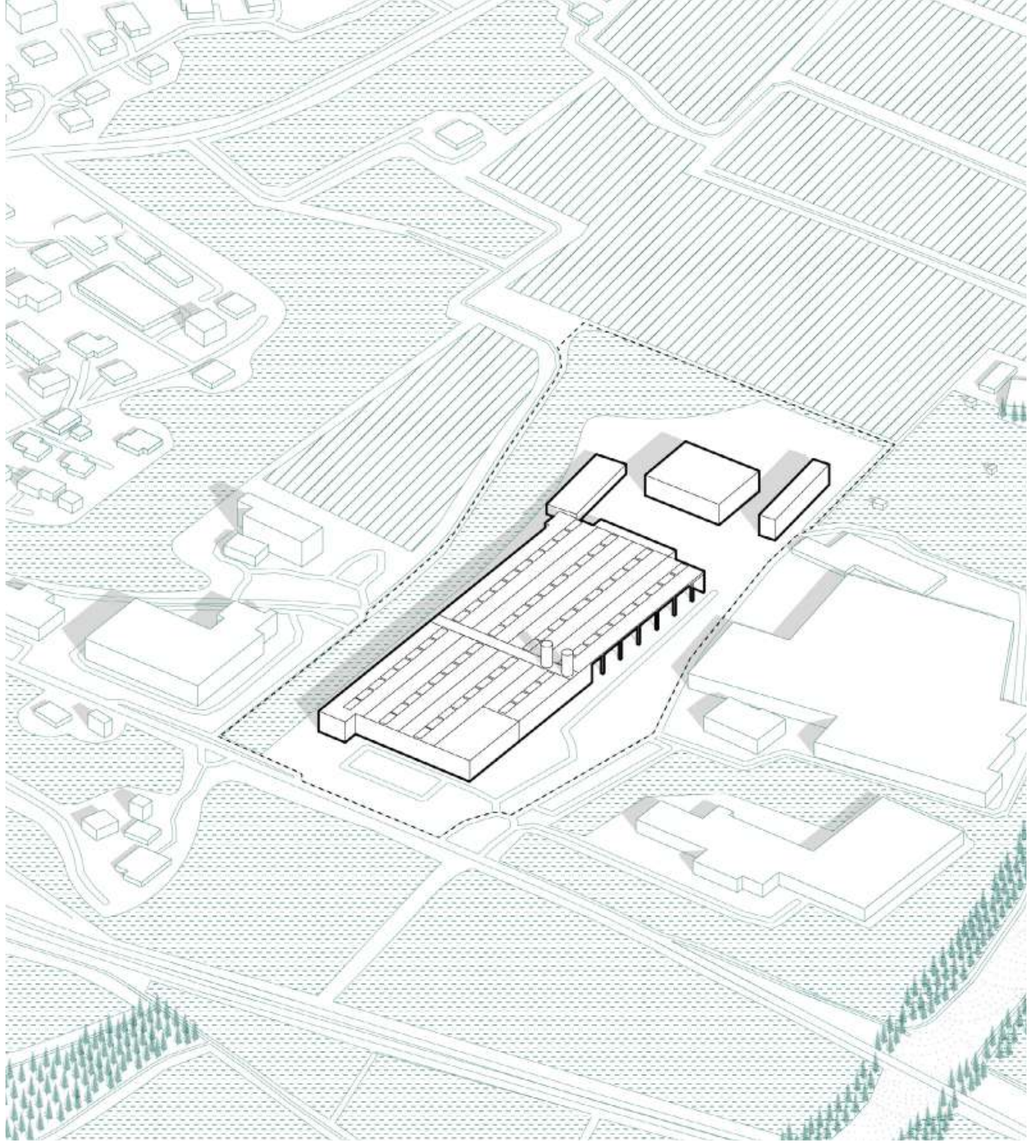


Figure 127, 128.
I.C.L.A. LEGNAMI from the outside and Street View.
Image from Google Maps.

Figure 129, 130, 131.
I.C.L.A. LEGNAMI from the inside.
Image from Google Maps.



XLAM DOLOMITI

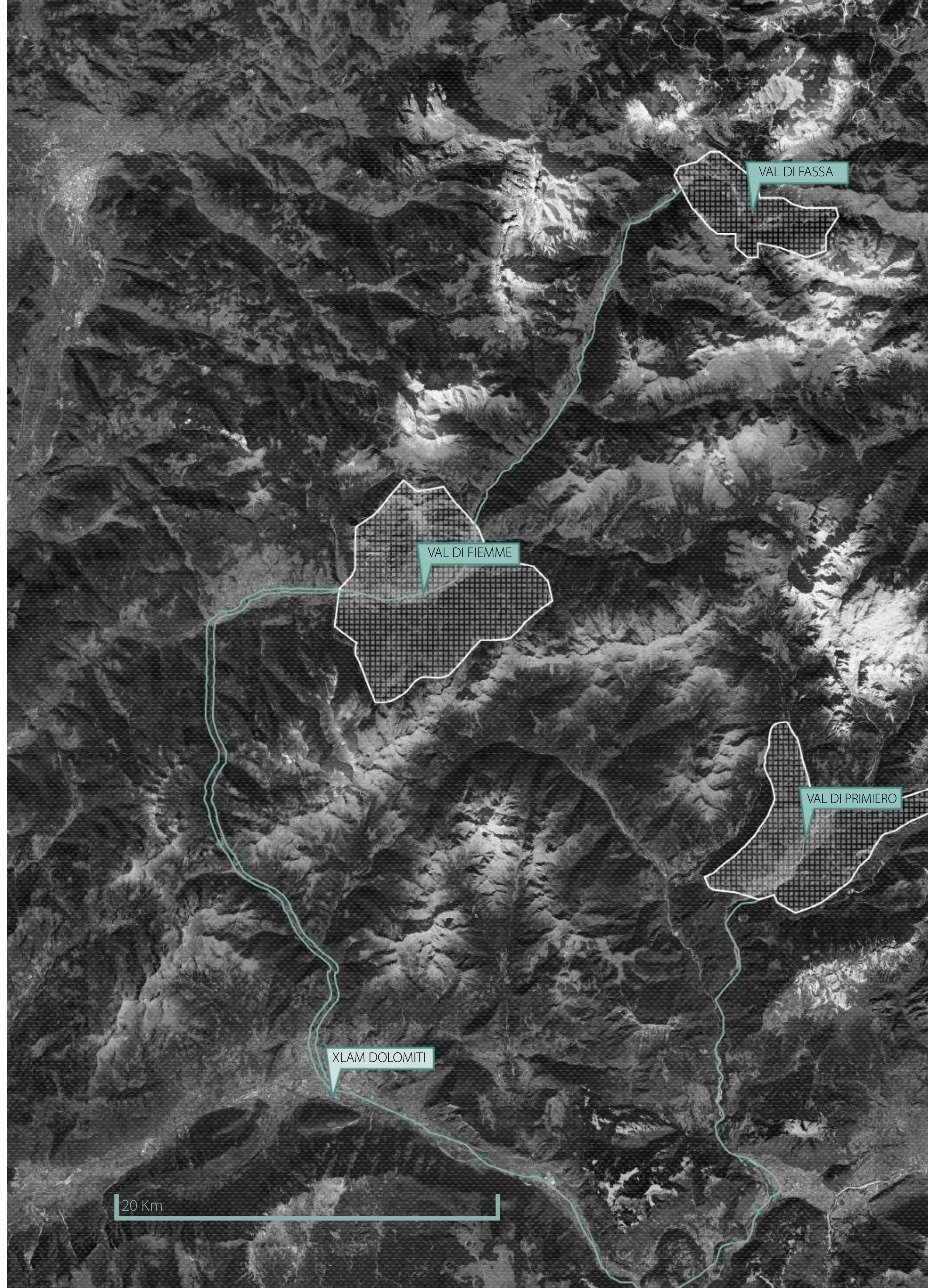
/ Factory area: Trento Valsugana
/ Plot area of the establishment: 7.28 ha
/ Fabrication area: 19 330 m^2
/ Factory space: 115 980 m^3
/ Area of material collection: 0.89 ha
/ Production scale: National/International
/ Type of wood they work with: Mainly Fir
/ Quantity of wood transporting in a forest truck to factory: aprox. 40 m^3

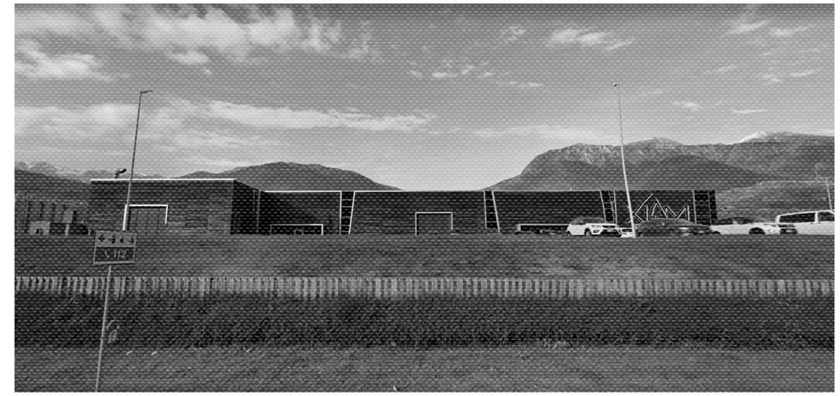
About 20% of the demand comes from forest in Trentino that obteins the logs in:
/ Val di Fiemme (aprox 55 km)
/ Primiero (aprox 58 km)
/ Fassa (aprox 75km from the factory)

The rest from German & Austrian wood from European forests.

Figure 132.
Axonometric view of the factory and its spatial environment. Illustrated by the author.

Figure 133.
Distance between the wood-source forest and the factory. Illustrated by the author.





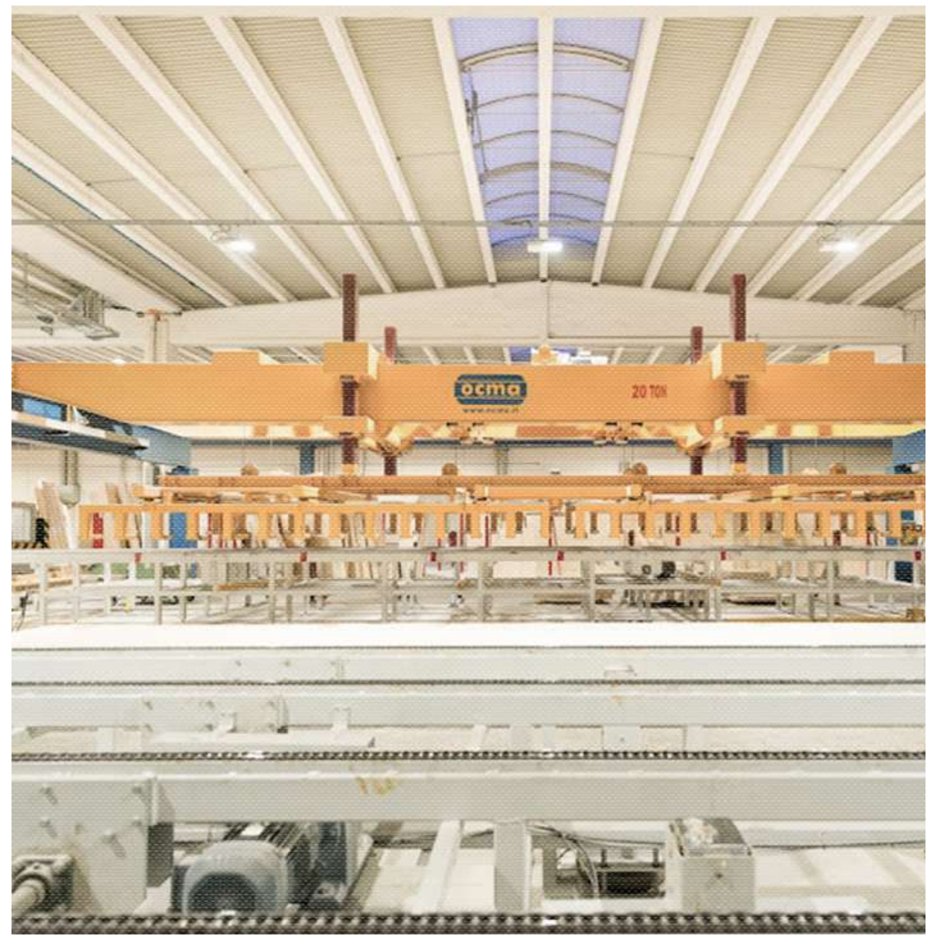
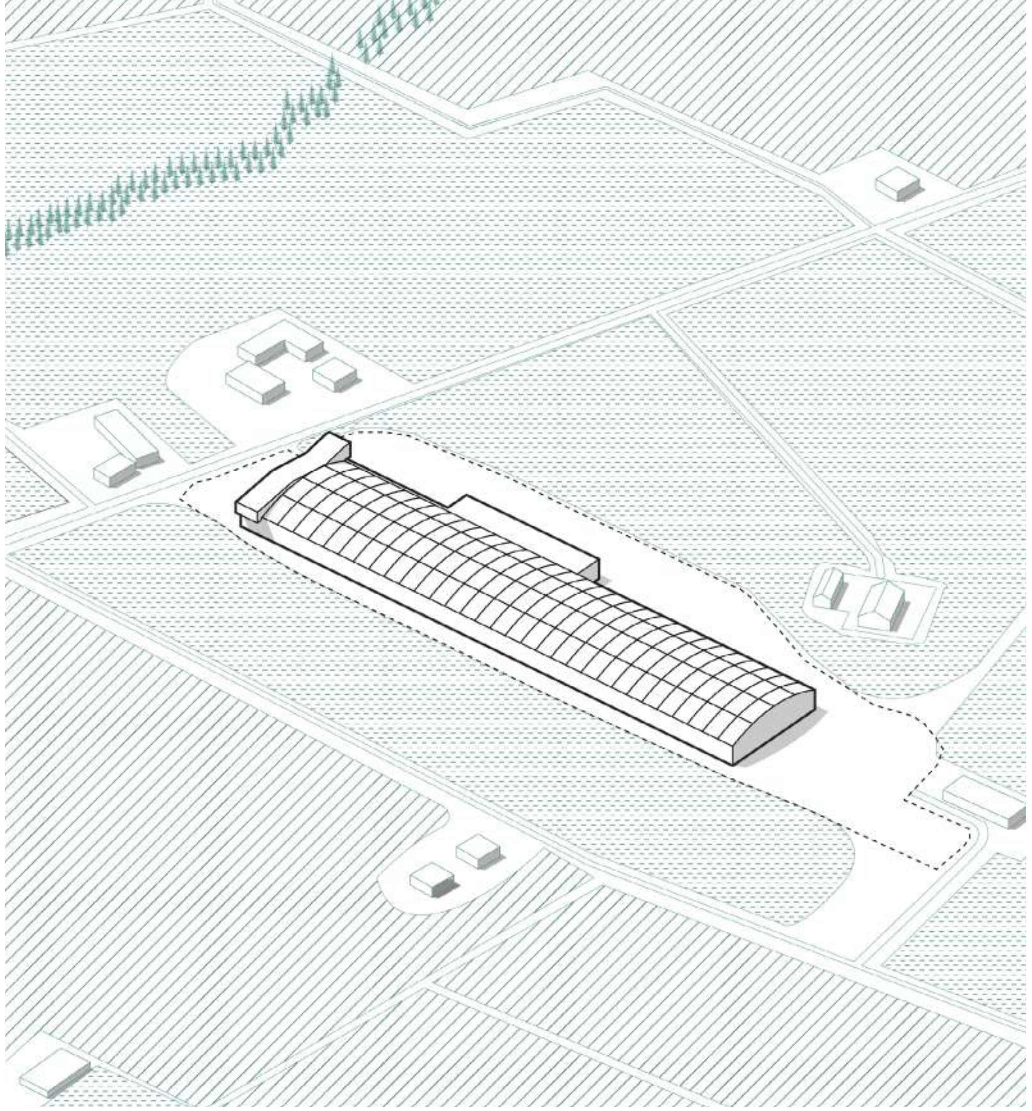


Figure 134, 135, 136, 137.
XLAM DOLOMITI from the inside and outside.
Image from Google Maps.

Model / Wood sustainable availability



XLAM LA COST

/ Factory area: Bettona (PG)
/ Plot area of the establishment: 5.70 ha
/ Fabrication area: 21 733 m^2
/ Factory space: 115 980 m^3
/ Area of material collection: 1.97 ha
/ Production scale: Mainly in central and northern Italy.
/ Type of wood they work with: Mainly Spruce & White Fir in small quantity.
/ Quantity of wood transporting in a forest truck to factory: approx. 50 m^3

About 5% of the demand comes from Italian forests in Trentino that obtains the logs in:

The rest from German & Austrian wood from European forests.

Figure 138.
Axonometric view of the factory and its spatial environment.
Illustrated by the author.

Figure 139.
Distance between the wood-source forest and the factory.
Illustrated by the author.

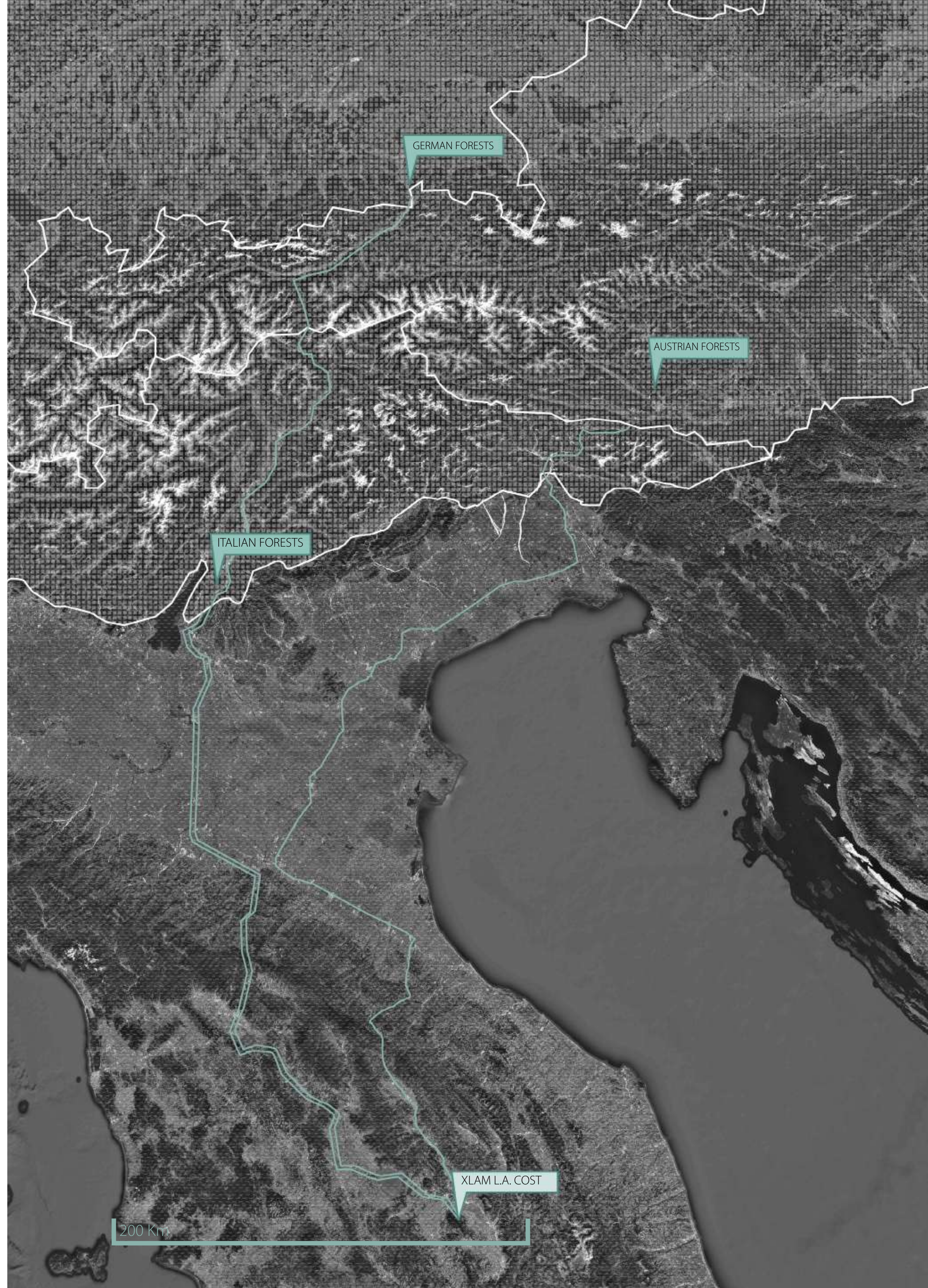
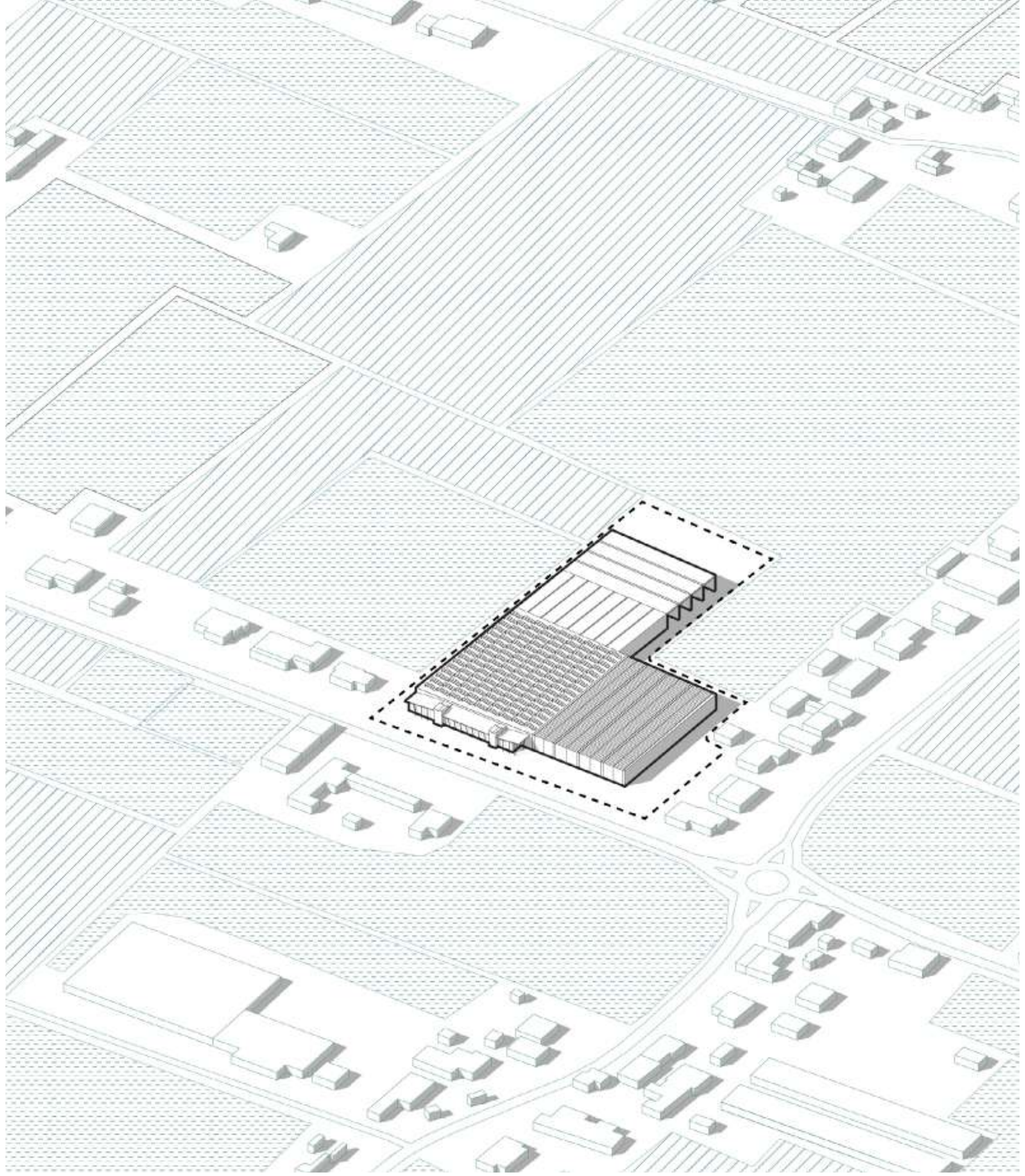


Figure140, 141, 142, 143.
XLAM LA COSTI from the inside and outside.
Image from Google Maps.



ARTUSO LEGNAMI S.R.L.

/ Factory area: Caselle (TV)
/ Plot area of the establishment: 1.95 ha
/ Fabrication area 8 380 m^2
/ Factory space: 66 400 m^3
/ Area of material collection: 0.5 ha
/ Production scale: Mainly in central and northern Italy.
/ Type of wood they work with: Mainly Fir.
/ Quantity of wood transporting in a forest truck to factory: approx. 40/60 m^3

The demand comes from German & Austrian wood from European forests.

Figure 144.
Axonometric view of the factory and its spatial environment.
Illustrated by the author.

Figure 145.
Distance between the wood-source forest and the factory.
Illustrated by the author.

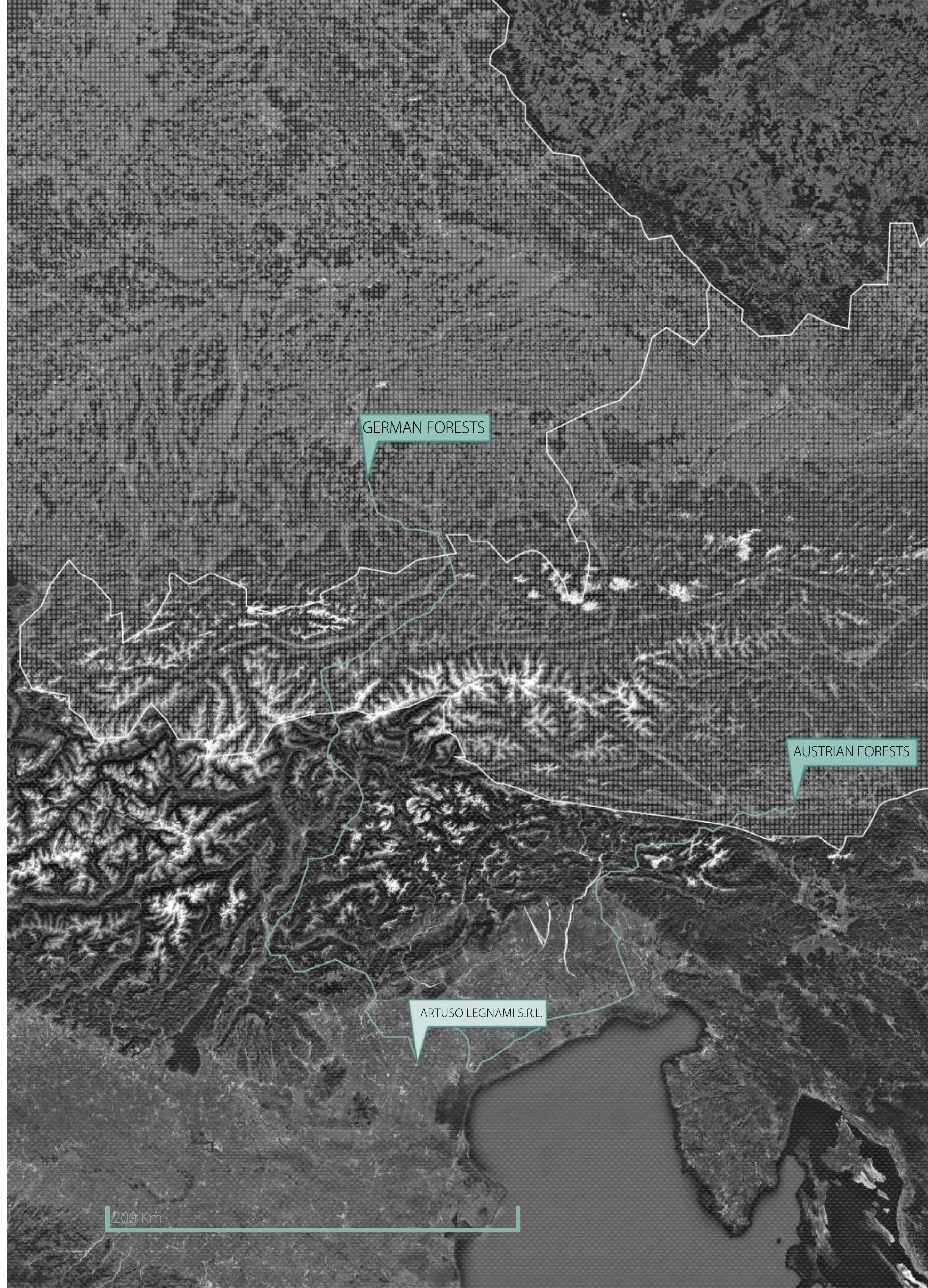


Figure 146, 147.
ARTUSO LEGNAMI S.R.L. from the Outside.
Image from Google Maps.

Model / Wood sustainable availability

CARBON ACCOUNTING AND WLC ASSESSMENT

As previously indicated, because it's a hybrid material building used in the model, the accounting of the CO_2 emissions is based on the timber materials.

In this context, in order to be able to analyse whether timber could be considered as sustainable the carbon footbrint and the management of the forests where the wood comes from, the impact of harvesting and processing the wood, and the end-of-life disposal of the wood products is going to be analysed. The determination of the Embodied Carbon , and its end-of-life scenarios (C3, C4) phases will be put under discussion by creating five possible senarios for the timber, such as two recycling scenarios, a composting, a reuse and a incineration scenario.

For this purpose, the accounting of the equivalent CO_2 emissions of the production, use and end-of life-phases leads to dig into an assessment called Whole Life Carbon Assessment.

According to the technical and regulatory references explained in the technical report DEC50. ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nell ciclo di vita di un manufatto edilizio¨ published by the Green Building Council Italia (2022).

The term "Whole Life Carbon" refers to a carbon balance that takes into account both the emissions related to the usage of a building (Operational Carbon), calculated in accordance with the energy requirements for air conditioning, lighting, and domestic hot water, and the Embodied Carbon emissions.

In order to understand how to calculate the accounting of this model, it is necessary to address some definitions related to this topic in order to frame the issue.

/ Embodied Carbon (EC);
Is utilized as an indicator by which to measure the energy efficiency and climate change impact of the life cycle of a given good, during one or more phases of the life cycle of a given good, be it a product or a building artefact.

it identifies a given quantity of substance (CO_2, methane, etc.) and assesses its contribution in terms of carbon dioxide equivalent, using appropriate conversion factors.

/ Operational Carbon (OC);
Is an indicator that accounts for the emissions of carbon dioxide equivalent in the use phase, released for the operation of a building artefact, and normalised against an appropriate unit of measurement (also called functional) appropriate.

OC also refers to the accounting of CO_2eq emissions associated with the consumption of energy to operate the systems or equipment serving the building (e.g. heating and cooling, lighting, ventilation, household appliances, etc.).

OC must be accounted for separately from Embodied Carbon (EC).

/ Whole Life Carbon (WLC);
Accounting for the equivalent CO_2 emissions over the life cycle of a building leads to an assessment called Whole Life Carbon Assessment.

It is also a carbon balance that considers both the emissions associated with the use of a building (Operational Carbon), determined on the basis of energy needs for air conditioning, lighting and domestic hot water, and Embodied Carbon emissions.

/ Bill-of-Quantities (BoQ);
Actual determination of the materials and products that make up the building. It also means the most precise quantity of materials and products delivered to the construction site, to which the production of waste from construction activities will correspond.

/ Specific Data;
For the purpose of accounting for Embodied Carbon, Specific Data refers to material and product specific data (e.g. plasterboard produced by company X) found in technical documents (e.g. EPD, PEF, Carbon Footprint, LCA studies) taken from databases and databanks or available from the manufacturer.

/ Circular Economy;
Economic model of production and consumption involving sharing, lending, reusing, repairing, reconditioning and recycling of materials and products: thus extending their life cycle and minimising waste production.

With regard to the accounting of Embodied Carbon, the Circular Economy is aimed at quantifying and assessing the potential environmental benefits or impacts associated with the processes of waste reuse and/ or recycling and the energy recovery of the Feedstock component (see Feedstock Energy).

The Circular Economy of a construction product is assessed in phase D - Beyond Life Cycle - and is accounted for separately from the remaining life cycle phases.

As mentioned above in order to account for the emissions referred to as Embodied Carbon (EC) which contribute as an indicator to the WLC assessment. The EC, its an indicator which refers to life cycle phases that cannot be subject to change.

The emissions created during the use phase and other phases of the life cycle of a building can be categorized taking into account the processes of extraction of raw materials and energy resources, transformation into semi-finished and finished products or derived energy resources, transport, installation and construction, replacement and maintenance, deconstruction and demolition, and even contemplating future post-demolition waste management scenarios, also evaluating their transformation into secondary raw materials, through recycling and/or reuse processes (Fig. 148).

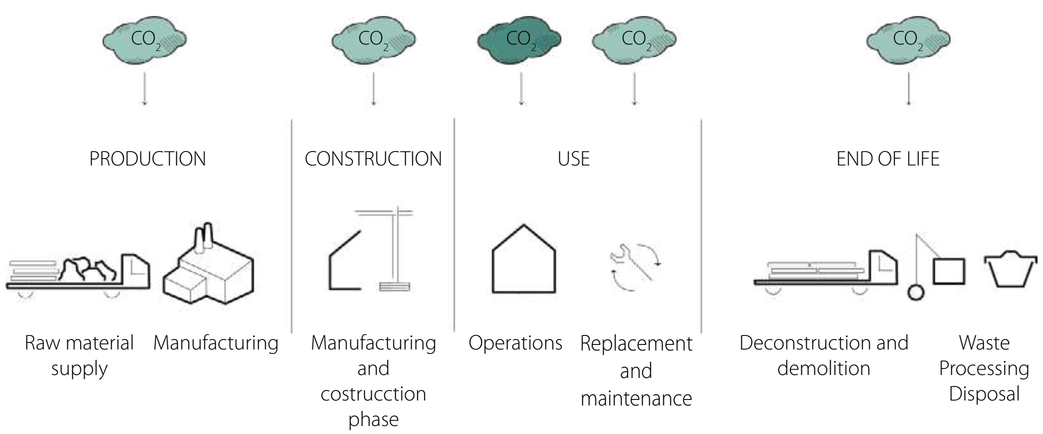


Figure 148.
CO2 emissions associated with the life cycle of a building construction.
Illustrated by the author in the baces of the technical report, ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nell ciclo di vita di un manufatto edilizio¨ (2022).

The EC, excluding the Operational stages, refers to phases A, B, and C of the life cycle of a building material. Additionally, phase D (Potential Benefits and/or Loads) can be independently accounted because it considers additional releases or removals outside the system boundary (Figure 149).

Phase D can therefore take into consideration environmental pressures brought on by improper disposal practices as well as advantages from recycling, reuse, recovery, and offsetting operations (such as carbon offsets and carbon uptake) (i.e. landfill).

According to various bibliographic and siteographic sources, there are three different categories of emissions that are taken into consideration in the methods established to measure or account for CO_2 equivalent emissions.

Scope 1 emissions are those produced directly as a result of a production process or the delivery of a service (e.g. greenhouse gas releases from the combustion of a boiler or furnace).

Scope 2 emissions, also known as indirect emissions, are the result of the transportation and production of the energy and derived resources needed in the production process.

Scope 3 emissions are those that a corporation makes but which are not proactively regulated and managed. They are similar to operations such as employee transportation or the manufacturing of goods needed to carry out specific tasks.

Therefore, the EC should be viewed as the total of all three categories of emissions.

Construction materials chosen during the design and execution phases in particular should be linked to Scope 3 emissions.

There are different classifications that can be identified for the life phases of a building product during the examination and assessment of the EC, in which they are classified as either "recommended" or "optional." The phases that are "recommended" must always be used in this assessment (stages A1-A3, B2-B5, C1-C4).

The "optional" stages, on the other hand, are those that may be used in the assessment where the level of complexity is typically higher and more accurate data can be acquired (B1-B3).

Also the "minimum scope of application" is added to these categories.

This indicates that in order to ensure a minimum verification of the CO_2eq emissions emitted, the production process of the manufacture of the materials and products (steps A1-A3) must be taken into account by the EC's evaluation.

On the other hand, there is a final phase that is designated as phase "D," which refers to the activities of recycling, reuse, and recovery to which the material under the demolition and waste transformation process (C1-C4) might be subjected. This phase, which considers potential scenarios for the recovery of construction and demolition waste, should be computed separately from the other phases.

If the demolition of an existing structure and/or the replacement of materials and products during the earliest stages of renovation are anticipated, phase D of the design phase may be evaluated.

In this instance, the evaluation is moved to year zero, or the year the structure was renovated.

The accounting of the EC should be kept apart from the accounting of a building's life cycle phases, which range from A to C, in this situation as well.

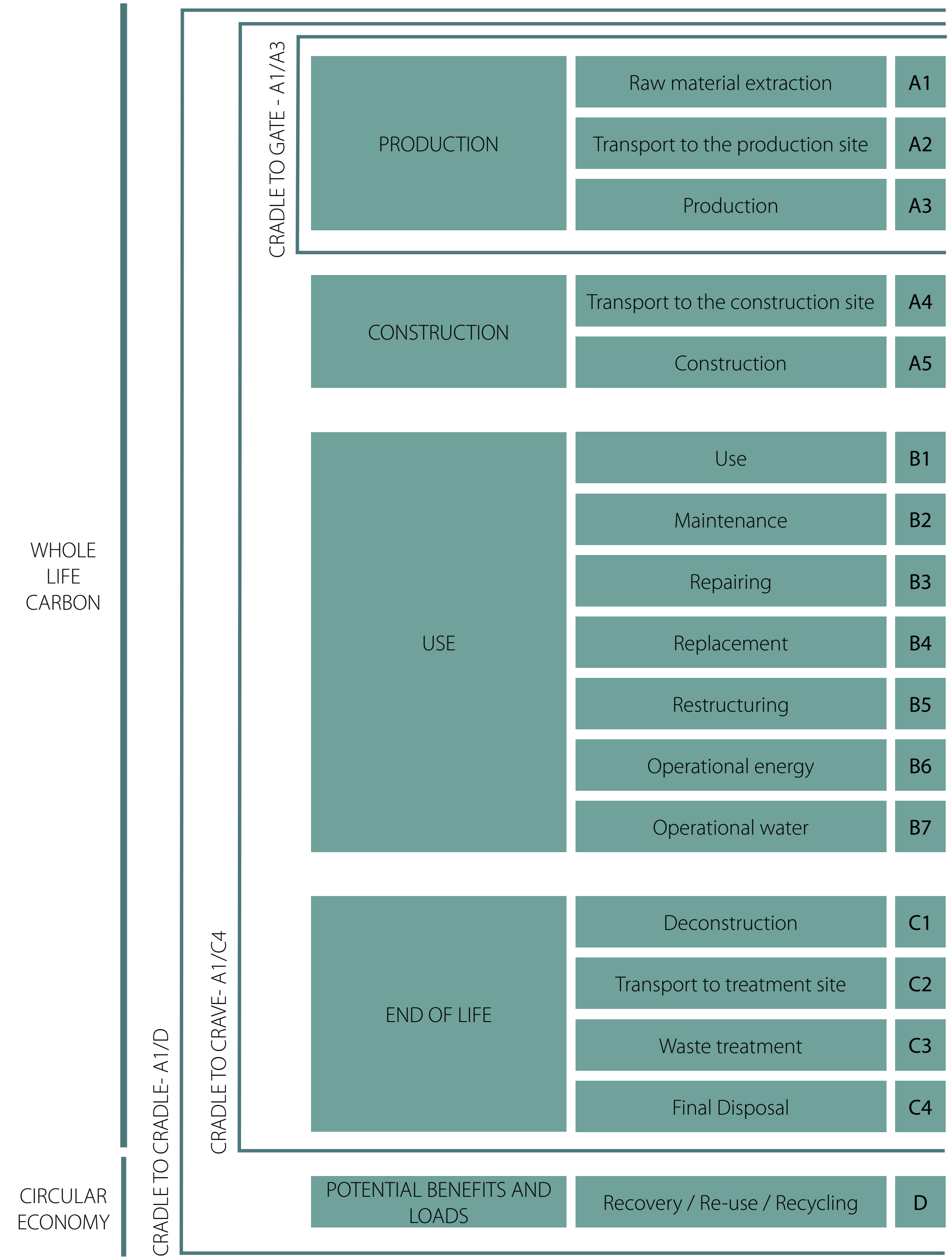


Figure 149.
System boundaries in relation to the life cycle of a building product .
Illustrated by the author in the baces of the technical report, ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nel ciclo di vita di un manufatto edilizio¨ (2022).

Also, the EC calculation should be seen as a sequential assessment with several phases depending on the project's stage of development, such as the preliminary, executive, or construction phases.

For instance, the preliminary phase is defined by a "basic" method of evaluating the EC of building construction. Using this approach, it is advisable to calculate the project's potential carbon emissions and, as a result, identify any potential countermeasures (e.g. substitution of materials with high EC content).

On the other hand, the executive phase is refered as an "advance" approach, where materials and technologies refer to specific products included in the project documents that go along with it, as well as equipment, methods of transportation, and systems that are used to service the building.

In addition, in order to make the accounting of the EC possible, the so called "possible scenarios" are often established.

Depending on the type of building, these scenarios allows comparisons between two projects to assess how well they perform in terms of CO_2 equivalent. And to evaluate future substitutions of materials and/or products whose life cycle is shorter than that of the reference time scenario (Fig. 150).

The methodology for calculating and evaluating the EC and, consequently, the Whole Life Carbon or Circular Economy of a project's lifecycle is shown in the following table (Fig. 151). This phases where proposed by the norm UNI EN 15978:2011.

TYPOLOGY	REFERENCE TIME SCENARIO	SOURCE
Temporary Buildings	It matches the duration of the event for which the building has been constructed.	-
Building artefacts with residential purposes	Minimum 50 years, maximum 60 years	Level(s); PEF BREEAM; UNI EN 15804:2021; RICS
Building artefacts with structural purposes	120 years	PAS 2080: 2013; RICS

Figure 150.
Time Reference Scenarios for the accounting and evaluation of CE.
Illustrated by the author in the baces of the technical report, ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nell ciclo di vita di un manufatto edilizio¨ (2022).

SCOPE OF EVALUATION	LIFE-CYCLE PHASES	BACKGROUND INFORMATION
-	All the phases	Material and product quantities (determined by Bill-of-Quantities or Design-as-Built)
Minimum scope of application	A1-A3 / Production	Specific emission factors from databases, metadata and/or EPDs
Whole Life Cycle Carbon	A1-A3 / Production	Specific emission factors from databases, metadata and/or EPDs
	A4 / Transport to the construction site	Emissions from distance, loading capacity and type of transport of materials and products delivered to the construction site.
	A5 / Construction	Emissions from construction site vehicles and equipment, as well as from waste produced by construction site operations
	B1 / Use	Carbon uptake by cement-based products , carbon offsetting through measures and emissions associated with plant operation in the reference time scenario.
	B2-B3 / Maintenance and Repair	Electrical requirements not included in B6 (OC)
	B4 / Replacement	Emissions associated with material and product substitution compared to the reference time scenario
	B5 / Renovation	Emissions and offsets associated with stages A1- A5 of new materials and products; emissions from stages C2-C4 of waste generated in demolition activities; emissions from stages C2-C4 of waste generated downstream of construction operations
	C1 / Deconstruction and Demolition	Emissions from construction site vehicles and equipment, as well as from waste produced by construction site operations.
	C2 / Transport	Emissions resulting from distance, loading capacity and type of means of transport of materials and products delivered to the waste treatment site
	C3 / Waste Treatment	Emissions from waste treatment operations generated by: construction, demolition, maintenance, repair and replacement operations; these may involve recycling, recovery, or pre-disposal treatments
	C4 / Disposal	Specific emission factors of products destined to disposal.
Circular Economy	D	Benefits and/or loads resulting from recycling, recovery and reuse of materials

Figure 151.
Summary of the areas of the EC process, with the corresponding phases of a building's life cycle and an indication of the information that each phase requires to be collected and processed.
Illustrated by the author in the baces of the technical report, ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nell ciclo di vita di un manufatto edilizio¨ (2022).

Model / Carbon balance evaluation

A COMPREHENSIVE EVALUATION MODEL

At this point is where we begin to define, in the most realistic way possible, even thow is difficult to arrange such a timely evaluation process, but in theory, an EC evaluation of the timber materials and products that contribute to the creation and care of the building model.

To assess the accounting for the EC of the study model, a Life Cycle Assessment (LCA) tool called One Click LCA (2015) has been used to evaluate the materials quantities in an inventory.

some of the reasons why we choose to use OneClick LCA:

/ *It helps to comply with regulations related to environmental impact assessments.*

/ *Has accurate material database from the companies products for more realistic results.*

/ *The use of OneClick LCA also facilitates accurate assessments by comparing the environmental impact of wood for the different end-of-life scenarios.*

In summary, OneClick LCA provides valuable information about the environmental impact of products and services that can be used to make informed decisions, improve sustainability performance, and comply with regulations.

It should be noted that the LCA tool has a limited database of materials. In cases where a specified material is not included in the database, the most similar material in terms of material composition was selected as a substitute.

It's important to note that the OneClick LCA tool also allows the input of data for different end-of-life scenarios, such as recycling, landfilling, and incineration.

The materials for the evaluation were represented within the model by using materials with associated Environmental Product Declarations (EPD's).

According to several environmental certifications available nowadays from the standpoint of many technical and scientific references, EPDs, refer to the life cycle analysis of the product based on an LCA study, which outlines the resource consumption (materials, water, and energy) and environmental consequences during the various stages of the product's life cycle.

The EPDs, provide information on the resource consumption and environmental consequences during the various stages of a product's life cycle, from raw material extraction to manufacturing, transportation, and disposal (EPDItaly. n.d.).

EPDs are subject to verification by an independent third party before they can be published.

Only accredited Certification Bodies are authorized to perform the verification and validation of EPDs using uniform methodologies and submitting to the control of Accredia. The act of publication allows companies to communicate the environmental impacts of a product or service to the market in a clear and transparent way (Ibid.).

RESOURCE NAME	TECHNICAL SPECIFICATION	QUANTITY m^3	QUANTITY kg
Cross laminated timber (CLT/XLAM)	400 kg/m3	524,2	209 680
Glued laminated timber (GLULAM)	464 kg/m3, 12% moisture content	50,8	23 571,2
Glued laminated timber roof truss	497 kg/m3	60,75	30 192,75
Wooden façade external facing, conifer, painted	420 kg/m3	420	11 760
TOTAL kg of timber			[264 456]

Figure 152.
Timber quantity as kg value used in the model.
Illustrated by the author.

MASS TIMBER PRODUCTS TYPES	EXTERNAL WALLS m^3	INTERNAL WALLS m^3	FLOORS m^3	COLUMS m^3	ROOF m^3	FACADE m^3	RAMP m^3	STRUCTURAL COMPONENTS m^3
6 FLOOR	[15]	[7,5]	[52]	[12,2]	[-]	[-]	[-]	[-]
5 FLOOR	[18,5]	[38]	[60]	[12,2]	[-]	[-]	[-]	[-]
4 FLOOR	[18,5]	[38]	[60]	[12,2]	[60,75]	[28]	[80]	[6,5]
3 FLOOR	[18,5]	[15,5]	[70]	[20,2]	[-]	[-]	[-]	[-]
COMERCE	[30]	[2,7]	[-]	[-]	[-]	[-]	[-]	[-]
TOTAL	[100,5]	[101,7]	[242]	[56,8]	[60,75]	[28]	[80]	[676,25]

Figure 153.
Timber quantity as m^3 value used in the model.
Illustrated by the author.

RESOURCE NAME	TECHNICAL SPECIFICATION	MANUFACTURER	EPD PROGRAM	EPD NUMBER	ENVIRONMENT DATA SOURCE	STANDARD	VERIFICATION	YEAR	COUNTRY	UPSTREAM DATABASE	DENSITY	PRODUCT CATEGORY RULES (PCR)	NOTES ABOUT PCR	PERFORMANCE RANKING
Cross laminated timber (CLT/XLAM)	400 kg/m^3	Artuso Legnami S.r.l.	International EPD System	S-P-01408	EPD of the X-LAM pannel	EN15804+A1	Third-party verified (as per ISO 14025)	2018	italy	ecoinvent	400.0	PCR 2012:01 Construction products and Construction services, Version 2.2 (2017-05-03)	Only with EN15804	CO_2 CML: 64 / 129
Glued laminated timber (Glulam)	464 kg/m^3, 12% moisture content	Rubner Holding	IBU	EPD-RUB-20180058-IBB1-FR	EPD Bois lamellé-collé Rubner Holding AG-S.p.A.	EN15804+A1	Third-party verified (as per ISO 14025)	2018	austria, italy	GaBi	464.0	Produits en bois massif, 07.2014	Only with EN15806	CO_2 CML: 94 / 129
Glued laminated timber roof truss, biogenic CO_2 not subtracted (for CML)	497 kg/m^3	BOIS DES ALPES	INIES	INIES_CPBP20211007_173652, 27516	FDES	EN15804+A1	Third-party verified (as per ISO 14025)	2021	france	ecoinvent	497.0	EN15804+A1	EN15804 +A1	CO_2 CML: 62 / 129
Wooden façade external facing, conifer, painted	420 kg/m^3	Treindustrien	EPD Norge	NEPD-310-180-EN	Exterior cladding with waterborne paint, Norwegian Wood Industry Federation	EN15804+A1	Third-party verified (as per ISO 14025)	2015	norway	ecoinvent	420.0	NPCR 015 Wood and wood-based products, rev1, 08/2013	Biogenic CO_2 separated	CO_2 CML: 12 / 105

Figure 154.
Data sources, One Click LCA.
Illustrated by the author.

This section begins by presenting the inputs used in the model, as shown in figures 152 and 153. 680 cubic meters of timber, was used in the assessment of the project under study, which focused solely on wood materials using the One Click LCA tool (2015).

It is also worth mentioning that this assesmet has been provided with standard values obtain by the software One Click LCA (2015) and by using data source in relation to the level of detail available at the current stage of design.

The initial step in this study was to input the necessary data into the software accordind the objetives of this study evaluating the potential impacts of wood use, analysing the biogenic carbon storage and the material production process which categorizes the material's life cycle into;

/ *Building materials*
/ *Construction site operations*
/ *Building area*
/ *Calculation period.*

In the context of building materials, the selection of the appropriate material is crucial. In this study, it is assumed that the manufacturer chosen is one of the previously mentioned suppliers, Artuso Legnami S.r.l.

This choice was made because it is the best match from the database related to the objectives of the research.

However, in some cases were the specific EPD form the material type was not found provided from Artuso Legnami S.r.l., alternative EPD manufacturers frequently used in Italy were used as a substitute. And in situations where no similar data could be found, a generic product data, of the software database with similar characteristics was employed. The precision of the results of the calculations is directly proportional to the accuracy of the information used.

Model / Carbon balance evaluation

Moreover, in order for the building materials phase to be complete, the One Click LCA tool requires information to be filled in with regard to;

/ *The quantity of the material in m^3.*

/ *The transport distance in kilometers, which determines how far is the product transported form manufactring to the construction site is going to be. And the type of transoport will be used, as in this case a trailer combination, 40 ton capacity, 100% fill rate.*

/ *The service life of the material.*

/ *Localisation.*

/ *End-of-life processing phase of the material, which will define as well by the end-of-life senarios addopted.*

For the category of construction site operations, a value of 1400 square meters, representing the Gross Internal Area of the building, was used to calculate the deconstruction/demolition scenarios (C1).

For the building area category, the Gross Internal Floor Area (IPMS/RIC) was used as a value. This value is referred to as 1400 square meters.

And for the calculation period, which refers to the useful life of the building, a period of 60 years was used as the reference.

Thus, this assessment reports on the development's "global warming potential" with the annotation "CO_2 equivalent (CO_2e)" for the Embodied Carbon, however the method for more accurately accounting for these life cycle stages requires further development.
Given these five scenarios (Fig 155), the expected results for each use would be;

For the recycling scenario, two scenarios were chosen to be analysed, scenario (B) goes through a 70% recycling process and the other 30% is destined for disposal in landfills and the scenario (C) 50% will go through recycling process and the other 50% is destined for disposal in landfills.

On both senarios the materials used in the building, are collected, processed, and reused in new products. This scenario would have a lower environmental impact compared to other end of life scenarios, as it conserves resources and reduces the need for new materials.

In the incineration scenario, the materials used in the building are burned to generate energy. This scenario would have a moderate environmental impact, as it reduces the volume of waste, but it generates emissions and ash that would need to be disposed of.

For the landfilling scenario, the materials used in the building are disposed of in a landfill. This scenario would have the highest environmental impact, as it consumes land resources and generates emissions and leachate that need to be treated.

WASTE TREATMENT / DISPOSAL **SCENARIOS**	DESCRIPTION	EC C3-C4
SCENARIO A	100% scenario, in which 100% of the waste (generated in the phases that characterise the life cycle of the timber) is destined for disposal in **landfills**	2,15 kgCO2eq/kg[A]
SCENARIO B	Scenario **70-30%**, in which 70% of the waste (generated in the phases that characterise the lifecycle of the timber) undergoes recovery processes and the remaining 30% is destined for disposal in landfills.	(–) CSC3+C4 = (–) (CSA1-A3+ 0,7)+(CSA1-A3+ 0,3) kgCO2eq/kg[A]
SCENARIO C	Scenario **50-50%**, in which 50% of the waste (generated in the phases that characterise the lifecycle of the timber) undergoes recovery processes and the remaining 50% is destined for disposal in landfills.	(–) CSC3+C4 = (–) (CSA1-A3+ 0,5)+(CSA1-A3+ 0,5) kgCO2eq/kg[A]
SCENARIO D	**Incineration** for energy recovery scenario, the Stored biogenic carbon is released into the atmosphere. Note: The figure coincides with that of A1-A3 but the sign is opposite [+], so the overall balance will therefore be 0.	(–) CSC3+C4 = (–1) * (– CSA1-A3)
SCENARIO E	**Reuse** scenario, the **'transfer'** of the sequestred carbon value, calculated in phaseA1-A3, is considered in phase C3. So in this case of reuse, no data must be reported. of CS. The timber used for the building is still in good condition and is able to be used for its intended purpose, the service life of the material is extended without undergoing any major alterations.Or the timber materials used in the building are salvaged and reused in other construction projects.	(–) CSC3+C4 = (–) CSA1-A3

A Circular scenario calculated on the basis of a generic wood-based product. Data taken from technical reference documents reference.*

Figure 155.
ECC3+C4 accounting of wood or wood-based waste (2015).
Illustrated by the author in the baces of the technical report, ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nel ciclo di vita di un manufatto edilizio¨ (2022).

RESULTS

The following graph (Fig.157) illustrates the results obtained for EC (global warming) in relation to each scenario's end-of-life phase.

It should be noted that due to the complexity involved in obtaining data to complete all the phases through which the material undergoes, it was decided to exclude phases C3-C4 of the One Click LCA tool, and analysing these phases according to the parameters, indications and technical and regulatory references explained in the technical report DEC50. ¨Strumeni per la decarbonizzazione: Contabilizzazione dell'embodied carbon nel ciclo di vita di un manufatto edilizio¨ published by the Green Building Council Italia (2022).

Following the results obtained, it is worth mentioning that there was no alteration with respect to the EC between phases A1-A3, A4, A5, B1-B5, C1 as it is not affected under the end-of-life processes of the different scenarios mentioned above.

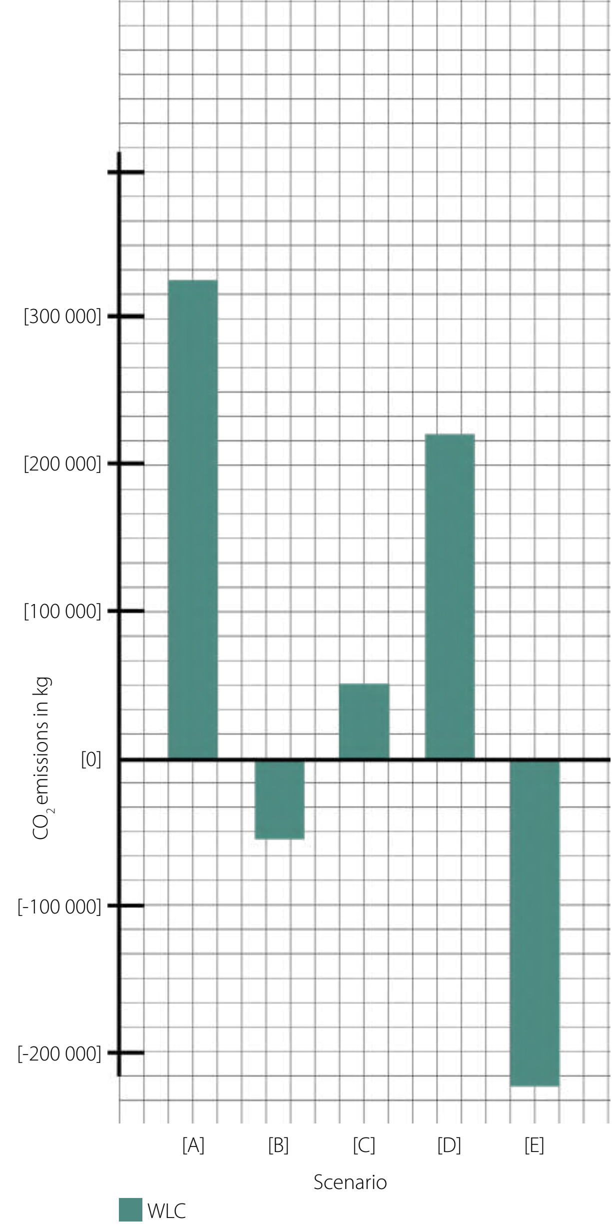
On the other hand, the EC values form C2, C3, C4 are analysed separately as they have different approaches according to the end of life senarios addopted.

By incorporating all the required values in the OneClick LCA tool, the total Biogenic carbon storage value of the wood is (-) 374 370,07 kg CO_2 eq emissions.

As the material proceeds through the phases, the EC of each phase is added to give a total value of -241 938,03 kg CO_2eq emissions, excluding the end-of-life phases. In what involves the C-phases, we start to see variations in the values of C2, C3-C4.

For the C2 value varies according to each scenario taking into account that each transported waste adopts its own travel route and differs according to the distances until it arrives at the location where waste will be treated.

Biogenic carbon storage kg CO_2e	A1 - A3 Construction Materials	A4 Transportation to site	A5 Construction	B1- B5 Maintenance and material replacement	C1 Deconstruction
[[-] 374 370,07]	[87 480,63]	[4 970,68]	[30 903,91]	[9 076,82]	[4 760]



Scenario	C2 Waste transport	C3 -C4 Waste Treatment/ Disposal	WLC
A	[425,8]	[568 580,4]	[331 828,17]
B	[1 064,49]	[176 127,6]	[-59 985,94]
C	[1 064,49]	[288 257,04]	[52 143,5]
D	[1 064,49]	[0]	[236113,54]
E	[-]	[-]	[-237 178,03]

Going on with the Waste Treatment(C3) and Disposal (C4) values. Each result obtained meets the expected results mentioned above, i.e. scenario A releases 568 580,4 kg CO_2eq, has much more emissions compared to the scenario B, which 70% of the material is recycle that has 176 127,6 of EC.

On the other hand, in scenario E no value was computed, as it is not affected by the fact that the material will be reused.

Finally, the WLC assesment for according end-of-life phase scenario, it can be seen that scenario A has a value of 331828,17 kg CO_2eq, followed by scenario D with more positive results, where the emissions are 236 113,54 kg CO_2eq, scenario C with 52 143,5 kg CO_2eq, and scenario B, where the total balance of emissions is negative with a value of (-) 59 985,94 kg CO_2eq.

In scenario B, the overall balance of emissions is negative, indicating that the entire life cycle of the project sequesters more CO_2 than it emits during all phases. This is one of the most favorable scenarios, with a value of -59 985,94 kg CO_2eq. And the most favorable scenario is E, with a value of -237 178,03 kg CO_2eq.

Figure 156.
Results of the WLC scenarios.
Illustrated by the author.

Figure 157.
Summary framework of accounting and valuation of timber's Embodied Carbon.
Illustrated by the author.

In conclusion, the results indicate that recycling scenarios (such as scenario B and C) or even the reuse (E), have a lower environmental impact compared to other end-of-life scenarios, as they conserve resources and reduce the need for new materials. The incineration scenario, scenario C, has a moderate environmental impact, as it reduces the volume of waste but generates emissions that need to be disposed of.

On the other hand, the landfilling scenario, scenario A, has the highest environmental impact, as it consumes land resources and generates emissions and leachate that need to be treated. Additionally, the release of CO_2 and CH_4 into the environment as a result of natural decomposition of the material, potentially increases the Carbon footprint.

In terms of biogenic carbon storage, the timber used in the building has a total value of -374 370,07 kg CO_2 eq emissions. Additionally, the overall balance of emissions for scenario B is negative, indicating that the entire life cycle of the project sequesters more CO_2 than it emits during all phases. This is one of the most favorable scenarios, with a value of -59 985,94 kg CO_2eq. This is particularly interesting, as this CO_2 footprint emissions suggests that using timber in construction materials could be considered a sustainable option if properly manage, and on the question of whether timber can be urban, bearing in mind that these scenarios give rise to possible factors such as a sustainable managment of production among others, it gives an idea that this model can be replicated in other cases and make us imagine thet it can be applied on a larger scale.

However, it is important to note that for a better consideration of the potential environmental impacts of such scenarios. It is crucial to evaluate the entire life cycle of a product, including end-of-life scenarios, in order to truly understand its environmental impact and determine if it is truly sustainable. Additionally, this study only evaluates the environmental impact of one type of construction material (timber) and it is important to compare it with other materials to have a complete overview of the situation.

The results of this study are encouraging, as they suggest that using timber in construction materials could be a sustainable option if properly managed and recycled. However, it is important to keep in mind the limitations of this study and further research is needed to truly understand the environmental impact of timber as a construction material. Additionally, It is crucial to invest in more sustainable end-of-life management options, such as recycling and composting, in order to truly make the use of timber in construction materials sustainable.

Returning to the research question of whether timber could be considered urban, one factor that can be evaluated is the availability of the required stock to supply an urban scale plan. Additionally, it can be imagined if the national forests could supply it, always keeping in mind a sustainable management scenario that is as realistic as possible.

To determine the sustainability of this approach, the next step in our research will be to calculate the urban-scale carbon footprint by using data from previous analysis and referencing all transformation zones that are either not yet implemented or are in the process of implementation, as stated in the current PRG. For zones in the process of implementation, we will take into account 50% of their values (Fig. 158).

The estimated total implementation area covers approximately 4 399 356 m^2 of surface area (ST) and 2 307 950,5 m^2 of occupiable building floor space (SLP). This SLP surface would require an estimated 70 050 505 m3 of mass timber materials, equivalent to 264 456 kg of wood.

State of impl. ZUT	N* ZUT	TOT. ST m^2	TOT. SLP m^2
■ (dark red)	[113]	[4 022 319]	[2 016 210]
■ (orange)	[12]	[754 074]	[583 481]

(*) For ZUT not implemented, the theoretical data of the data sheets.

Figure 158.
State of implementation of the current ZUT's in Torino, (2022). Illustrated by the author.

Based on the most realistic scenario from our model analysis, Scenario B, and its ability to sequester CO_2, we estimate a potential reduction of -15 889 393,28 kg of CO_2 eq for the total transformation areas.

For a greener transformation scenario in Torino, the required timber material of 264 456 kg of wood could be obtained from forests in the north of Italy in the Alpine zone. These pure coniferous and mixed forests make up over 10% of the total Italian forests, approximately 11 million hectares. The Alpine zone in the regions of Piedmont, Lombardy, Veneto, and Trentino holds 1 100 000 hectares of forests.

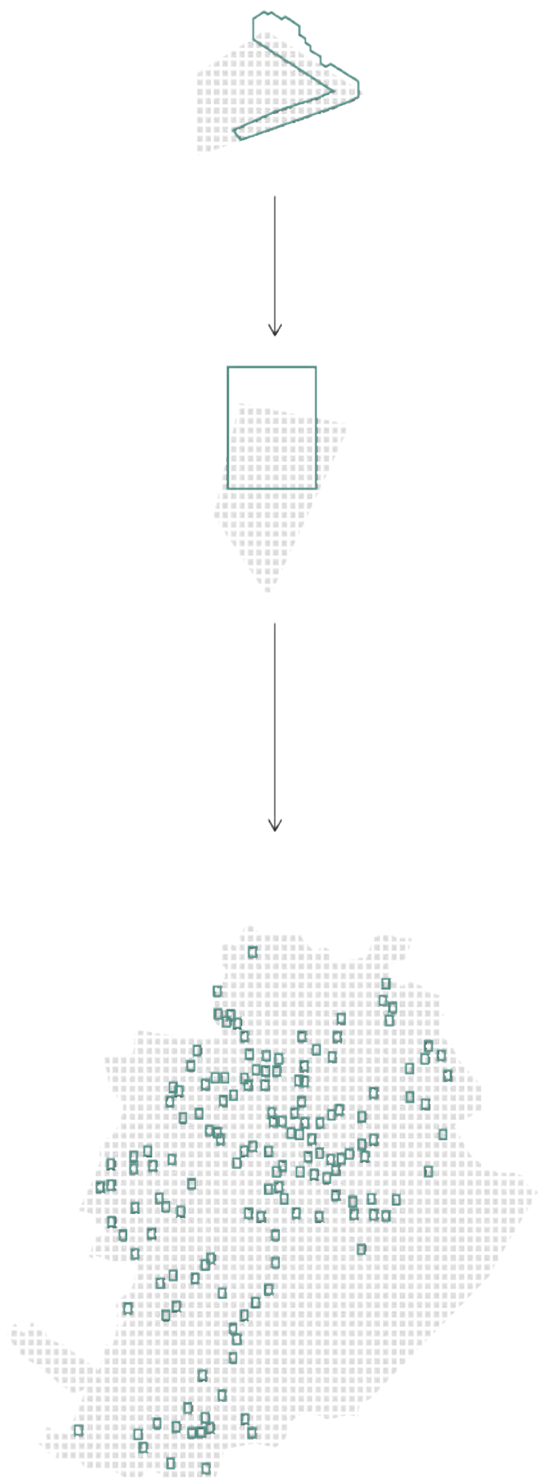


Figure 159.
Representation of the greener transition for ZUT's.
Illustrated by the author.

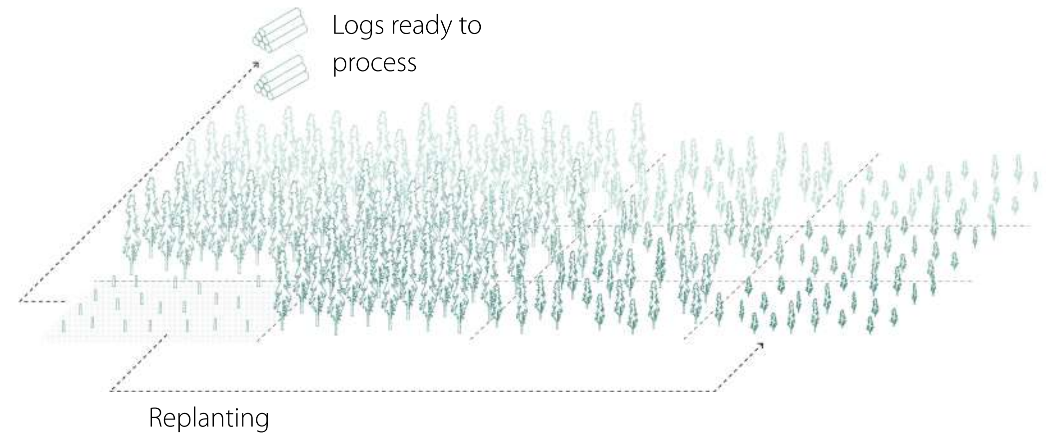


Figure 160.
Efficient managment of forest, cycle of rotation.
Illustrated by the author.

Regardless of how much biogenc carbon stores a tree has, the analysis method starts with one that has already grown.

This plan includes for a 45-year harvesting cycle that will result in a manner of permanently preserving the forests within each harvested allotment (Fig. 160).

For the 680 m^3 of the building model, according to various bibliographic and siteographic sources, we can estime that a single clear cut of approximately 200 ha of mixed conifers forest will be necessary. However, if we consider doing it sustainability, taking into account a rotational periods for harvesting of 45 years, it will be necessary 52 977 ha to produce that volume of timber in a single year.

/ To make definitive evaluations, future research should include more detailed analyses of local forest stocks, topography, harvesting strategies (based on extrapolations of mixed conifer stands forest growing stock volume), and end-of-life scenarios in order to draw clear conclusions.-

/

Conclusion

Torino, taking into account both the mitigation and adaptation strategies adopted in the past years could without any doubt adapt the case explored in this study as a mitigation strategie to take action for a more sustainable transition and a proper design of the city.

The scenario examined may be used as one of the steps taken to achieve the goal of lowering CO_2 emissions while also reducing the effects of heat waves by improving the well-being of citizens. The city's transition would have great positive results, considering that climate change issues could definitely decrease.

This scenario also shows that the forest areas in Italy would have a positive effect in relation to the demand for this material, so that similar scenarios can be recreated, in relation to the demographic values obtain in relation by the hypothetical case applied for Torino.

Regarding if wood can be urban, or if can it be a mayor material for building cities, we could say that by using timber at an urban-scale material we may utilize this tremendous need for building developments to help offset carbon emissions rather than increasing them. The model use in the study has shown a real potential of the material considering that there's a growing wealth of evidence which shows that climate change is accelerating and the demographic predictions of an expanding urban population.

In light of the challenges and opportunities that will appear due to the demands of the projected global urbanization, as well as the environmental impacts that could cause the common structural alternatives.

The use of wood as a building material for urban purposes can offer a credible alternative to the building demands of the projected global urbanization. This appears to be possible thanks to the development ,as shown in this work, of the mass wood technologies, products, and industrial assembly for bigger urban areas.

To achieve this, however, it would need to be recognized and, the building standards updated in order to draw the attention of engineers, architects, forestry managers, environmentalists, and also, city leaders.

The material consumption patterns and building practices that have dominated urban construction and building typologies for more than a century, and which we now recognize to represent enormous environmental danger, may change as a result of these material selection and political advancements.

Far from defining wood as a perfect solution for cities, the study shows that cities have the ability, by expressing critical and technical tools for making conscious choices in planning and architecture, to implement this idea, providing in the background that it could create more awareness about dealing with nature, among citizens, by the simple fact that wood is used, encourage responsible management of wood, and give this resource an added value that will eventually lead to reforestation of forests.

This makes us think that the city's future architecture might be harvested from trees.

/

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**Quotations from the Italian bibliography were translated into English by the author.*

/

Annex

MASTERPLAN

In this case, the starting point of this model was based on the search for that milestone by which said sector could be characterized, with Stazione Dora being one of the most important in the city and which is currently almost abandoned. This station represents a significant entrance to the city, collecting people from more than 20 points, including the direct connection it has with the airport, that is, the Dora Station can be considered the main international reception for people heading to the city. That is why this project is taken into account as a welcome point, but when we reinterpreted we went further, assuming that it could become that point of exchange where you arrive, take a break and then continue connecting in different ways with the city.

From this analysis, we move forward in the construction of a concept that, in addition to having certain links with the context, will also achieve a uniform language that can give the project greater strength. The process that was carried out was synthesized in two phases and 6 main steps, starting with:

1. *The recognition of the existing buildings, where certain decisions were made after taking an inventory and investigating each one.*
2. *In this step it was decided to preserve a total of five buildings which were characterized by having a historical architectural value or a significant structure that could later contribute to the project;*

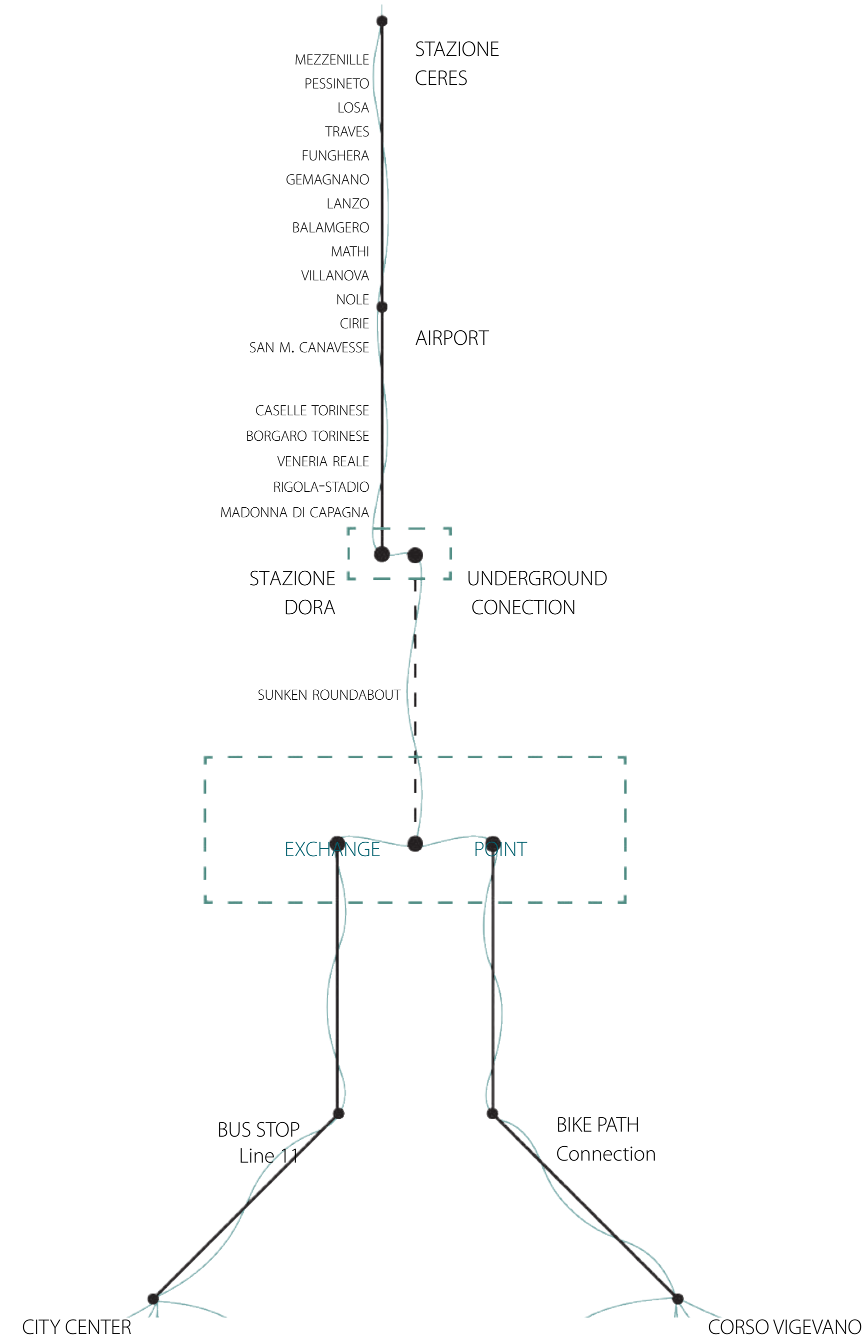
3. *The dynamics with respect to the internal facades of each building and a possible interaction between them were analyzed.*

In the second face, 4. *A geometric composition was proposed which could involve each building and at the same time consider the intentions dictated by the context.*

5. *Said composition was reinterpreted in such a way that it was understood as an envelope, which allows the project to be read as a whole.*

6. *Finally with the established form and the defined buildings, this envelope is now considered a compositional element but at the same time tectonic, a green platform that interacts differently at each point of the terrain, creating different spatialities thanks to the topography and buildings existing. This final result is the concept we concider is a starter point for a greener Torino.*

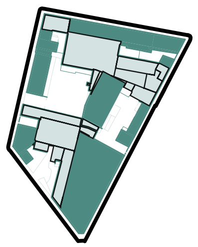
GENERAL CONCEPT



General Concept.
Illustrated by the author.

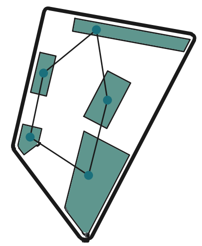
1/ORIGINAL BLOCK

The site analysis establishes the guidelines before starting to intervene.



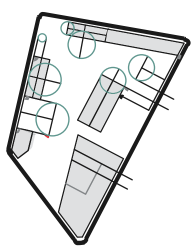
2/BUILDINGS TO KEEP

Certain buildings are maintained, and then their relationship is analyzed.



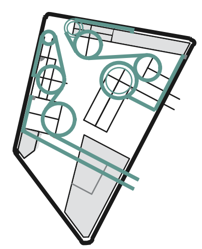
3/INNER DINAMICS

A dynamic is develop inside the block, according to the internal facades of the buildings.



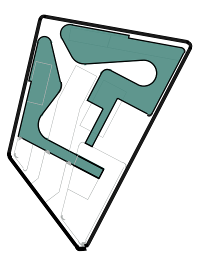
4/GEOGRAFIC COMPOSITION

It is geometrically composed from some intentions that the block and the context dictate.



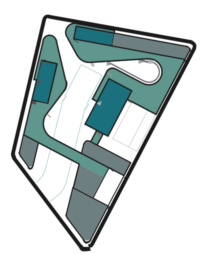
5/ENVELOPE SHAPE

A volumetric union is proposed to create a composition that can be read as a whole.



6/FINAL CONCEPT

As a final view, a complex of buildings linked by form and function is presented.



INTERACTIVE FACADES
People atraction

CALL TO ATANTION
Platform over the railway

RETHINKING RAILWAY
Linear park to rehabilitate

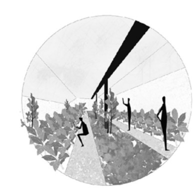
COMMUNITY USE
Daily use for people

COURTYARD
Public inner dynamic

GREEN BALCONIES
Vertical urbam farm

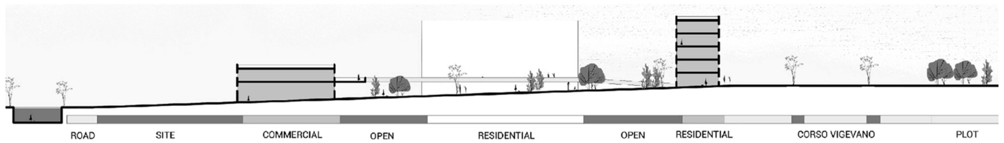
NOIRE GALERY
Groundfloor conection

PRODUCTIVE TERRAZES
Food production

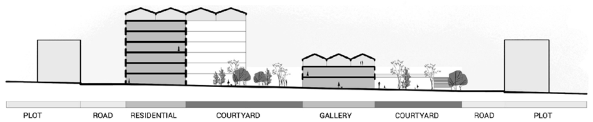


General Concept.
Illustrated by the author.

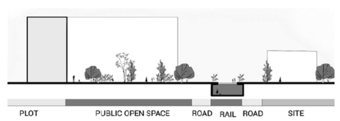
SECTIONS & AXONOMETRIC



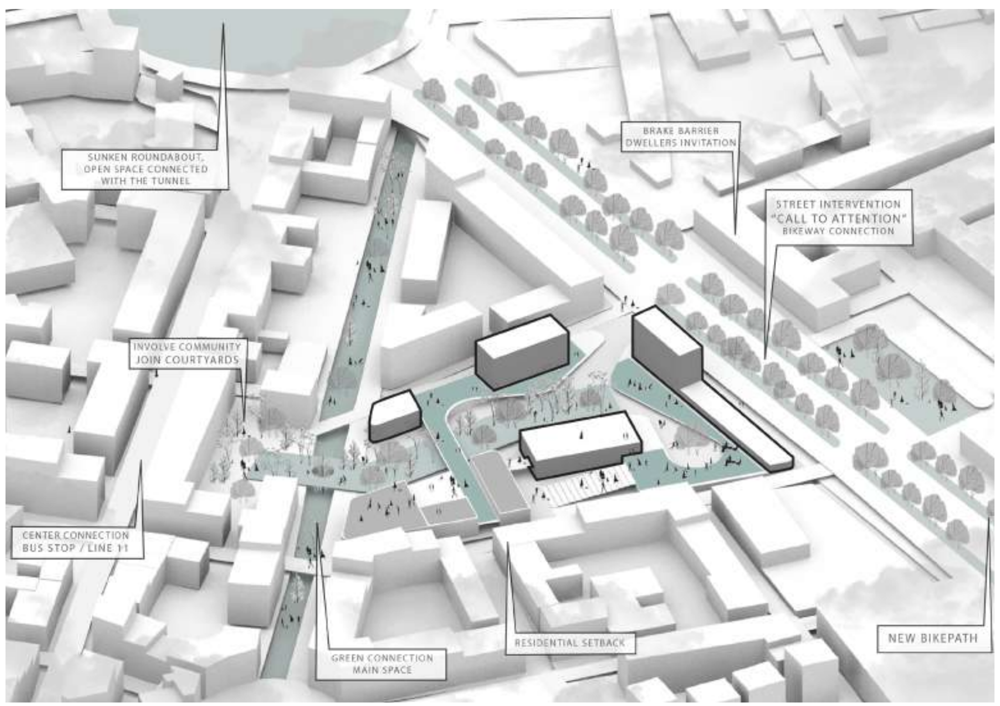
SECTION B, B'
Scale 1: 500



SECTION A, A'
Scale 1: 500



SECTION C, C'
Scale 1: 500



Sections & Axonometric.
Illustrated by the author.

PLOT DESIGN

Based on the previous analysis of the context and following the guidelines outlined in the concept of the prototypical master plan model, which was based on a unifying platform, the design continued to be developed, but this time only half of the land. All this process is graphically explained later with a series of steps that help to illustrate all the intentions involved until reaching a final result.

As a synthesis, it can be said that the model as a starting point began by analyzing the existing building that is located in Corso Vigevano, which due to its historical value for the year of construction and its architectural style of the moment, it was decided to preserve the facade and structure from the existing buildings, which are also composed of modules.

This is why in the model is composed by been projected 80 % of mass timber materials and an approximate 20 % concrete and steel, Considering that the new proposal of the site would be all the part comprising the timber materials and the part restored and mantained is because its important historical value which is the of concrete and steel parts of the model.
Then, following these modules and following the initial intentions of the master plan, two new buildings were proposed, each one designed with different characteristics and dimensions but at the same time creating a single volume that helps to build the urban edge and in turn a semi-private internal space within the block.

Later it was proposed to pierce the entire complex thus creating certain connections with the context in order to involve the community and through design make a call to them as a means of attracting people to the interior. As a next strategy, they began to play with the heights of the hand always of the modules with which the whole design was composed, breaking with those differences in heights through the creation of different terraces at different levels as a kind of staircase, with the purpose of being able to grant at least one green space with important dimensions at each level.

Finally, with the consideration of the topography, a grandstand was proposed that leads people from the lowest level of the land to the first and second floors of the entire main building, in a friendly way with a green route that respects the percentages of inclination that make possible the mobility of people in wheelchairs.

And it was in this way that the compositional and volumetric phase of the project was consolidated; With some ideas previously raised, at this point a final functional program begins to be proposed and established that fits and involves all of the above. A program that is lived through the same journey and that is strongly linked to the entire project. Starting with the existing building of the Noire Gallery located in the center of the block, as a cultural center for recreation, composed of a theater, exhibition rooms and spaces linked to the courtyards.

This point is also considered the starting point of the route, where you begin to ascend through the stands until you reach the main building which welcomes you with a terrace and connects you to a horizontal commercial axis parallel to Corso Vigevano, composed of shops, a bar and restaurant, gym, recreation spaces and finally with the hotel; point that is considered the most hierarchical of the project and which was developed in detail.

1/ PLATAFORM

Coming from the previous materplan concept of linking the buldings through platforms.

2/ MODULES

Through the analysis of the structure a modulation was established for the whole composition.

3/ NEW BUILDINGS

Following the modules of the old structure, new buildings are added to achieve the concept.

4/ CONNECTIONS

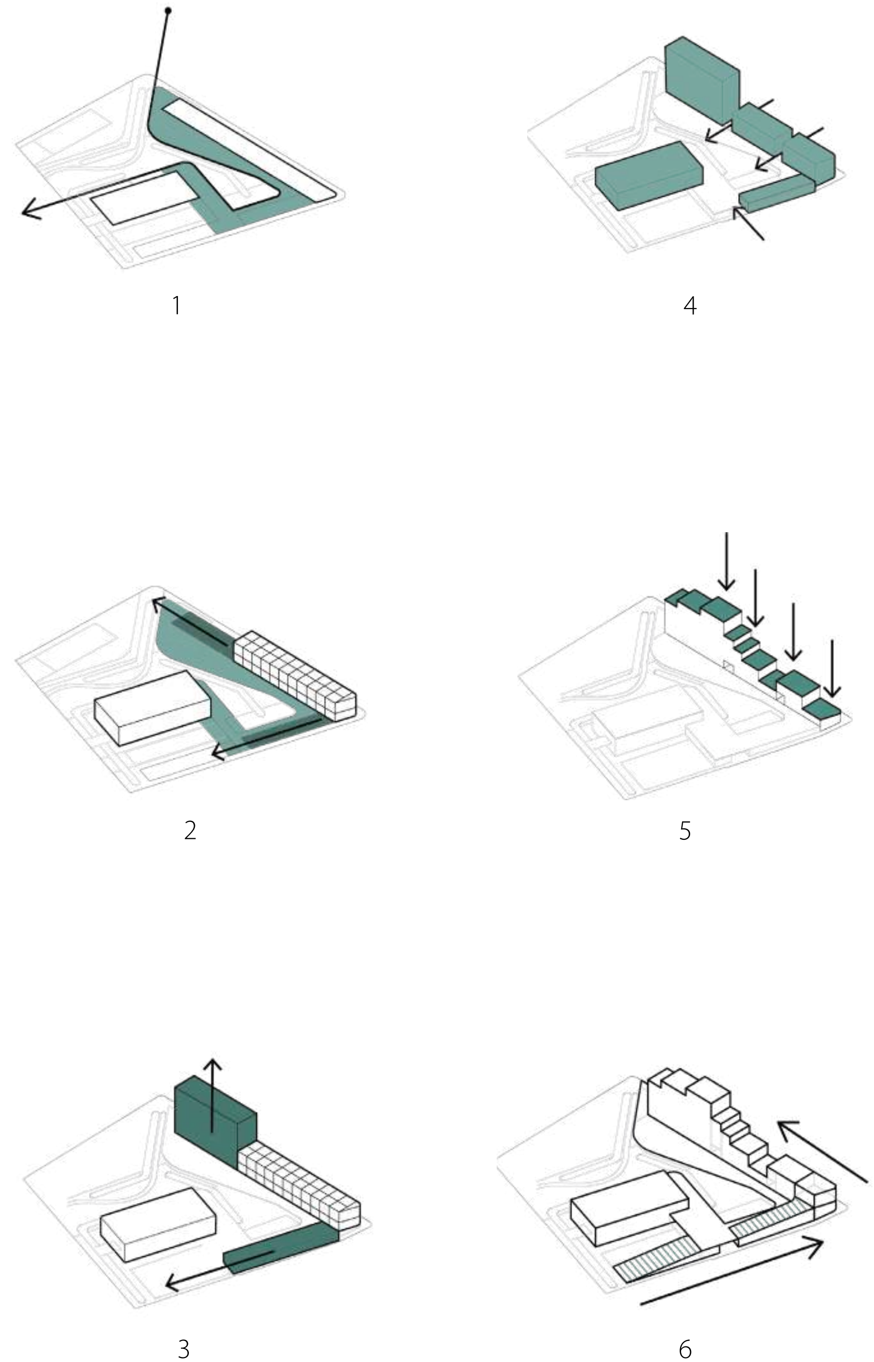
Break the volume in order to respond to the context and invite the community.

5/ TERRACES

Creation of different open spaces through the configuration of the levels of each module.

6/ PATH

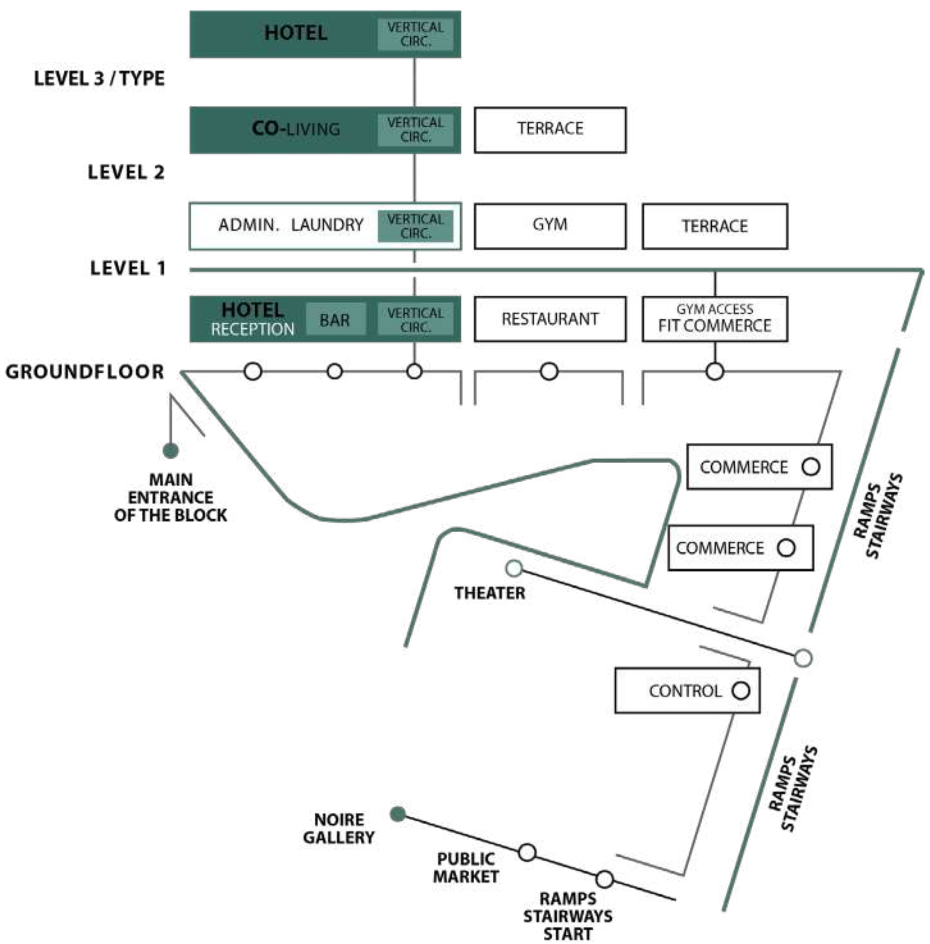
Finally a granstand is proposed to offer the user the experience of the program through a circuit



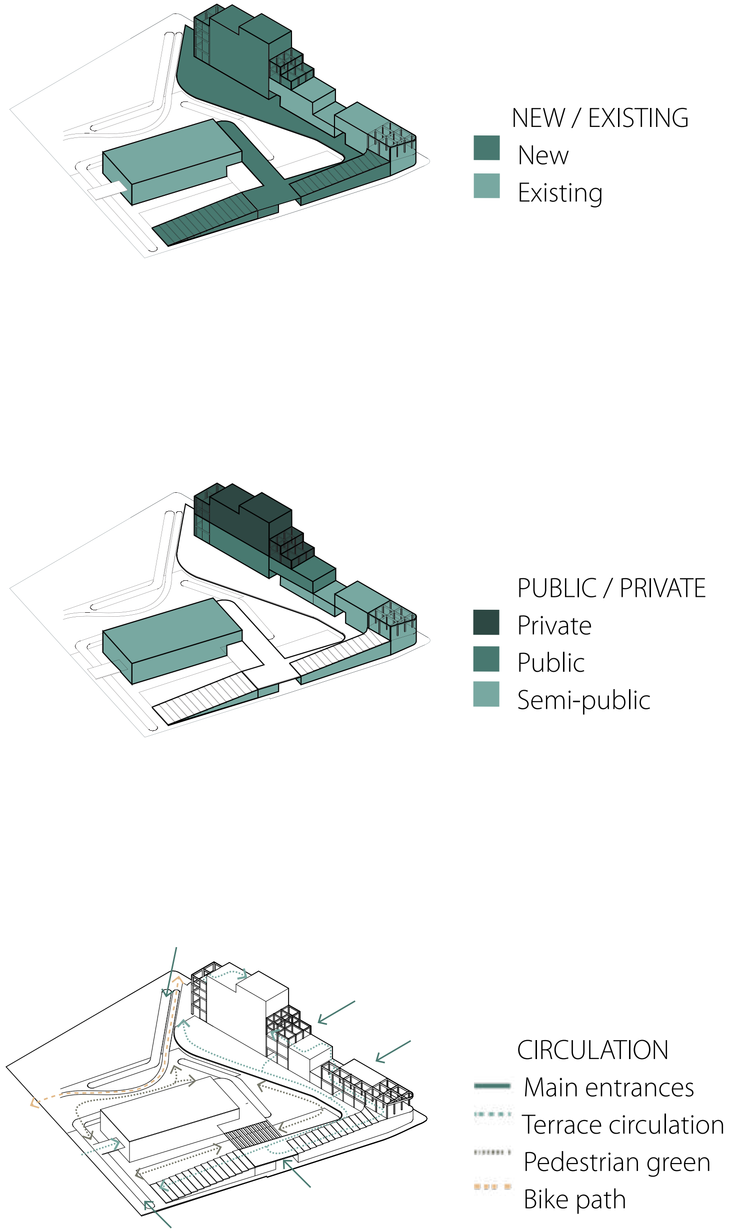
Plot Design.
Illustrated by the author.

Annex

FUNCTIONAL PROGRAMME



Funtional Programme.
Illustrated by the author.



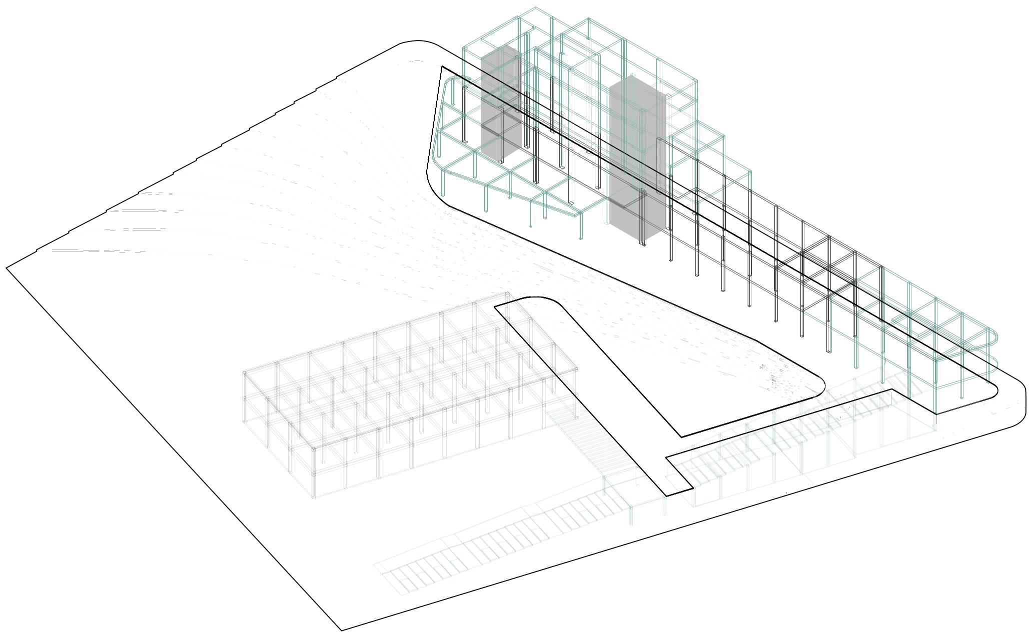
Funtional Programme.
Illustrated by the author.

GENERAL STRUCTURE

For the timber structural components of the main building, a network of Glulam beams extend along the building, connecting to Glulam columns along the building, connecting to Glulam columns algong the perimeter of the module.The beams and columns support the timber floor panels.

The columns used vary in cross-section according to their application on the different floors, i.e. the columns on the third floor have a rectangular cross-section of 40.60 cm, while the last three floors of the main building have columns of 30 cm. 30 cm square cross-section.

As far as the walls are concerned, CLT panels of varying dimensions were used, with 15 cm thick panels for the internal walls and 30 cm thick panels for the external walls.



Stairs structure - CONCRETE

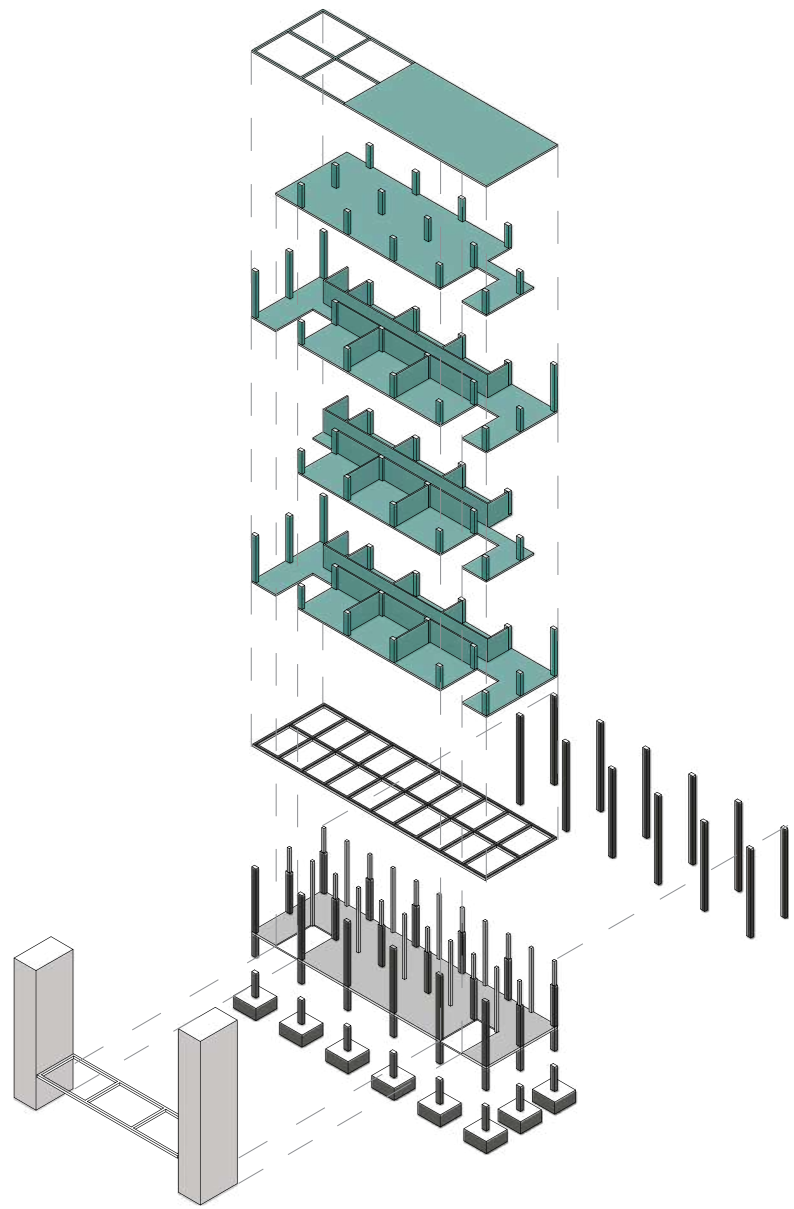
Columns - REINFORCED CONCRETE

Grid base (2nd floor) - STEEL

Slabs and walls - CLT

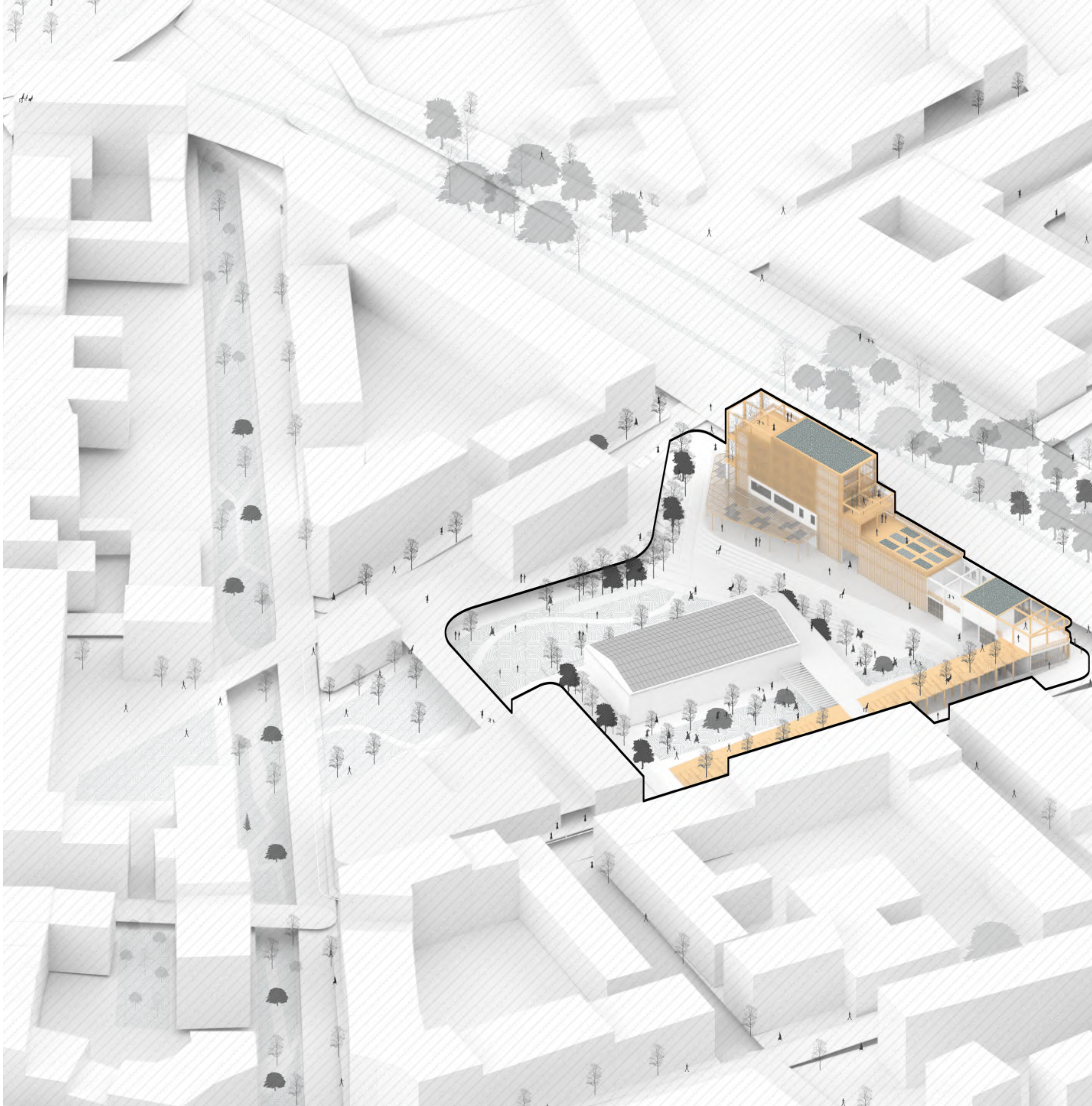
Columns and beams - GLULAM

Structural Axonometric.
Illustrated by the author.



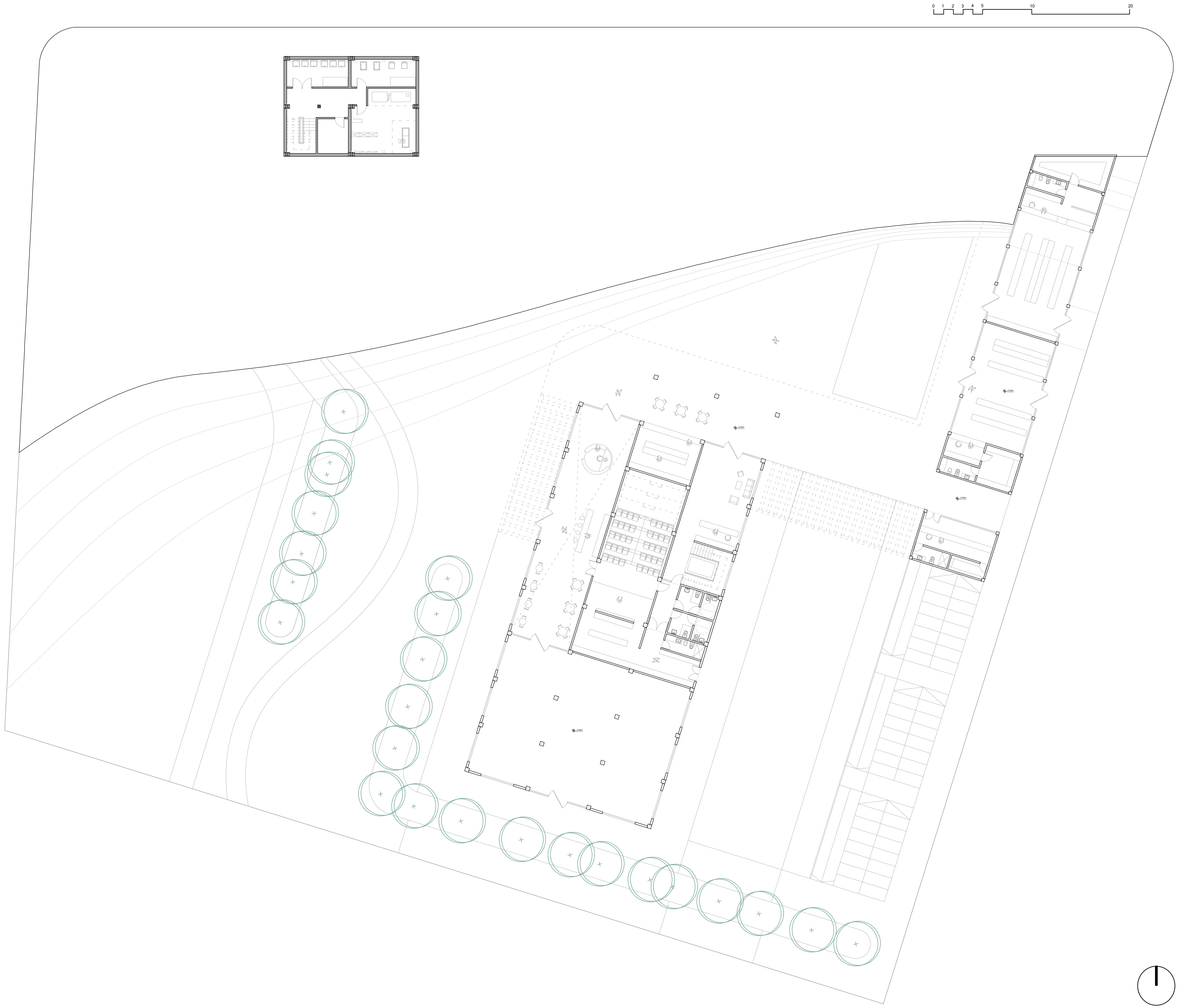
Axonometric Structural Exploded View.
Illustrated by the author.

Annex

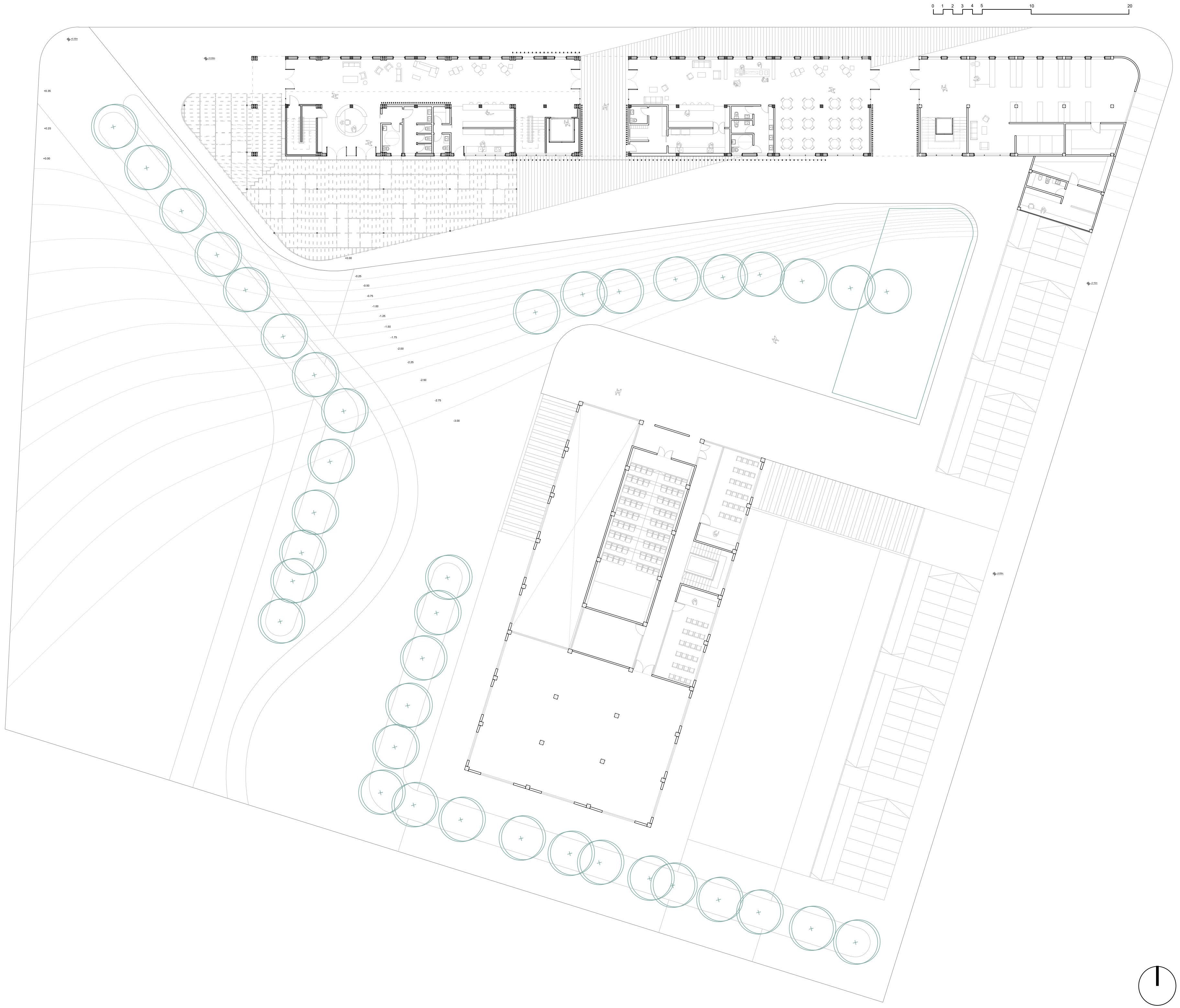


Axonometric View, ZUT Transformed.
Illustrated by the author.

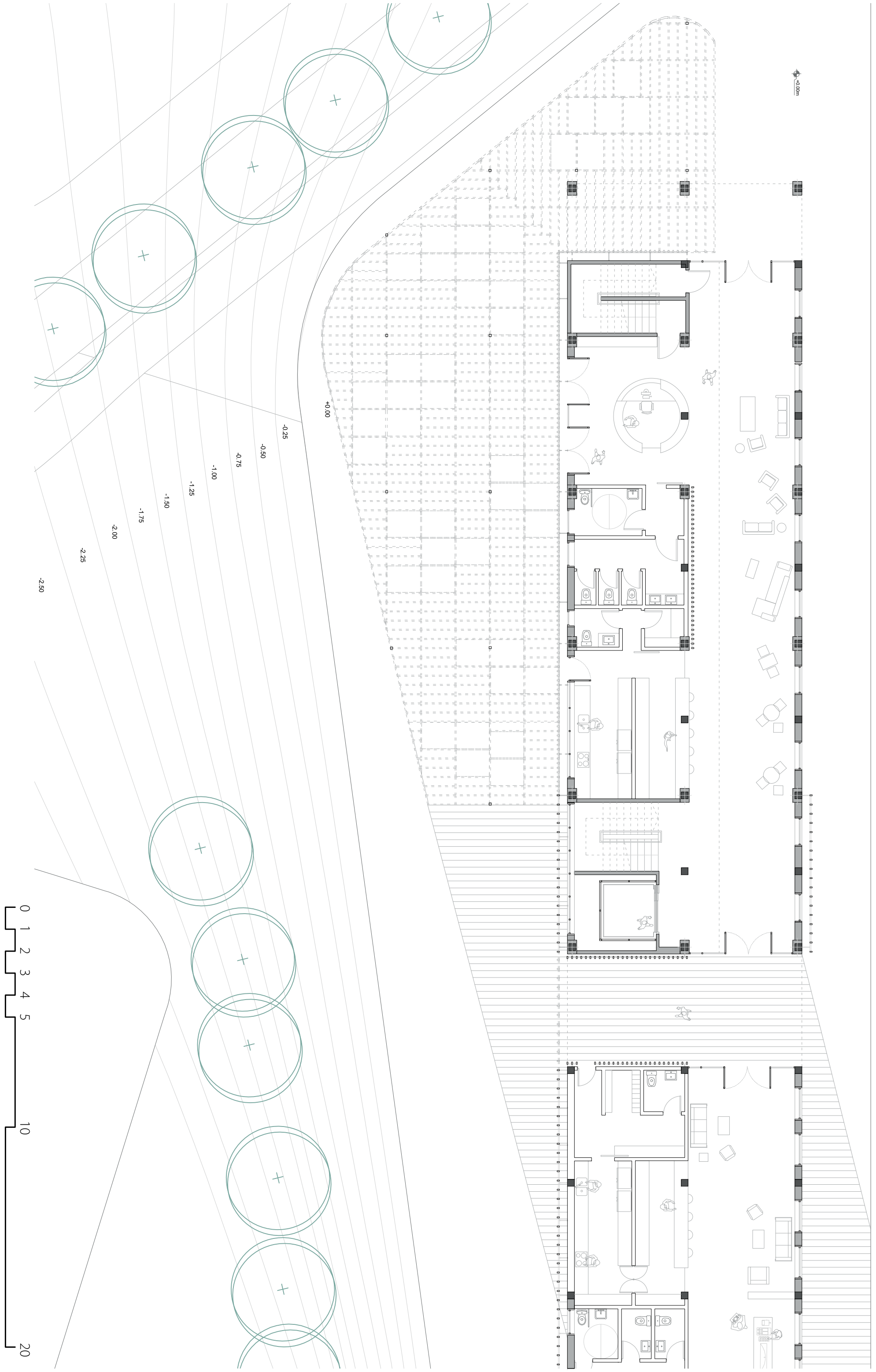
PLANS



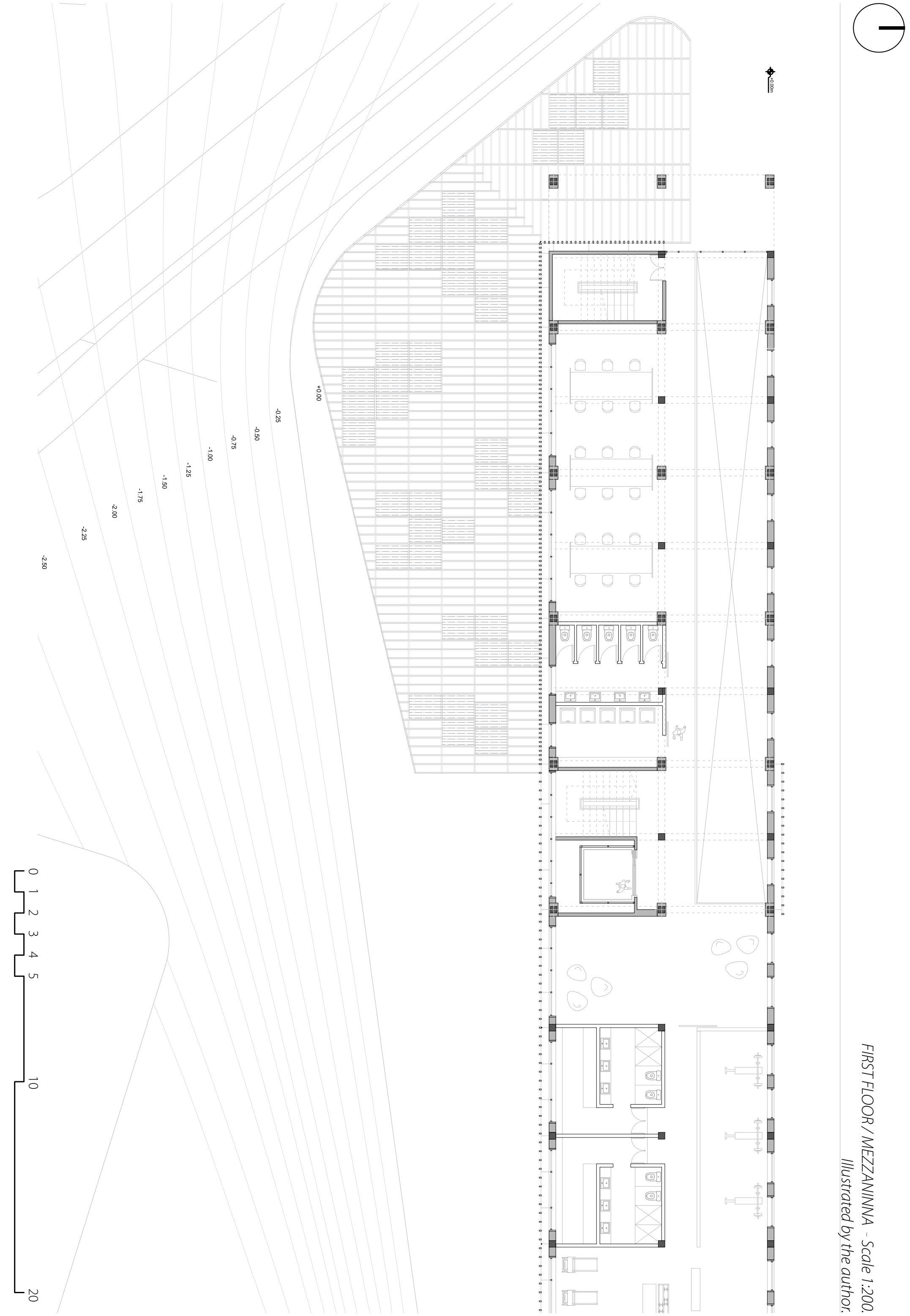
GROUNGFLOOR -3.00m - Scale 1:500
Illustrated by the author.



GROUNGFLOOR 0.00m - Scale 1:500.
Illustrated by the author.

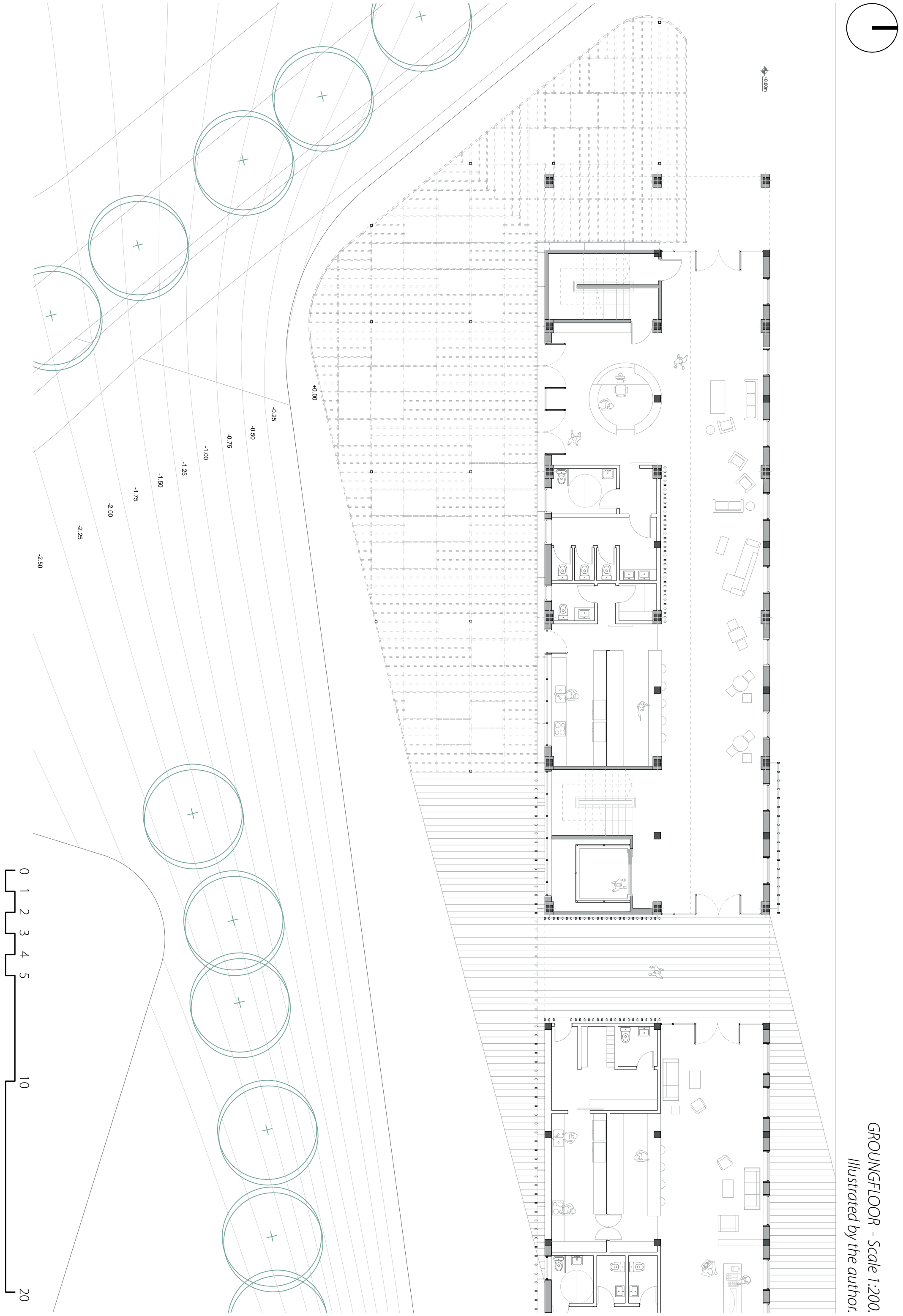


GROUNGFLOOR - Scale 1:200.
Illustrated by the author.

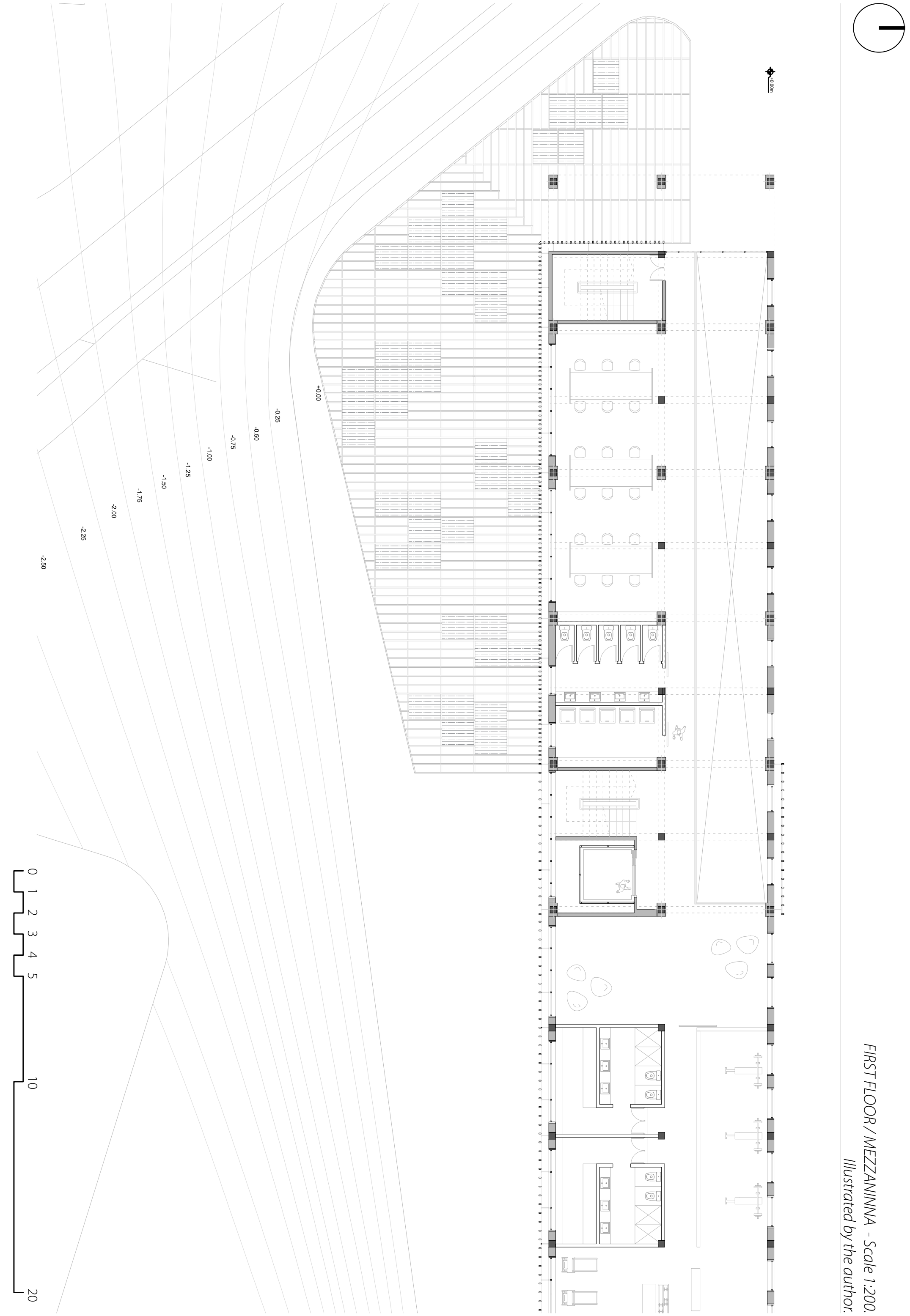


FIRST FLOOR / MEZZANINNA - Scale 1:200.
Illustrated by the author.

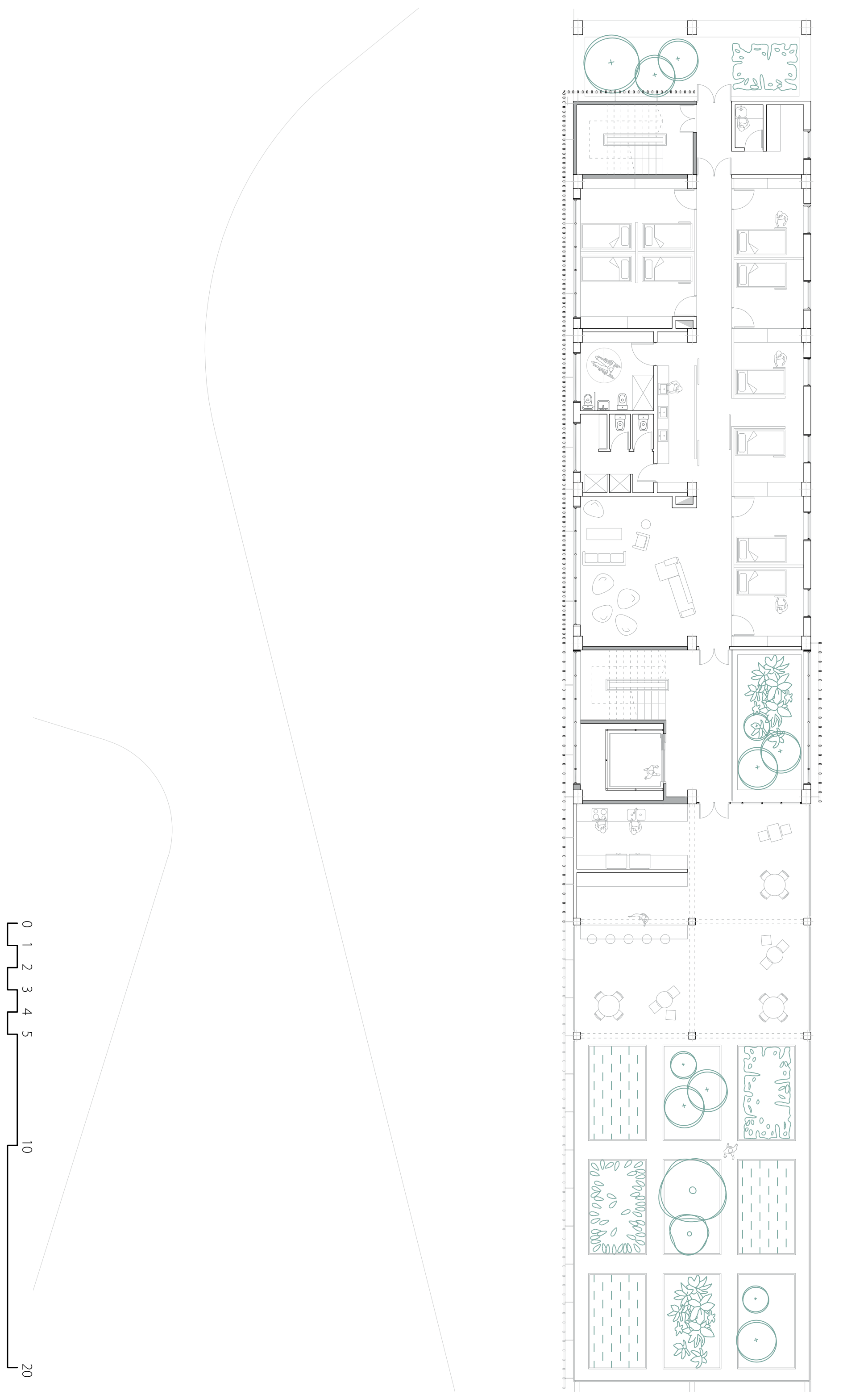
Annex



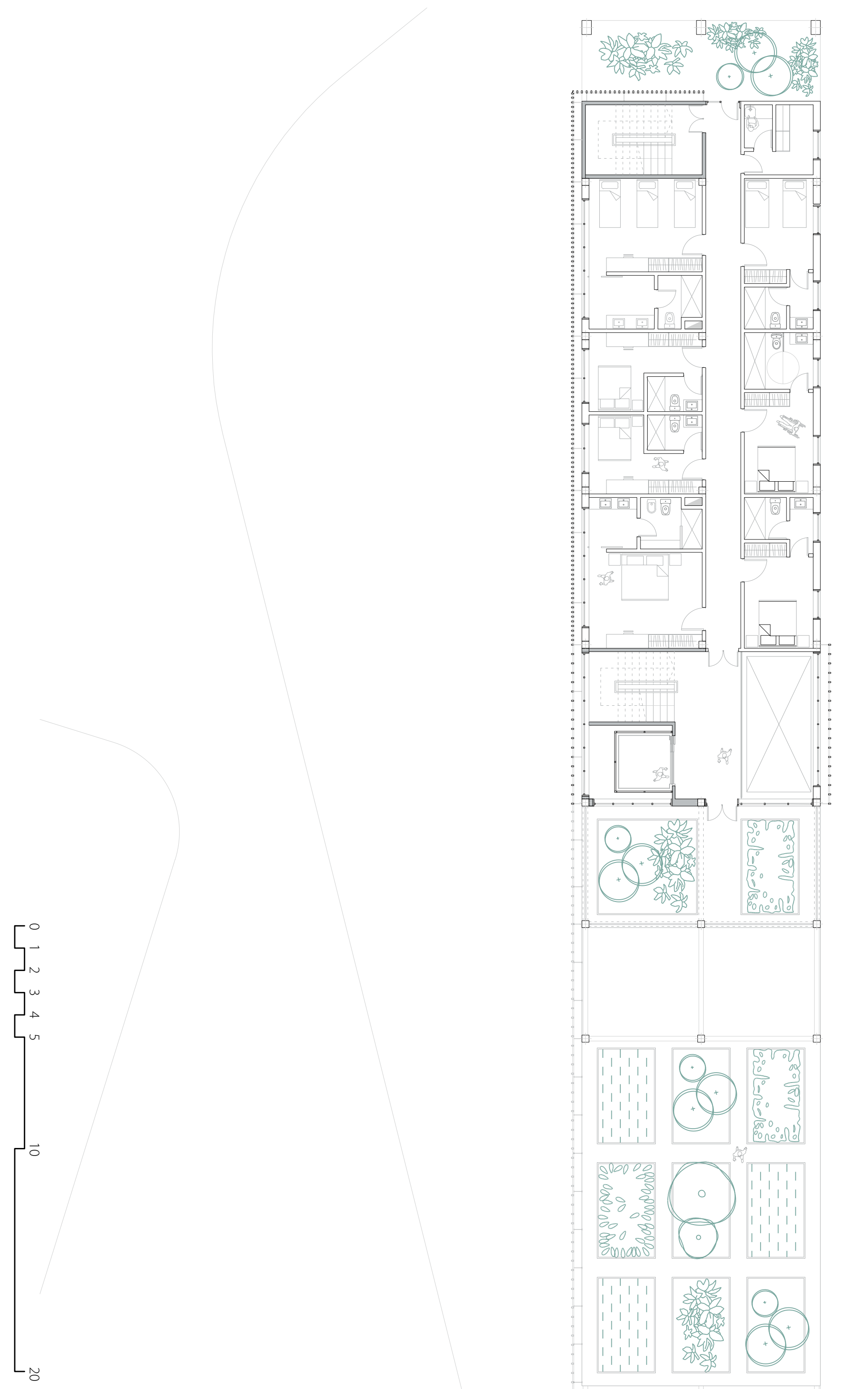
GROUNGFLOOR - Scale 1:200.
Illustrated by the author.



FIRST FLOOR / MEZZANINNA - Scale 1:200.
Illustrated by the author.

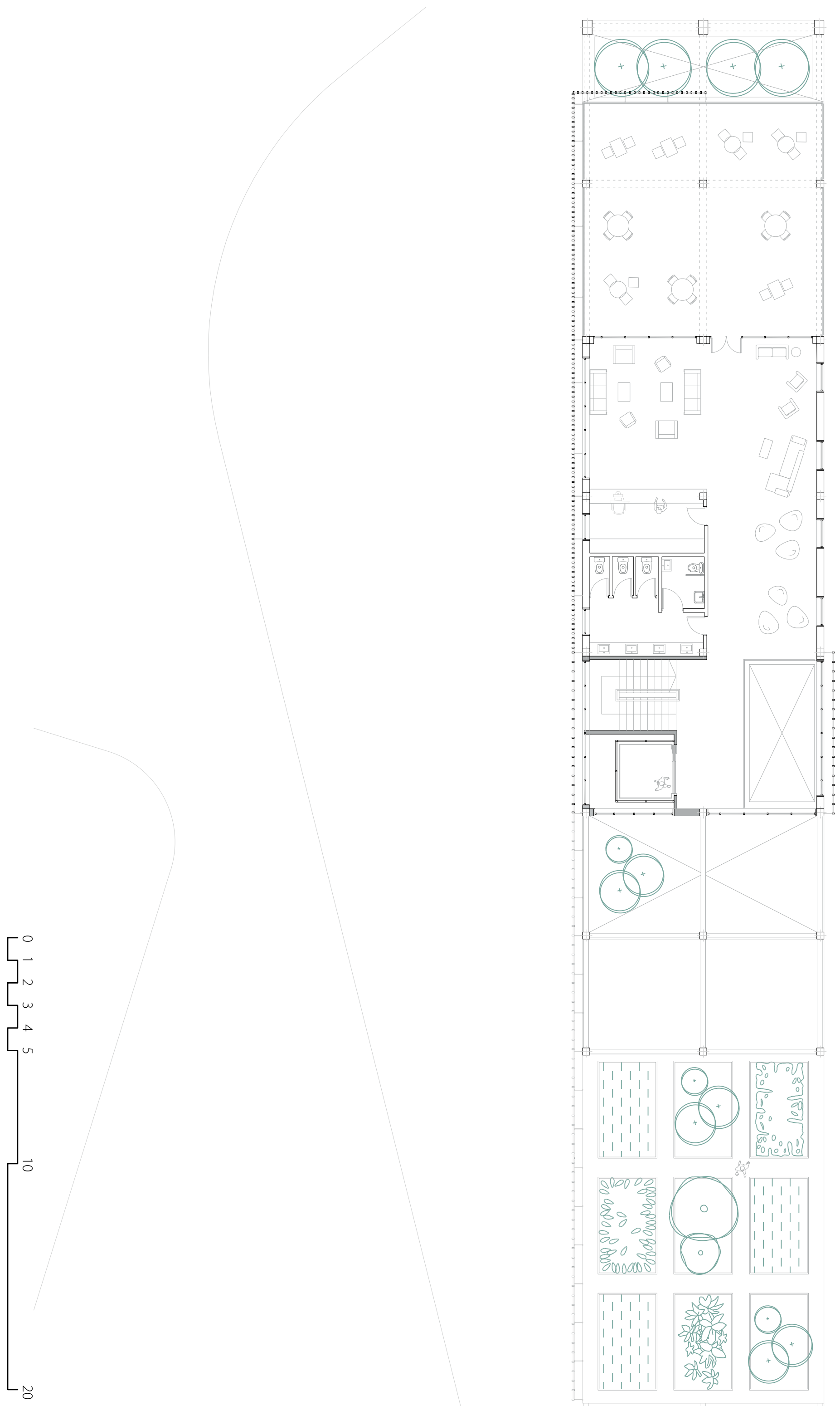


SECOND FLOOR / CO-LIVING - Scale 1:200.
Illustrated by the author.



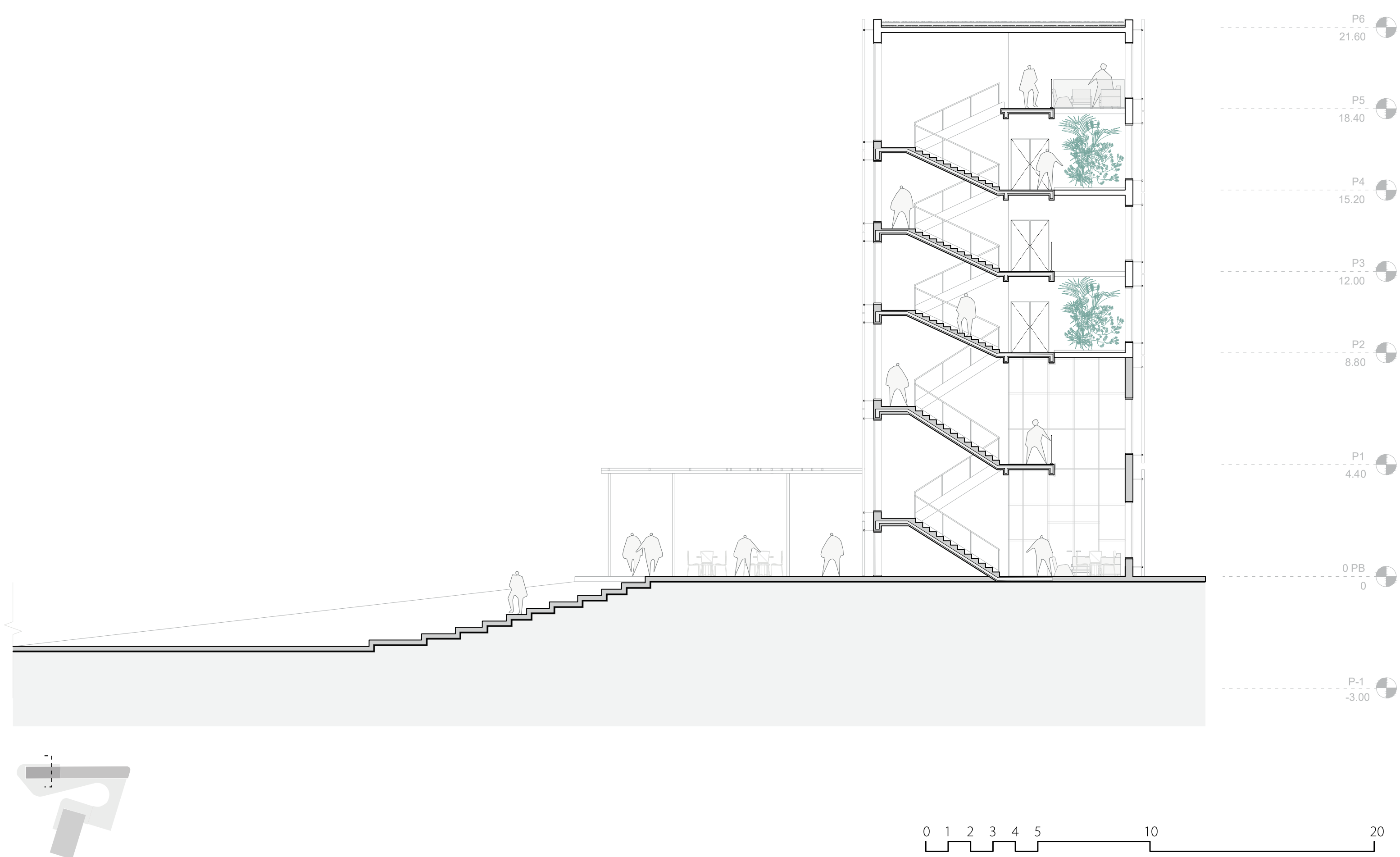
GROUNDFLOOR - Scale 1:200.
Illustrated by the author.

Annex

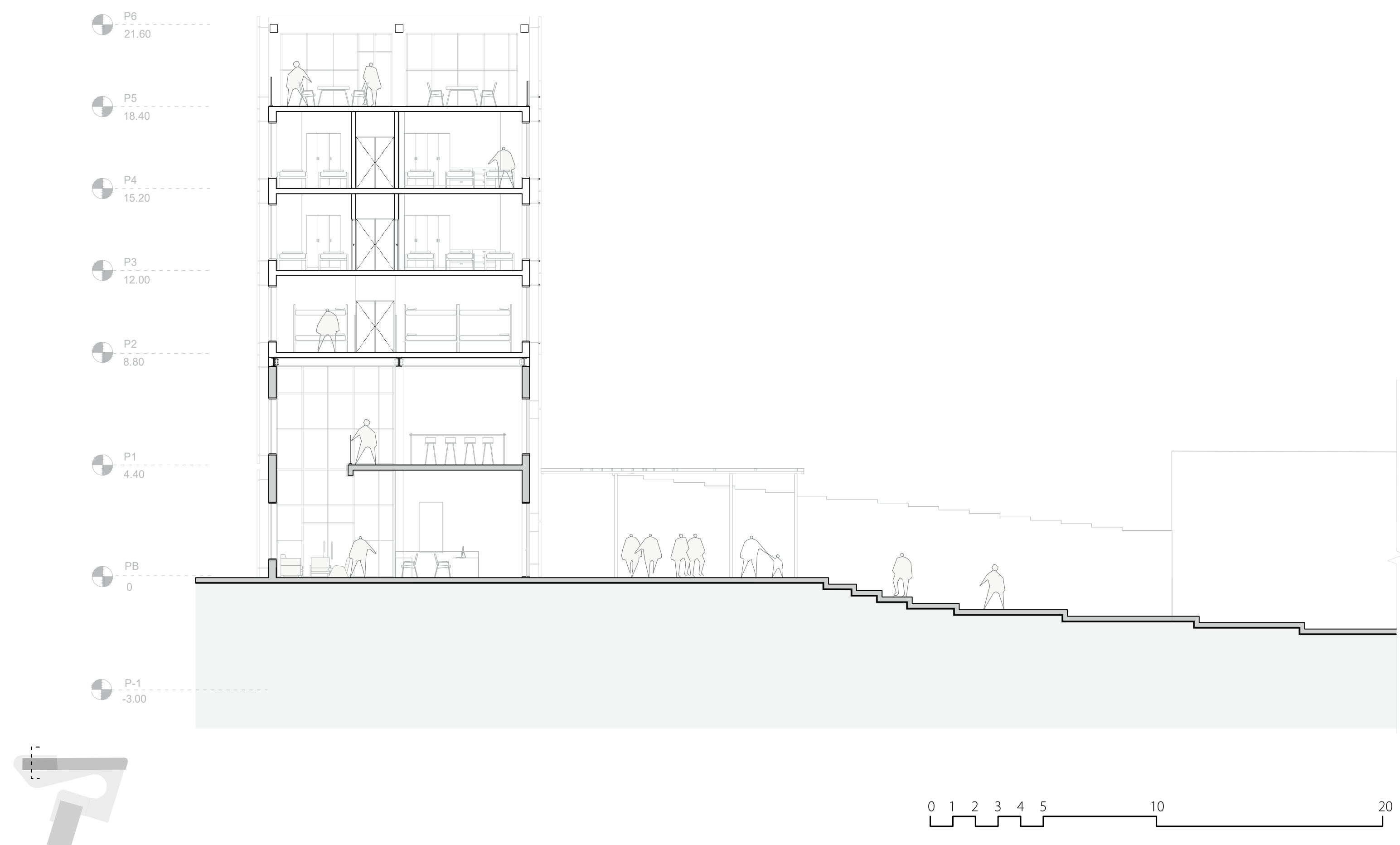


THIRD AND FOURTH FLOOR / HOTEL - Scale 1:200.
Illustrated by the author.

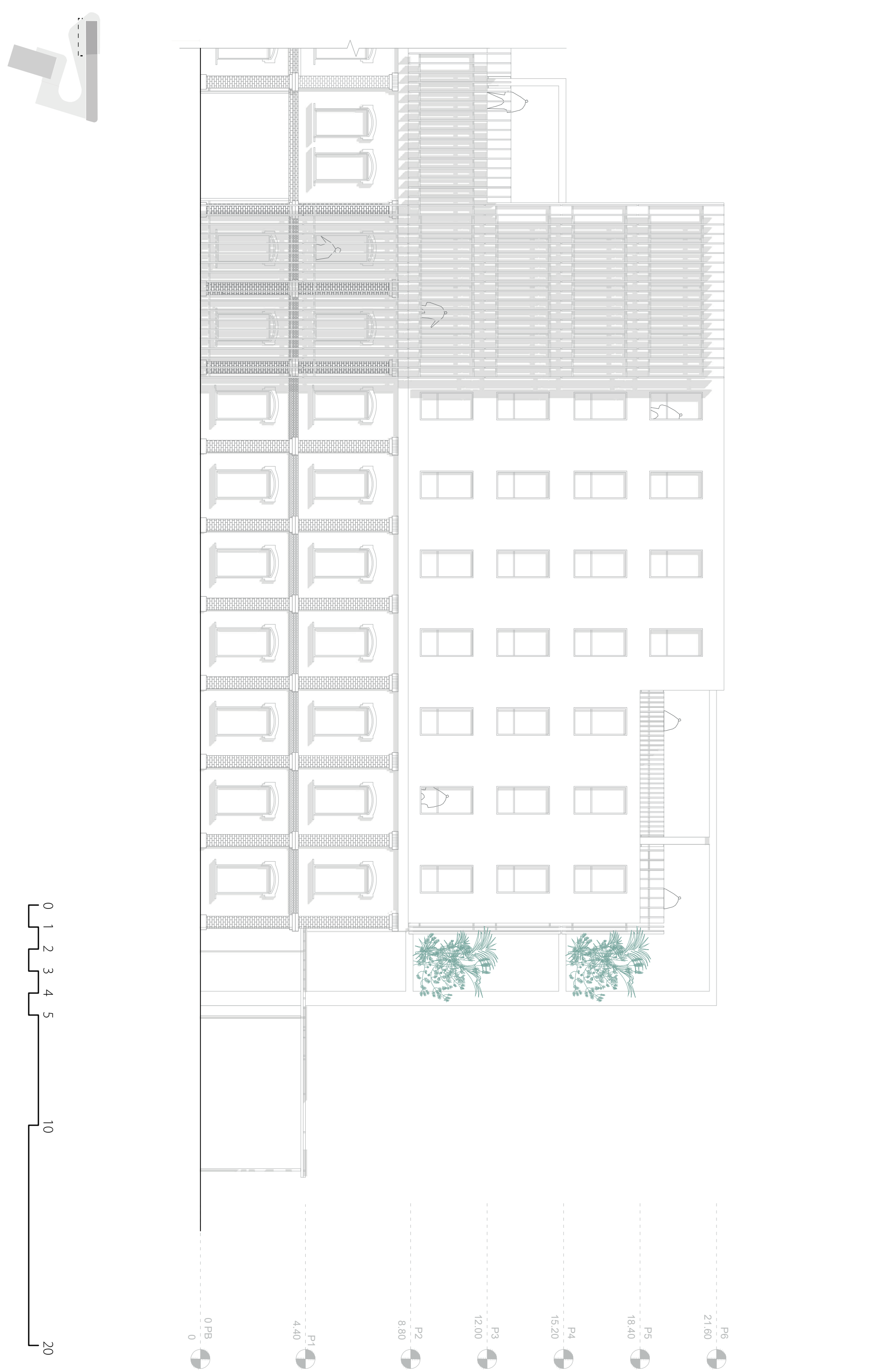
SECTION A, A' - Scale 1:200.
Illustrated by the author.



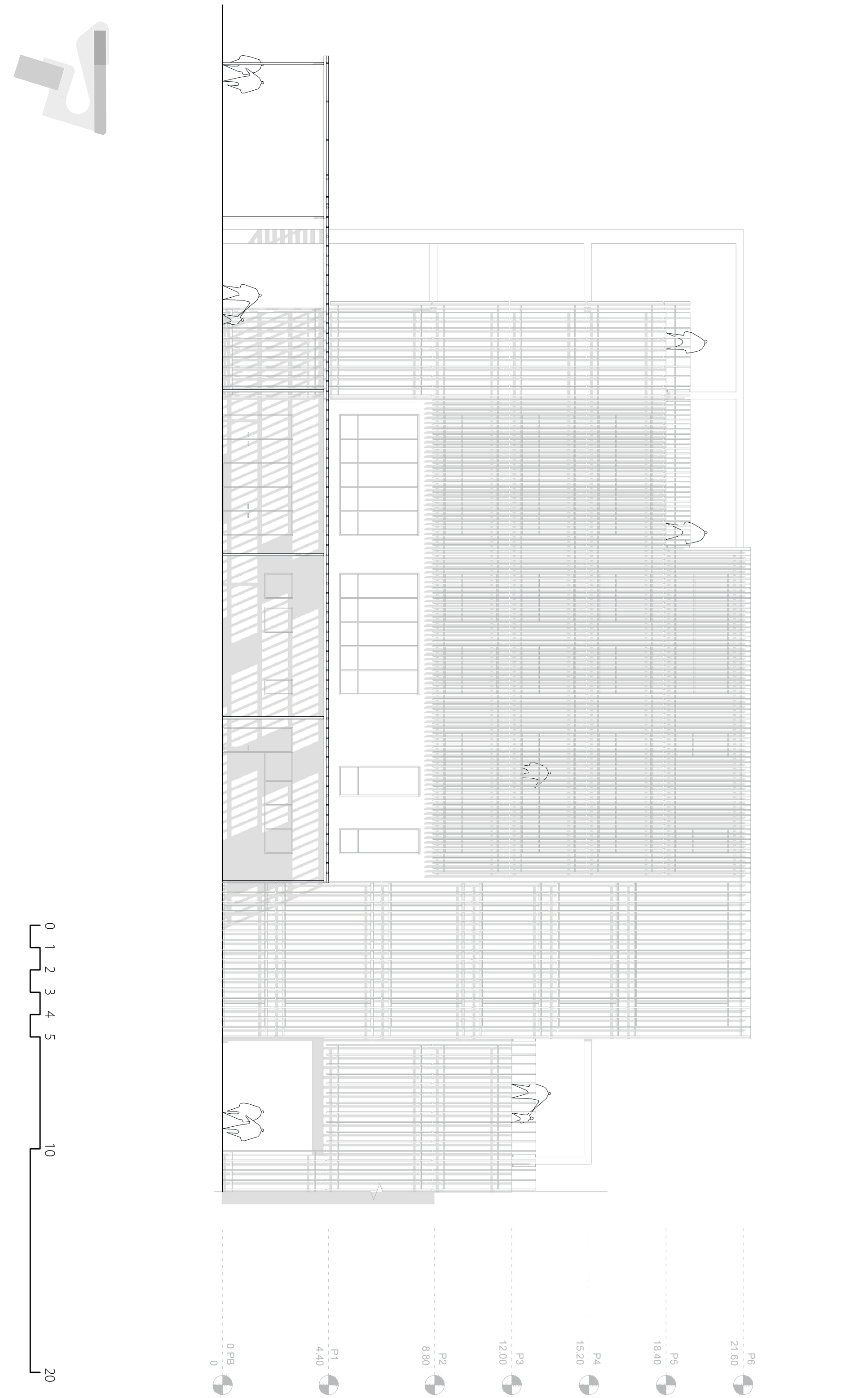
SECTION B, B' - Scale 1:200.
Illustrated by the author.



SECTION C, C' - Scale 1:200.
Illustrated by the author.



SOUTH FACADE - Scale 1:200.
Illustrated by the author.



SOUTH FACADE - Scale 1:200.
Illustrated by the author.

1/ EXISTING BUILDING

Current two floors building on site, which is intended to rethink to propose a new use for it.

2/ TO DEMOLISH

- Brick: three faces of walls
- Concrete: fist floor slab
- Steel: roof

3/ TO KEEP

- Main facade
- Structure

4/ EXTENSION

It is proposed to grow the building a longitudinal module towards the back.

5/ REINFORCE COLUMS

Some column axes were selected which are proposed to reinforce in order to add more levels to the building.

6/ CONCRETE BASE

This will be the final concrete base that will support the new building with more levels.

7/ NEW LEVELS

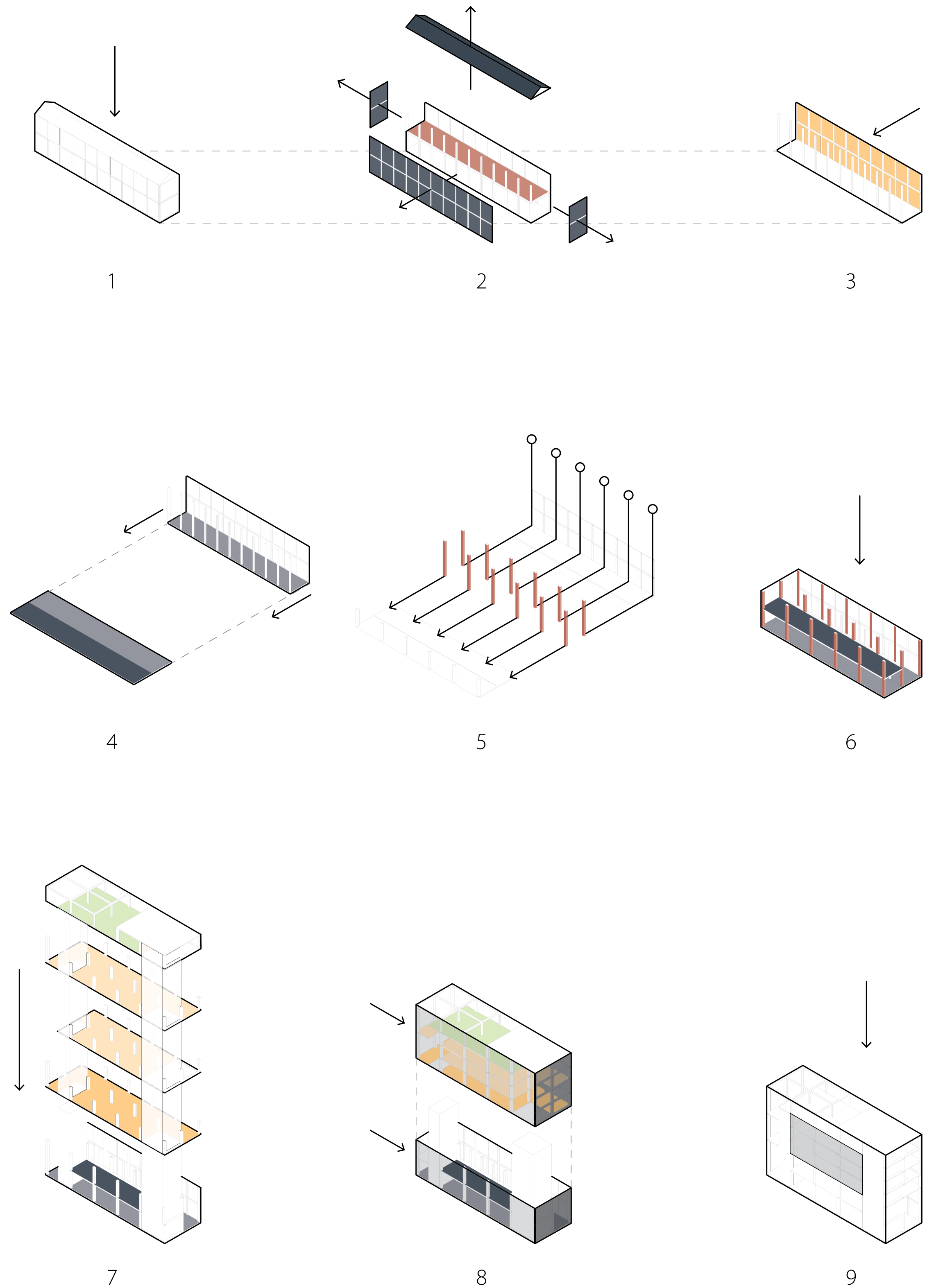
2nd level: Co-living
3rd level: hotel
4rd level: hotel
5th level: terrace / skybar

8/ MATERIAL DIVISION

The building is divided into two bodies which are differentiated by their materiality, wood and concrete.

9/ FINAL BUILDING

The final result of the intervention by taking advantage of an existing structure.



Concept diagramma.
Illustrated by the author.

CONCEPT AND PROJECT

In this design phase, the main priority has always been to design the neighbourhood, how through a proposal it could help to combat the greatest number of existing problems from the environmental point of view at an urban level, taking into account aspects such as the incidence of the sun, the presence of green spaces or recreational spaces, the analysis of the roads in the streets surrounding the land, the pedestrian mobility by users who inhabit the area, which can be summarized as the analysis of the dynamics that are developed in the sector.

All this with the simple purpose of generating a proposal as close to the real thing as possible and that beyond innovating architecturally or technologically, rather, through the methods already known, seek to solve these needs and help mitigate this climate change.

In the same way, this proposal also seeks to be that reference for future works or interventions that are carried out in the place, thus having as a result a set of friendly buildings both with the users and with the environment.

The main considerations that this project has, can be translated into 4 strategies implemented for the contribution of the so-called urban metabolism, which are:

1- The consideration of the existing buildings in the intervention block, their recovery to adapt them and change their use. This in order to minimize the amount of waste generated at the time of construction, which in turn contributes to the economic issue due to the fact that important parts of the buildings were maintained including their structures, which translates into monetary savings and of resources.

2- The orientation of buildings according to solar incidence, a strategy that is directly aimed at reducing the use of air conditioning systems in summer and heating in winter. In this case, the main building has its two main facades and the largest one facing north and south, while the other two are endowed with a large amount of vegetation, to combat the heat in the summer case and in the case of winter, serve as open spaces for recreation where the incidence of the sun becomes an enjoyment for users.

3- The arrangement of 80% of the project surfaces (patios and roofs), for green areas such as terraces, spaces for cultivation, vegetation for the collection of water and green bleachers as a route. While that remaining 20% is intended for the provision of solar panels which will be responsible for providing almost the entire complex with electrical energy.

4- Finally, 80% of the project is proposed to be carried out with wood, a resource which is considered renewable and, in turn, due to its assembly technology, if you want to remodel or dismantle, you can reuse most of the material used.

DETAILS SECTIONS

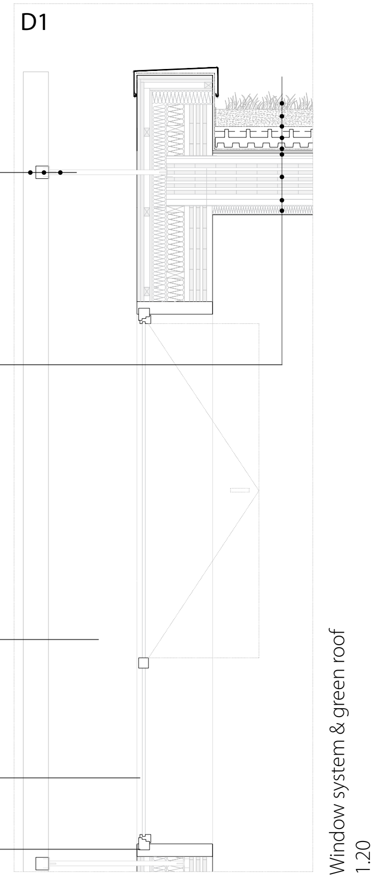
wooden structure
horizontal wooden structure
steel supports

Selected vegetation
DAKU ROOF SOIL 2 [80 mm]
DAKU STABILFILTER SFE [1,30 mm]
DAKU FSD 20 [82 mm]
Waterproof anti-root covering
Impact insulation layer
CLT slab
Sealing
Sound insulation layer

Side-hang window system

Glass

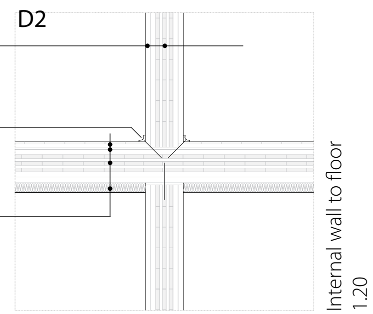
Wooden frame



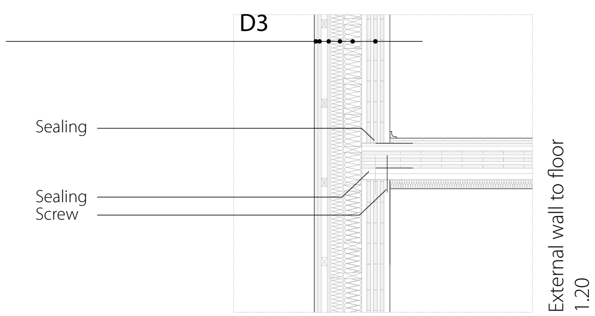
CLT slab
Internal cladding

Screws

Flooring
Impact insulation layer
CLT slab
Sound insulation layer

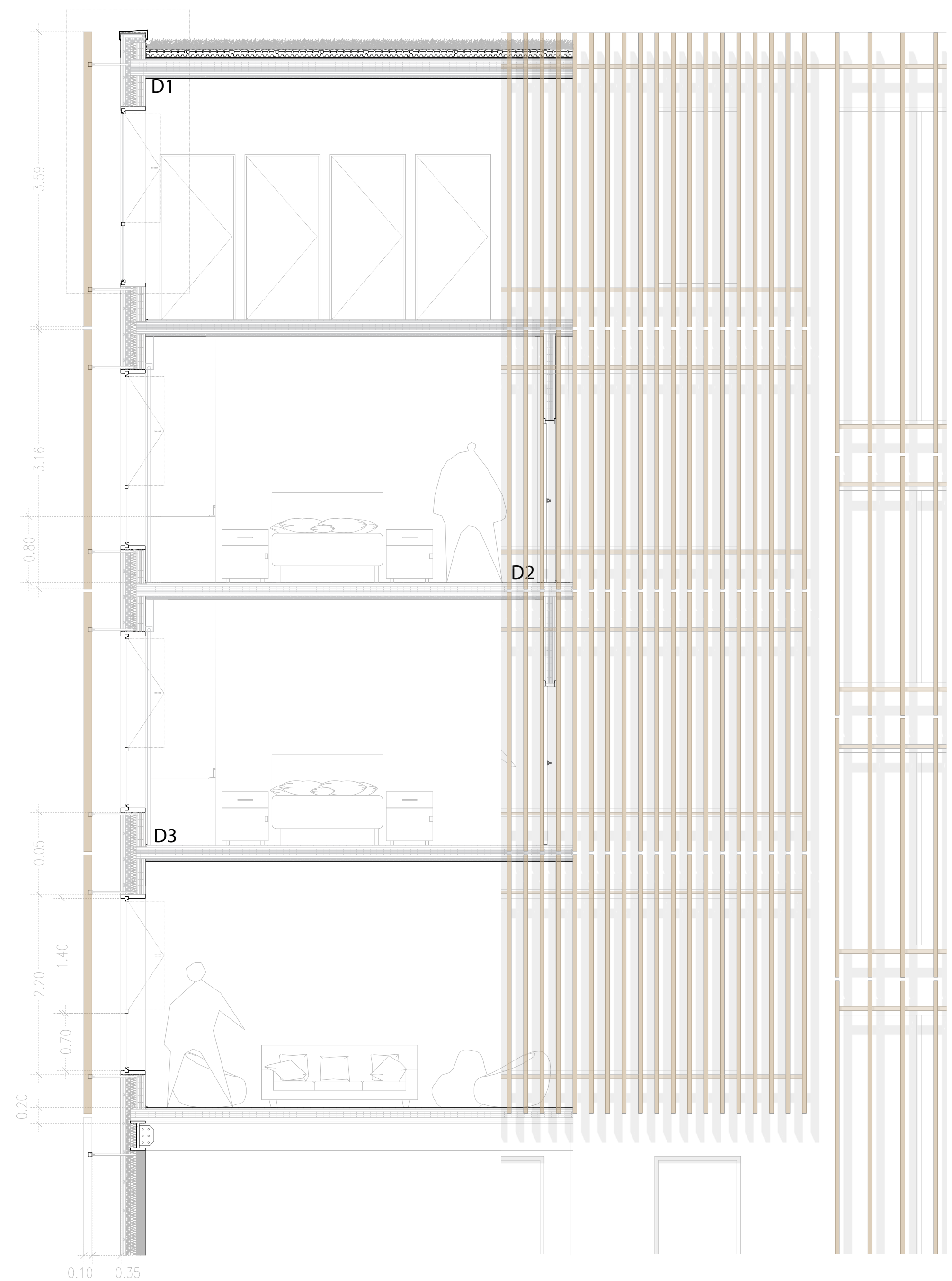


Cladding
Vertical battens
Wind protection layer
Thermal insulation
Vcapour retarder
CLTpanel



CROSS SECTION

SOUTH FACADE

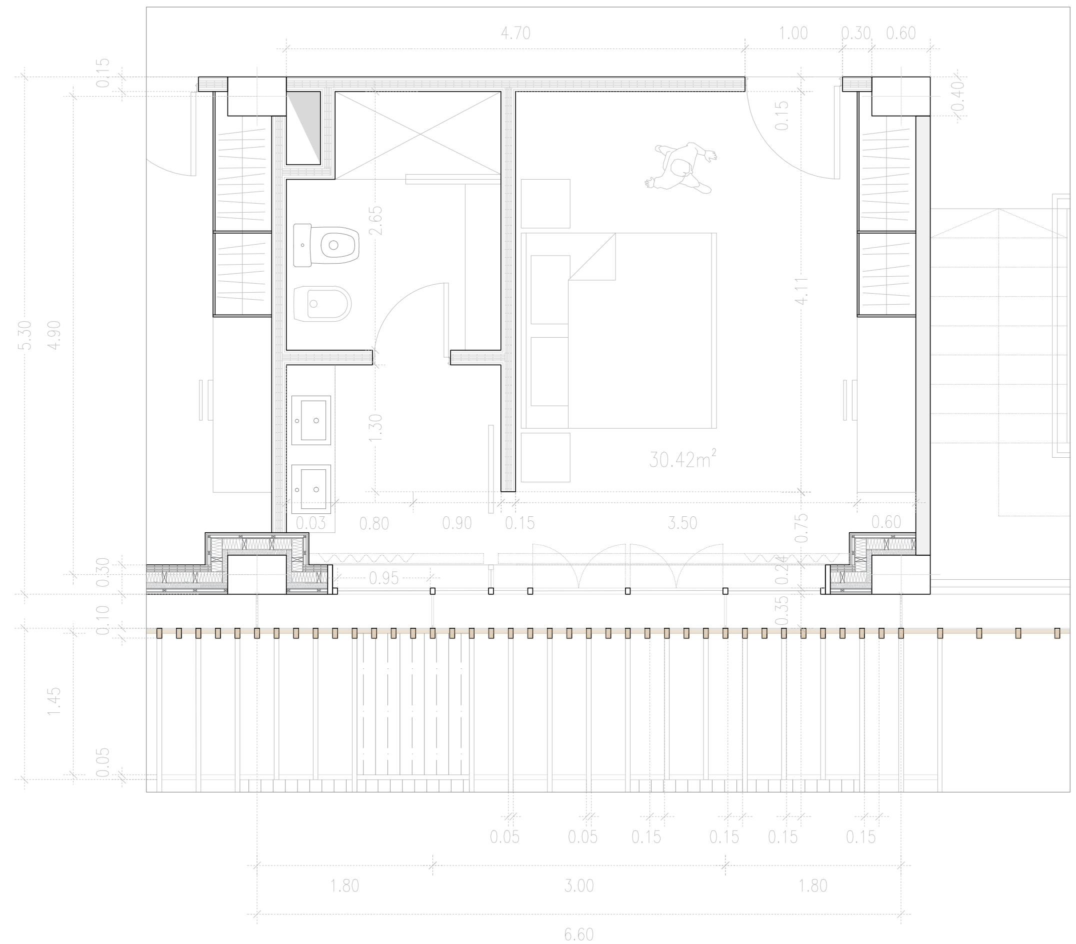


Details.
Illustrated by the author.

NORTH
FACADE
1.50

Details.
Illustrated by the author.

FLOOR
PLAN
1.50



Details.
Illustrated by the author.

Axonometric View of the Main Building. Illustrated by the author.

/ The aim of this thesis is to explore the extent of the sustainability of wood as a possible building material for an ecological transformation of a city. The very hypothesis is that timber construction solutions, at an urban scale, are a critical tool in the global effort to mitigate climate change by turning dense urban cities into a continuous "carbon sink" that functions alongside the capacity of forests that are its renewable source.

In addition, the second hypothesis of this work is that timber construction and wood are not inherently sustainable, and that the extent to which they are sustainable when applied to urban building technologies should be investigated and possibly modelled. In this sense, such an inquiry and modelization may be useful not only in terms of wood research but also in terms of urban strategy planning, as it may provide a set of quantitative and qualitative indicators that could frame planners' choices and size the specific guidelines each strategic plan states.

The thesis is divided into three parts. The first one, "Wood," explores the relationship between forests and humans by pointing out not only some emergent aspects of its evolution and geographies but also delving into the processes of timber production (making trees artificial) and, more specifically, the wood's benefits in terms of carbon footprint.

The second and third parts are instead more specifically focused on wood as a building material for cities. While the second part provides some examples of the use of wood on different urban scales, the third one tries to inquire into the very research question of the thesis: Can wood be urban?

Far from defining wood as a perfect solution for cities, the thesis explores critical and technical tools for making informed choices in planning and architecture.