ALMA MATER STUDIORUM -UNIVERSITA` DI BOLOGNA

Master's degree in Architecture and creative practices for the cities and landscape

Revitalization of the former Ravone railway yard: adaptive reuse of the 'Temporanea' warehouse with integration of a solar greenhouse as a bioclimatic design

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Abstract

This thesis explores the revitalization of the former Ravone railway yard in Bologna through the adaptive reuse of the ‘Temporanea’ warehouse, integrating a solar greenhouse as a key element of bioclimatic design. The project aims to transform a neglected industrial space into a vibrant community hub that promotes sustainability, social interaction, and economic growth. By repurposing the existing structure, the initiative preserves the historical significance of the site while addressing contemporary urban challenges. The integration of a solar greenhouse not only enhances energy efficiency through passive solar strategies but also serves as an educational tool for sustainable practices, providing fresh produce for the community. This approach exemplifies how adaptive reuse can foster environmental resilience and social cohesion, setting a precedent for future urban regeneration projects. The findings highlight the potential of bioclimatic design in creating multifunctional spaces that cater to diverse community needs while promoting ecological stewardship. Ultimately, this thesis contributes to the discourse on sustainable architecture and urban revitalization, demonstrating the importance of innovative design in transforming urban landscapes.

Key words:

Urban Revitalization-Social Cohesion-Solar Greenhouse-sustainable architecture.

Chapter. 1. Introduction

Urban regeneration has emerged as a powerful tool for transforming underutilized or abandoned spaces into vibrant community assets. This process in Bologna is particularly crucial due to the city's historical significance and the challenges it faces in adapting to modern urban demands. As a city rich in cultural heritage, Bologna must balance the preservation of its architectural legacy with the need for sustainable development. This thesis explores the potential of renovating an abandoned railroad site into a multifunctional social centre and greenhouse. Definition of urban regeneration as "a comprehensive and integrated vision and action which seeks to resolve urban problems and bring about a lasting improvement in the economic, physical, social and environmental condition of an area." (Roberts, 2017).

The research focuses on the renovation of a historical structure with a dismissed freight yard, aiming to create a space that fosters social interaction, environmental sustainability, and community well-being. By delving into case studies and architectural strategies, this study demonstrates how repurposing forgotten spaces can bridge the gap between past and future, creating hubs of activity that promote both social cohesion and ecological mindfulness.

This project addresses multiple facets of urban revitalization, including the integration and enhancement of green infrastructures within urban areas. These green lungs contribute to the overall health and aesthetic of the cityscape. Through this holistic approach, the thesis aims to illustrates a stance for sustainable, community-oriented development in urban regeneration projects.

1.1 Literature Review

This literature review examines the key concepts, theories, and empirical studies relevant to urban regeneration, adaptive reuse of industrial spaces, and the integration of social centres and urban agriculture. The review is structured around three main themes:

- **Urban Regeneration and Adaptive Reuse**

Urban regeneration has become a crucial strategy for revitalizing cities and addressing urban decay, Colantonio and Dixon (2011) argue that successful urban regeneration projects must balance economic, social, and environmental factors. Furthermore, resilience plays a crucial role in urban regeneration, as it enables cities to adapt to changing conditions and recover from disruptions, thereby ensuring long-term sustainability and livability (Altrock, 2018). Urban regeneration projects often aim to revitalize areas that have experienced economic decline or environmental degradation, and resilience is key to making these transformations durable and effective (Roberts, 2017).

Adaptive reuse is a significant strategy within urban regeneration, as it involves repurposing existing structures for new uses, thereby preserving cultural heritage and reducing the environmental impact of new construction (Bullen & Love, 2011). This approach not only conserves resources but also contributes to the resilience of urban areas by maintaining the historical and cultural fabric of cities while accommodating modern needs (Colantonio & Dixon, 2011). By integrating adaptive reuse into urban regeneration, cities can enhance their resilience, ensuring that urban spaces remain vibrant and functional in the face of future challenges (Bullen & Love, 2011).

- **Social Centres and Community Engagement**

Social centres play a vital role in fostering community cohesion and providing spaces for civic engagement. Amin (2008) emphasizes the importance of public spaces in nurturing social interactions and building community resilience. The concept of "third places," introduced by sociologist Ray Oldenburg in 1989, refers to social environments distinct from the home and workplace, such as cafes, parks, and libraries. These spaces serve as neutral grounds where people can gather, interact, and build community ties (Oldenburg, 1989). Third places are accessible and welcoming, characterized by a stress-free atmosphere that encourages inclusivity and informal social interactions (Rosenbaum, 2006).

A recent study by Rantala et al. (2024) explores the role of community spaces in promoting social inclusion and well-being, particularly in diverse urban environments. This research highlights how well-designed social hubs can facilitate interactions among residents, thereby enhancing community ties and fostering a sense of belonging. The findings align with earlier studies by Cattell et al. (2008) and Fincher and Iveson (2008), which also emphasize the positive impacts of community spaces on social inclusion.

- **Urban Agriculture and Greenhouses**

Urban agriculture has gained prominence as a strategy for promoting sustainability, improving urban environments, and enhancing food security. Food security refers to the condition where all individuals have reliable access to sufficient, safe, and nutritious food to meet their dietary needs for an active and healthy life. It encompasses four key dimensions: availability, access, utilization, and stability (Mougeot, 2006). Urban agriculture offers potential benefits such as improved nutrition, reduced food miles, and enhanced community engagement, especially when integrating social spaces like coffee shops with greenhouses.

The integration of greenhouses in urban settings offers unique opportunities for year-round food production, enhancing the dynamism of neighborhoods (Specht et al., 2014). Greenhouses are effective examples of environmentally friendly spaces, designed to minimize carbon emissions and reduce the depletion of natural resources. These structures often feature glass walls and roofs to maximize natural light, along with shading extensions to protect from direct sunlight. Greenhouses also employ advanced irrigation systems that dispense precise amounts of water, significantly reducing water usage and often recycling excess water within the greenhouse (Karpenko et al., 2022).

Air composition within greenhouses is carefully regulated using fans to circulate air, eliminate humid vapors, and reduce extreme solar heat, fostering optimal plant growth. Furthermore, greenhouses often rely on renewable energy to power equipment and lighting, further reducing their carbon footprint. The use of sustainable and environmentally friendly building materials also contributes to climate resilience and circularity in greenhouse design (Karpenko et al., 2022). The potential of community greenhouses to serve as catalysts for social interaction and community building has been increasingly recognized in recent years. Lamalice et al. (2018) highlight how community greenhouses can contribute to food security and social cohesion in Arctic communities. Reisman (2012) explores the multifaceted roles of urban community greenhouses, emphasizing their potential to foster education, community engagement, and

local food production. Furthermore, El Bilali et al. (2021) discuss the importance of sustainable agri-food systems, which community greenhouses can support by promoting local, environmentally-friendly food production and community involvement. These studies collectively underscore the significance of community greenhouses not just as food production spaces, but as hubs for social interaction, education, and sustainable community development.

- **Historical context of urban regeneration and adaptive reuse in Italy, Bologna**

The Bologna plan for preserving its historical center, established in 1969, marked a pioneering approach in urban conservation, emphasizing the protection of the entire historic urban fabric rather than focusing solely on individual monuments. This "area conservation" strategy aimed to maintain the integrity of Bologna's cultural heritage while promoting social cohesion and preventing gentrification through public participation in the planning process. By integrating physical restoration with social policies, Bologna set a precedent for holistic urban regeneration, balancing the preservation of historical elements with the needs of contemporary urban life (Bravo, 2009).

Following World War II, urban regeneration became increasingly important in Italy as cities faced the dual challenge of rebuilding while preserving their cultural heritage. Bologna's conservation efforts since the 1960s, particularly the Bologna Plan, served as a model for other cities by demonstrating how to preserve historical urban fabric while improving living conditions (Bandarin & Van Oers, 2012). In the 1970s and 1980s, Bologna, like many European cities, shifted towards the adaptive reuse of industrial heritage in response to deindustrialization and urban revitalization needs. This trend involved transforming former factories into cultural spaces, a practice that continues today.

A prominent example is the MAST Foundation, established in 2013. MAST stands for Manifattura di Arti, Sperimentazione e Tecnologia (Manufacture of Arts, Experimentation and Technology) and serves as a cultural and philanthropic institution focused on art, technology, and innovation. Housed in a multifunctional complex of 25,000 square meters on a former industrial site near Coesia's headquarters, MAST exemplifies successful adaptive reuse.

The complex features an Innovation Gallery with interactive exhibits. This adaptive reuse not only preserves industrial heritage but also creates vibrant cultural hubs within the urban landscape. The ongoing trend in Bologna highlights the value of industrial heritage and its potential for contemporary reimagining. This approach aligns with sustainable urban

development by reducing the need for new construction while preserving historical elements (Bullen & Love, 2011).

In recent years, Bologna's urban regeneration has focused on sustainable development and social inclusion. This is exemplified by the ongoing regeneration of the Bolognina neighborhood, which aims to address modern urban challenges while maintaining the city's rich historical and cultural legacy (Comune di Bologna, 2020).

1.2 Synthesis and Research Gap

While extensive research exists on urban regeneration, adaptive reuse of industrial sites, and bioclimatic design as separate fields, there is a notable gap in literature that integrates these elements, particularly in the context of historical industrial sites. This gap is significant as the combination of repurposing industrial structures with innovative bioclimatic interventions, such as solar greenhouses, remains underexplored. This integration presents unique opportunities for sustainable urban development that have not been fully examined in academic discourse.

The potential for these integrated approaches to simultaneously address multiple urban issues - including social cohesion, food security, environmental sustainability, and economic revitalization - in the context of industrial site regeneration requires further exploration. The complexity of combining these elements within a single project presents both challenges and opportunities that are not adequately addressed in existing research.

This thesis aims to address this research gap by examining how the renovation of a historical industrial structure into a combined social center and solar greenhouse can contribute to urban regeneration, community building, and sustainable development. By analysing existing projects and proposing innovative solutions, this research seeks to provide a more holistic understanding of how industrial adaptive reuse, bioclimatic design, and community-oriented spaces can be integrated to create resilient and vibrant urban environments.

The following sections will delve deeper into each of these themes, critically analysing existing projects which can serve as references and identifying key principles that will inform the proposed renovation project.

1.3 Integrated approaches to urban renewal

The revitalization of underutilized or neglected urban spaces in historic cities is a critical component of contemporary urban regeneration strategies. Innovative designs, which integrate principles of sustainability and inclusivity, can transform these areas into vibrant, multifunctional community hubs that address both social and environmental challenges. The reuse and adaptation of existing structures, often referred to as adaptive reuse, not only preserve the cultural and historical heritage of a city but also contribute to the reduction of urban sprawl and the carbon footprint associated with new construction (Bullen & Love, 2011).

A key aspect of urban regeneration is the shift from traditional top-down planning approaches to more participatory processes that engage local communities in the design and decision-making stages. This method ensures that the revitalized spaces meet the specific needs of the local population, fostering a stronger sense of ownership and stewardship (Healey, 2006). The co-creation of public spaces, where citizens actively contribute to the design, usage, and maintenance of urban areas, promotes social cohesion and inclusivity, making cities more resilient and adaptable to future challenges (Agyeman & Evans, 2003).

Incorporating green infrastructure is another innovative approach to urban regeneration. By integrating natural elements like parks, green roofs, and urban forests, cities can mitigate the effects of climate change, improve air quality, and provide essential recreational spaces for residents. For instance, the High Line in New York City, a former elevated railway track, was transformed into a public park that not only revitalized the surrounding neighborhood but also became a model for sustainable urban regeneration (Lindsey, 2013).

Additionally, the strategic use of public art and cultural activities can breathe new life into abandoned urban spaces. Public art serves as both a cultural expression and a tool for economic development, attracting tourists and creative industries that contribute to the local economy (Zukin, 1995). In historic cities, these interventions can be especially impactful by highlighting the intersection of modernity and heritage, offering a dynamic narrative that connects the past with the future (Landry, 2011).

In conclusion, the revitalization of urban spaces in historic cities requires a multidisciplinary approach that considers architectural innovation, community participation, sustainability, and cultural preservation. By employing these strategies, cities can transform neglected areas into vibrant, multifunctional spaces that not only enhance the urban fabric but also foster social, economic, and environmental benefits. As Altrock (2018) suggests, such transformations can

create a positive feedback loop, where revitalized spaces attract investment, tourism, and community engagement, further enhancing the city's long-term resilience and prosperity.

- **Promotion of Community Interaction**

Integrating social spaces such as parks, plazas, and community centers into urban design can encourage interaction among residents. These spaces can host events, markets, and cultural activities, strengthening community ties and promoting a sense of belonging. By creating spaces that encourage social interaction, residents have more opportunities to engage with each other, fostering a stronger sense of community and belonging (Cattell et al., 2008).

- **Sustainability and Resilience**

Innovative architectural solutions can address environmental challenges by incorporating sustainable practices. Green buildings, energy-efficient systems, and the use of local materials can reduce the ecological footprint of new developments, making them models for sustainable urban living (Fiacco & Talamini, 2021).

- **Economic Opportunities**

Enhancing the social aspect of urban areas through innovative design can attract businesses, artists, and entrepreneurs. Creating spaces that support local commerce and artistic expression can stimulate economic activity and provide job opportunities for residents (Roberts, 2017).

- **Inclusivity and Diversity**

Designing spaces that cater to diverse populations is essential for fostering inclusivity. Innovative designs can incorporate features that accommodate various age groups, abilities, and cultural backgrounds, ensuring that all community members feel welcome and valued (Fincher & Iveson, 2008).

- **Health and Well-being**

Access to green spaces, recreational facilities, and community gathering areas can enhance the physical and mental well-being of residents. Innovative designs that prioritize health can contribute to a higher quality of life in urban settings (Colantonio & Dixon, 2011).

1.3.1 Urban Revitalization Through Green Infrastructure

While the revitalization of urban spaces encompasses a wide range of strategies, one innovative approach gaining traction is the integration of green infrastructure with sustainable building practices. This intersection of urban renewal and environmental design has led to the emergence of urban agriculture projects, particularly the incorporation of greenhouses within city landscapes. These structures not only contribute to urban food production but also serve as models for energy-efficient design in urban settings (Garnett, 2013).

Greenhouses, traditionally associated with rural or suburban environments, are now being reimagined as integral components of urban regeneration projects. By adapting greenhouse technologies to urban contexts, cities can create multifunctional spaces that address food security, community engagement, and sustainable energy use simultaneously (Alberti, 2016). Of particular interest is the application of passive energy strategies in urban greenhouses, which aligns with broader goals of reducing carbon footprints and enhancing the overall sustainability of revitalized urban areas (Kittler et al., 2020).

1.3.1.1 Passive Energy Utilization in Greenhouse Design

The concept of passive energy utilization in architecture, particularly in greenhouse design, revolves around harnessing natural energy flows to create sustainable, low-energy environments. Passive solar greenhouses are designed to maximize solar gain, reduce heat loss, and maintain a stable internal climate without relying heavily on mechanical systems. This approach is crucial for reducing energy consumption and promoting sustainability in agricultural practices (Drottberger et al. 2023).

- **Solar Energy Absorption and Heat Retention**

Solar Radiation: Passive solar greenhouses are strategically oriented, often with a south-facing aspect in the Northern Hemisphere, to capture maximum sunlight (Fenice Energy, 2024). The sun's shortwave radiation enters through the glazing and is absorbed by the ground and thermal mass materials, such as water-filled barrels or stone walls, which store and slowly release heat (Jakob Dahlin, n.d.).

Heat Distribution: The absorbed heat warms the air inside the greenhouse, creating a natural convection current. As the warm air rises, it circulates throughout the space, effectively maintaining a stable and warm environment conducive to plant growth (Thomaier et al., 2015).

- **Environmental Regulation**

Temperature Control: Passive greenhouses use natural ventilation, such as operable windows or vents, to regulate temperature. This system allows excess heat to escape and utilizes convection currents to maintain a balanced internal climate, reducing the need for mechanical cooling (Specht et al., 2014). By leveraging these natural processes, passive greenhouses can effectively manage temperature fluctuations, ensuring a stable environment for plant growth (Fenice Energy, 2024).

Air Humidity and Velocity: Natural ventilation also plays a critical role in controlling humidity and air movement within the greenhouse. By allowing fresh air to circulate, the greenhouse can maintain optimal humidity levels and air velocity, ensuring a healthy environment for plants with minimal mechanical intervention (Thomaier et al., 2015).

- **Energy Efficiency and Integration with Building Systems**

Heat Transfer to Adjacent Structures: Passive solar greenhouses can be integrated with nearby buildings to enhance overall energy efficiency. The heat generated within the greenhouse can be transferred to adjacent structures, reducing their heating requirements and creating a symbiotic relationship that maximizes energy use (Drottberger et al., 2023).

Chapter. 2. Methodology

This section outlines the research approach for studying the renovation of the former Ravone railway yard into a new social center and greenhouse, with a focus on passive energy strategies. The methodology employs a combination of qualitative case study analysis and practical implementation of energy efficiency methods, directly informing the design proposal.

2.1 Research Design

The study utilizes case study analysis and the practical design of passive energy strategies to inspire and guide the design and implementation of the renovation project for the Ravone Ex-railway yard. Case studies have been selected in the domain of urban regeneration projects, with a focus on those that have successfully integrated social centers and greenhouses with passive energy systems. Their design concepts, architectural features, and community engagement aspects have been analyzed to extract applicable strategies for the Ravone project.
Data Sources: Academic journals, project reports, architectural plans, and when possible, virtual or physical site visits have been used to gather comprehensive information on each case study.
Case Study Application to Design:
Community Engagement: Lessons from the Old Mill Social Center and Koćmierzów Manor House will inform the design of multipurpose spaces and community involvement strategies for the Ravone project.
Adaptive Reuse: The Fabbrica dell'Aria case study will guide the integration of innovative air purification systems and sustainable technologies in the repurposed railway structure.
Urban Agriculture: The Farmhouse Design Concept will inspire the implementation of vertical farming and modular design elements in the Ravone greenhouse.
Passive Energy Strategies: The study focuses on the following passive energy strategies, adapted to the specific context of the Ravone railway yard:

- **Natural Ventilation:** Utilizing design elements that promote airflow and reduce the need for mechanical cooling, considering the existing structure and local climate conditions (ScienceDirect, 2024).
- **Daylighting:** Maximizing natural light through strategic placement of windows, skylights, and reflective surfaces to reduce the need for artificial lighting, taking

into account the orientation and structure of the existing railway building (BEE Incorporation, 2024).

Chapter. 3. Case Study analysis

This chapter examines four exemplary projects that demonstrate the potential of adaptive reuse and innovative design in transforming urban spaces. These case studies “Federation Square, Fabbrica dell'Aria, Gary Comer Youth Center, and The Farmhouse Design Concept” illustrate how underutilized or unabundant areas can be revitalized and repurposed to serve contemporary urban needs.

Each project showcases approaches to combining diverse functions, such as integrating greenhouses with social spaces. The analysis focuses on three key aspects: design concept, community engagement, and architectural features. Examining these elements provides a comprehensive understanding of each project's approach to urban revitalization.

3.1 Case Study 1: Federation Square

Location: it is located in the heart of Melbourne, opposite the iconic Flinders Street Station and adjacent to the Yara River.

Designer: Lab architecture studio in partnership with Bates Smart,

3.1.1 Project overview:

Federation Square is a significant urban revitalization project in Melbourne, built on the site of the former Jolimont Railway Yards and Princes Bridge railway station. Announced in 1996, the project aimed to create a vibrant civic space that connects the city center with the Yarra River (Trust Advocate, n.d.). It spans 3.8 hectares built atop a complex railway deck ,and opened on October 26, 2002, Federation Square houses cultural institutions and public spaces, fulfilling its role as a civic and cultural hub (Fed Square, n.d.). Since its opening, it has become an iconic destination, attracting millions of visitors annually and serving as Melbourne's primary gathering place for events and festivals (State Library Victoria, 2020).

Figure 1: Federation square

3.1.2 Design Concepts:

Federation Square's design is inspired by fractals, featuring complex patterns that are identical both on a smaller and larger scale. The project aimed to create a vibrant civic space that connects Melbourne's city center with the Yarra River. The design concept emphasizes the idea of 'Federation', bringing disparate parts together to form a coherent whole. It deviates from the traditional grid layout characteristic of both Modernism and Melbourne city, instead opting for a series of interlocking and cascading spaces that open at various angles into the city, creating unexpected connections and vistas

3.1.3 Architectural Features

The square's distinctive architecture is characterized by its deconstructivist style, with both plan and elevations designed around slightly angular, 'cranked' geometries. The facade system uses three primary materials - sandstone, zinc (both perforated and solid), and glass - arranged in a triangular pinwheel grid pattern. This modular system creates a unified exterior design regardless of viewing distance. The complex includes nine separate buildings, an open-air amphitheater, and is built atop a sophisticated deck over railway lines. Key features include the Atrium, a five-story high laneway-like space with glazed walls and roof, and three prominent 'shards' that frame the square space.

3.1.4 Community Engagement

Since its opening in 2002, Federation Square has become a central gathering place for Melbourne, hosting over 2,000 events annually and attracting millions of visitors. It serves as a cultural hub, housing institutions such as the Ian Potter Centre: NGV Australia and the Australian Centre for the Moving Image (ACMI). The square's open design and diverse programming encourage public participation, with events ranging from cultural festivals and live performances to public screenings and markets. Its role as a civic space is further enhanced by the inclusion of restaurants, cafes, and bars, making it a popular destination for both locals and tourists. The square's design and function have successfully created a space that fosters community interaction and cultural engagement in the heart of Melbourne.

3.2 Case Study 2: Fabbrica dell'Aria

Location: Florence, Italy.

Designer: PNAT (Plants and Nature Applied Technologies), in collaboration with neurobiologist Stefano Mancuso and the architecture firm Lombardini22.

3.2.1 Project Overview:

The Fabbrica dell'Aria (Air Factory) is an innovative botanical air purification system that enhances indoor air quality using plants. It features a transparent, cube-shaped structure with vertical plant arrangements and a closed-loop hydroponic system. The installation serves both aesthetic and functional purposes, filtering air pollutants while promoting sustainability and well-being. Real-time monitoring demonstrates the effectiveness of this plant-based air purification system.

Figure 2: Fabbrica dell'aria

3.2.2 Design Concepts

Air Purification: The greenhouse uses plants to filter and purify indoor air, removing 97-99.7% of air pollutants.

Closed-Loop System: It employs a hydroponic system that mimics natural air and water purification processes.

Plant Selection: The installation uses various plant species known for their air-purifying qualities, including Philodendron, Pothos, Spathiphyllum, Dracaena, Ficus, Kentia, and Strelitzia.

Monitoring System: Real-time sensors measure and display air quality improvements, allowing visitors to see the system's effectiveness.

Lighting: An artificial lighting system adapts to both the architectural space and the plants' physiological needs.

(Lombardini22, n.d.)

3.2.3 Architectural Features

Transparent, cube-shaped structure

35 square meter greenhouse design

Vertical plant arrangements

Integrated water circulation system (PNAT, n.d.).

3.2.4 Community Engagement

Educational Tool: The installation serves as an informative exhibit on air purification and sustainable practices.

Visual Centerpiece: The transparent design makes it a striking focal point, attracting interest and promoting awareness.

Improved Work Environment: In office settings, it enhances air quality and employee well-being.

Multifunctional Space: The greenhouse can potentially be used for workshops, presentations, or as a relaxation area (Adamo, 2021).

3.3 Case Study 3: Gary Comer Youth Center

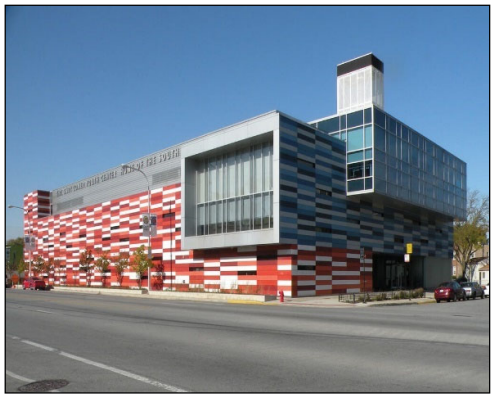
Location: Chicago, USA

Designer: John Ronan Architects. known for its innovative and contextually sensitive designs

3.3.1 Project Overview:

The Gary Comer Youth Center was built on the site of a former vacant lot and an abandoned industrial area. Before its transformation, the location was underutilized and contributed to urban decay. It is a multifunctional community facility that integrates educational spaces with urban agriculture. Completed in 2006, it features a rooftop greenhouse that produces over 1,000 pounds of organic produce annually. By combining innovative design with community-focused programming, the center serves as a model for addressing urban challenges related to education and food security.

Figure 3: Gary Comer Youth Center



3.3.2 Design Concept

The Gary Comer Youth Center's design emphasizes the integration of educational spaces with urban agriculture. The project focuses on sustainability and community empowerment, aiming to provide a multifunctional facility that serves local youth while promoting environmental awareness. The design concept revolves around creating a vibrant, engaging space that combines learning, recreation, and food production in an urban setting.

3.3.3 Architectural Features

The center features a striking 8,160-square-foot rooftop greenhouse, which serves as both a functional growing space and an architectural highlight. The building incorporates sustainable elements such as geothermal heating and cooling systems, energy-efficient design, and the productive greenhouse. The colorful, modern exterior design makes the center a visually distinctive landmark in the neighborhood. Interior spaces are designed to be flexible and multifunctional, accommodating various activities and programs.

3.3.4 Community Engagement

Center offers a wide range of programs and activities designed to engage and benefit the local community, particularly youth. These include educational programs, culinary classes, and urban agriculture education. The rooftop greenhouse not only produces over 1,000 pounds of organic produce annually but also serves as an educational tool, teaching young people about sustainable food production. The center hosts various community events and provides a safe, nurturing environment for local youth to learn, grow, and connect with their community.

3.4 Case Study 4: The Farmhouse Design Concept

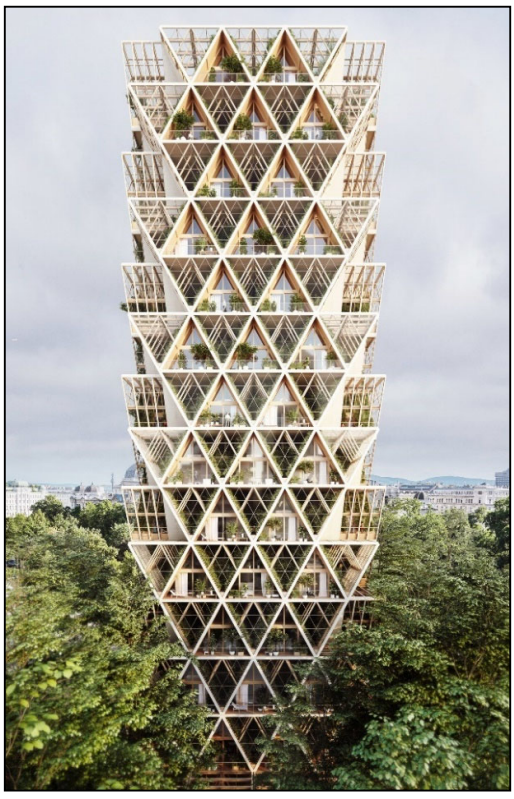
Location: This is a conceptual design.

Designer: Architecture studio Precht.

3.4.1 Project Overview:

The Farmhouse is a conceptual design by architects Fei and Chris Precht, aimed at integrating vertical farming with modular housing. This innovative approach seeks to reconnect urban residents with agriculture and promote sustainable living. The Prechts relocated from central Beijing to the mountains of Austria, where they grow their own food, which inspired the development of The Farmhouse concept (Precht, 2021).

Figure 4: The Farmhouse conceptual design



3.4.2 Design Concepts

Modular Housing and Vertical Farming: The Farmhouse integrates modular homes with vertical farms, promoting sustainable living and self-sufficiency by allowing residents to grow their own food (Dezeen, 2019).

Sustainability: The design addresses climate change and food shortages by shortening supply chains and reducing reliance on extensive farmland (ArchDaily, 2019).

3.4.3 Architectural Features:

Prefabricated A-Frame Modules: Constructed from cross-laminated timber (CLT), these flexible modules feature integrated systems for electricity, insulation, and gardening (Dezeen, 2019).

Three-Layer Wall System: The walls consist of three layers for finishes, structure, and gardening, enhancing functionality (Designboom, 2019).

Natural Ventilation: Angled walls create buffer zones for natural light and ventilation, improving the living environment.

3.4.4 Community Engagement

Shared Gardens and Markets: The design includes communal gardens and an indoor farmers market, fostering community interaction.

Educational Opportunities: Spaces for classes on ecology and sustainability promote community involvement in sustainable practices (Architecture + Design, 2022).

Figure 5: Comparison of case studies

Feature/Aspect	Federation Square	Fabbrica dell'Aria	Gary Comer Youth Center	The Farmhouse Design Concept
Project Overview	Adaptive reuse of a former railway	A botanical air purification system that enhances indoor air quality.	Transformation of vacant lot into youth center with rooftop greenhouse	Reconnection of urban residents with agriculture
Design Concept	Emphasizes connectivity and integration, reflecting the idea of 'federation'	Uses plants to remove 97-99.7% of air pollutants, combining function and beauty.	Integration of education, community space, and urban agriculture	Modular housing and vertical farming
Architectural Features	angular, deconstructive architecture.	A 35 square meter, transparent cube with vertical plant arrangements.	Colorful modern design, rooftop greenhouse, flexible interior spaces.	Prefabricated A-Frame modules with a three-layer wall system
Community Engagement	central gathering place for cultural events and festivals	Serves as an educational tool and multifunctional space for workshops.	Youth programs, culinary classes, urban agriculture education	Shared gardens and markets
Materials Used	uses sandstone, zinc, and glass for aesthetic coherence	Glass, hydroponic components, and various air-purifying plants.	Durable, low-maintenance materials suitable for high-traffic areas	Recycled and certified wood, bamboo
Sustainability	Acoustic isolation and green spaces	Features a closed-loop system and energy-efficient lighting for eco-friendliness.	Geothermal heating/cooling, systems, productive greenhouse.	Energy-efficient design and minimized waste

Figure 6: Comparison of case studies regarding the relevance to the designated project

Feature	Federation Square	Fabbrica dell'Aria	Gary Comer Youth Center	The Farmhouse Concept
Adaptive Reuse	repurposing existing buildings for new uses	Integrated into existing building	New construction on a former vacant lot	N/A (new construction)
Sustainability	passive cooling systems, rainwater harvesting, and energy-efficient lighting	Plant-based air purification	rooftop greenhouse, geothermal heating/cooling	Vertical farming, modular design
Community Engagement	preserving cultural heritage and fostering community identity	Educational tool	youth programs, culinary classes, and urban agriculture education	Shared gardens, markets
Architectural Innovation	non-orthogonal geometries and a modular facade system	Transparent cube design	Integrates a large rooftop greenhouse with a modern, colorful building design	A-frame modules
Urban Agriculture	-	Indoor air-purifying plants	rooftop greenhouse	Vertical farming
Relevance to Ravone Project	Relevance: High Demonstrates successful adaptive reuse in urban settings.	Relevance: High adaptive reuse of industrial space and innovative sustainability	Relevance: Medium to High Provides a model for community engagement and urban agriculture	Relevance: Medium Offers insights into integrating agriculture in new designs.

3.5 Key Lessons for the Project:

Multifunctional Spaces: Federation Square and Gary Comer Youth Center exemplify the creation of versatile spaces serving multiple purposes. For Ravone, this suggests designing flexible areas that can host various community activities, workshops, and events.

Integration of Nature: Fabbrica dell'Aria's innovative air purification system and Gary Comer Youth Center's rooftop greenhouse showcase creative ways to incorporate greenery and natural elements. The Ravone project should prioritize integrating green spaces, potentially including a greenhouse or indoor garden areas.

Community-Centric Design: Federation Square's public plaza and The Farmhouse Concept's shared spaces emphasize community involvement. Ravone should include areas that foster community interaction, such as open squares, shared gardens, or co-working spaces.

Sustainable Technologies: Drawing from Federation Square's passive cooling systems and Fabbrica dell'Aria's plant-based air purification, Ravone should incorporate sustainable technologies like energy-efficient lighting and natural ventilation systems.

Educational Opportunities: Following Gary Comer Youth Center's example of youth programs and urban agriculture education, Ravone could include educational components about sustainability, urban farming, and local history.

Preserving Industrial Heritage: Federation Square's approach to blending modern design with its urban context is particularly relevant for the Ravone railway yard, which has a similar need to balance industrial heritage with contemporary use.

By incorporating these lessons, the Ravone railway yard renovation can create a space that is not only functional and sustainable but also deeply connected to the community and respectful of its historical context. The project has the potential to become a model for adaptive reuse and community-centered design in urban regeneration.

Chapter. 4. History of the site of intervention

The Ravone area in Bologna, Italy, located at Via Camillo Casarini 19, encompasses over 30 hectares, including the former railway yard. Strategically positioned near the city center and Bologna Centrale railway station, this area has undergone significant transformation over the years. Once a bustling freight yard integral to Bologna's transportation and logistics network, it facilitated the movement of goods and materials, supporting the city's industrial and commercial activities throughout the early 20th century.

In 2010, the freight yard was closed, leading to a period of abandonment and urban decay. This closure created an opportunity for regeneration, which was realized in 2019 with the launch of the DumBO (Distretto Urbano Multifunzionale di Bologna) project. Covering almost 40,000 square meters, DumBO is described as one of the largest temporary urban regeneration spaces in Europe, aiming to repurpose the abandoned freight yard into a vibrant cultural and social hub.

The transformation into DumBO was a strategic response to the challenges of urban decay, social disconnection, and economic stagnation. A unique private-public-civic partnership enabled the transformation of the space and supported the identification of diversified functions for the area. Studio PERFORMA A+U project played a critical role by developing a masterplan focused on temporary uses, designed to facilitate dialogue between various stakeholders, including the DumBO Scientific Committee (Università di Bologna, 2018).

This multifunctional space includes both warehouses and open areas, featuring multiple pavilions and outdoor zones designed for culture, art, social activities, music, and sports. The project emphasizes community engagement, fostering collaboration among businesses, cultural associations, institutions, and citizens. It hosts a wide range of events, from art exhibitions and music festivals to workshops and sports activities.

Furthermore, DumBO places a strong emphasis on sustainability and social innovation, supporting initiatives focused on the circular economy, visual design, and cultural events. The area's evolution has been influenced by changing economic dynamics, urban planning initiatives, and the growing influence of the University of Bologna, whose city-widespread campus has played a vital role in shaping the character of the area (Altrock, 2018; Bullen & Love, 2011; Colantonio & Dixon, 2011).

Figure 7: Dumbo area before intervention

Figure 8: Master plan suggested by Performa A+U studio

Figure 9: Dumbo after intervention

Chapter. 5. Design

5.1 Site analysis

This chapter presents a focused site analysis of the project area, examining its historical context, mobility, nearby facilities, and environmental features. These elements are essential for understanding the site's potential and constraints, ensuring that the proposed design effectively responds to its context.

The historical analysis reveals the area's evolution and heritage elements that may influence the design. Mobility patterns and infrastructure are assessed to promote accessibility and sustainable movement, while the study of nearby facilities identifies potential synergies and gaps in services. Finally, the environmental features analysis examines the site's natural characteristics, informing a design that is both sustainable and responsive. Together, these analyses provide a comprehensive foundation for a contextually appropriate and functional design that meets community needs.

Figure 10: Territorial framework

Figure 11: Site's history analysis

Figure 12: Time line analysis

Figure 13: Mobility analysis

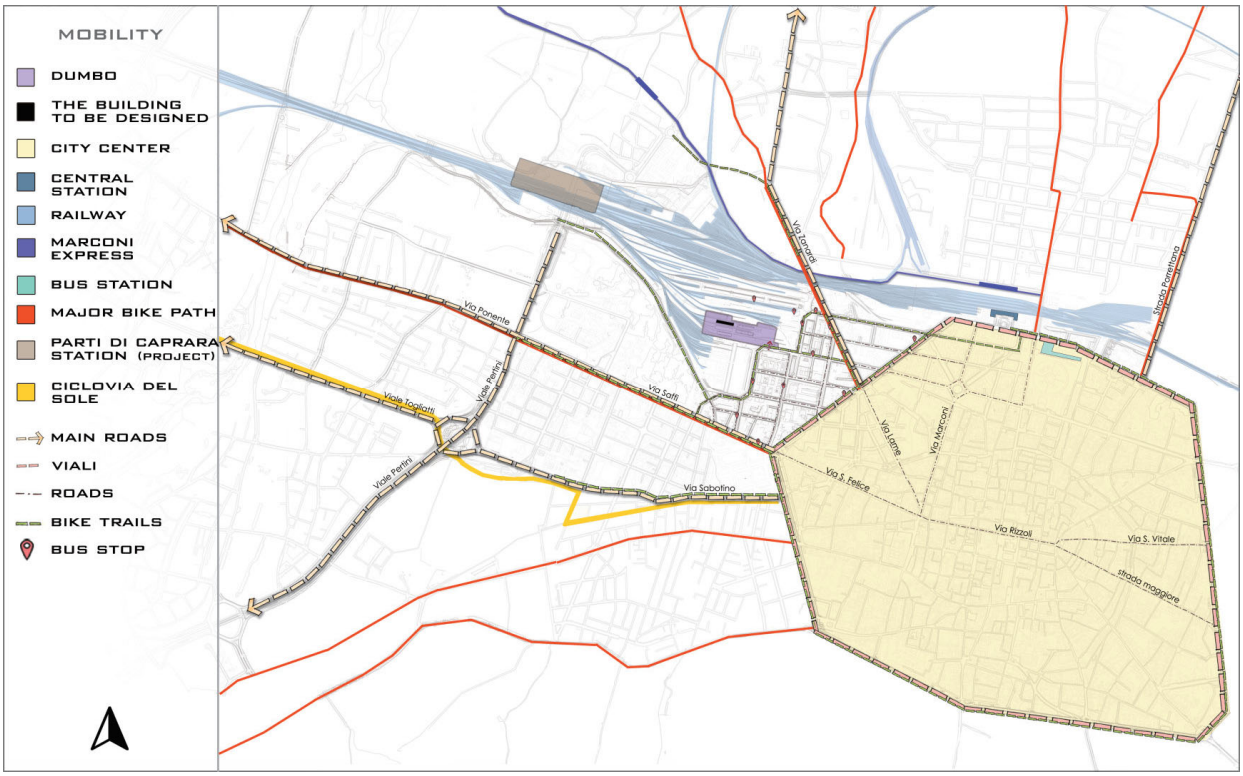


Figure 14: Nearby facilities analysis

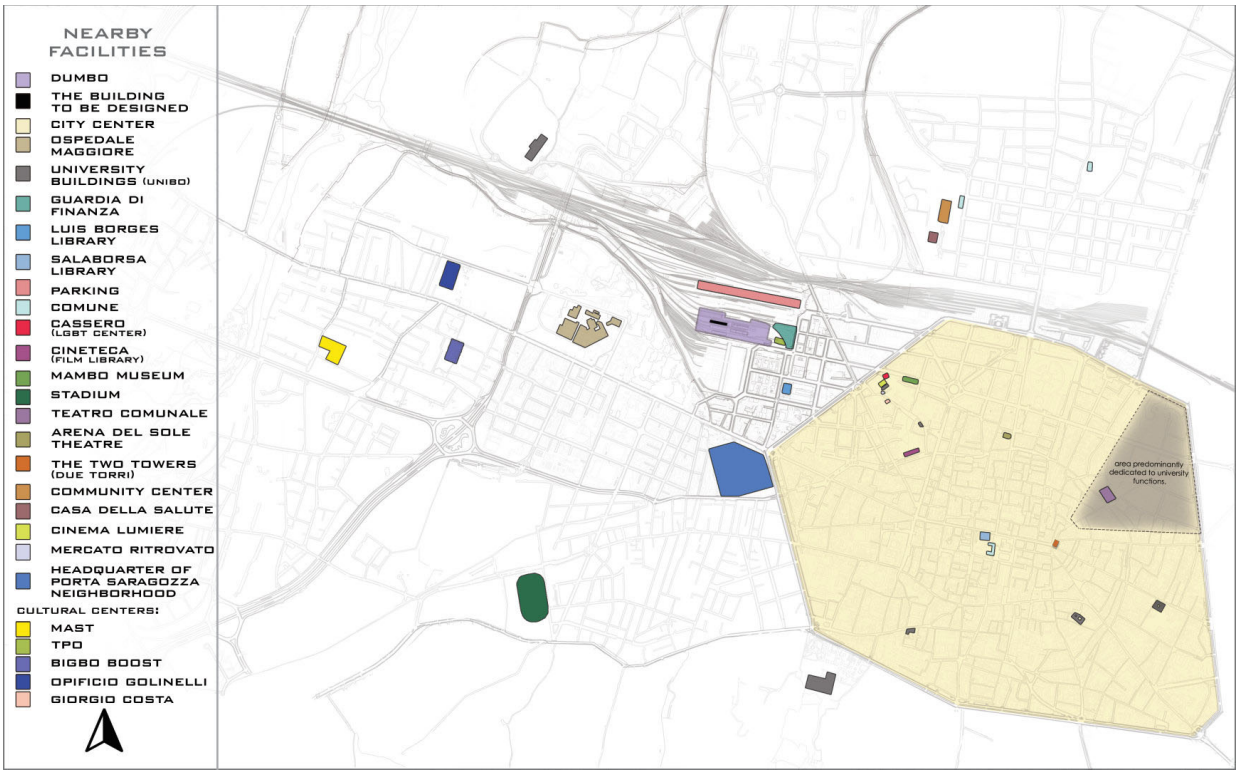


Figure 15: Environmental features analysis I

Figure 16: Environmental features analysis II

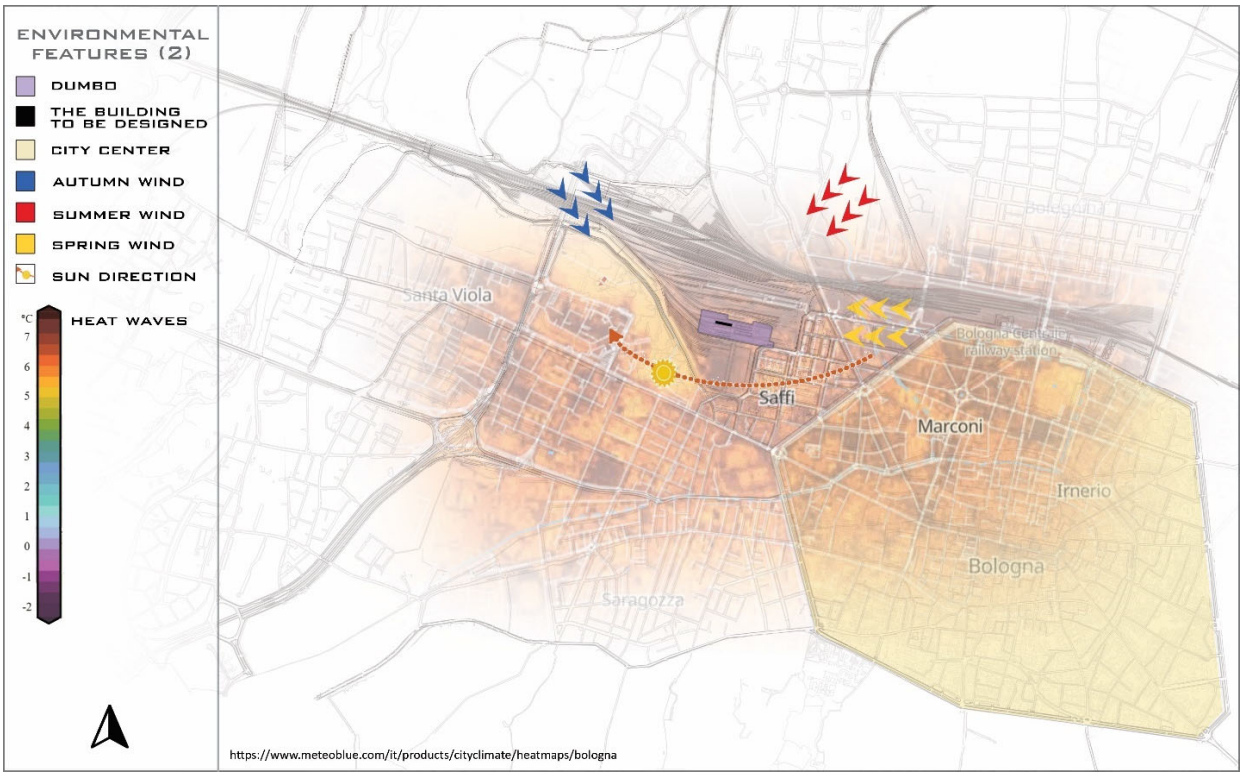
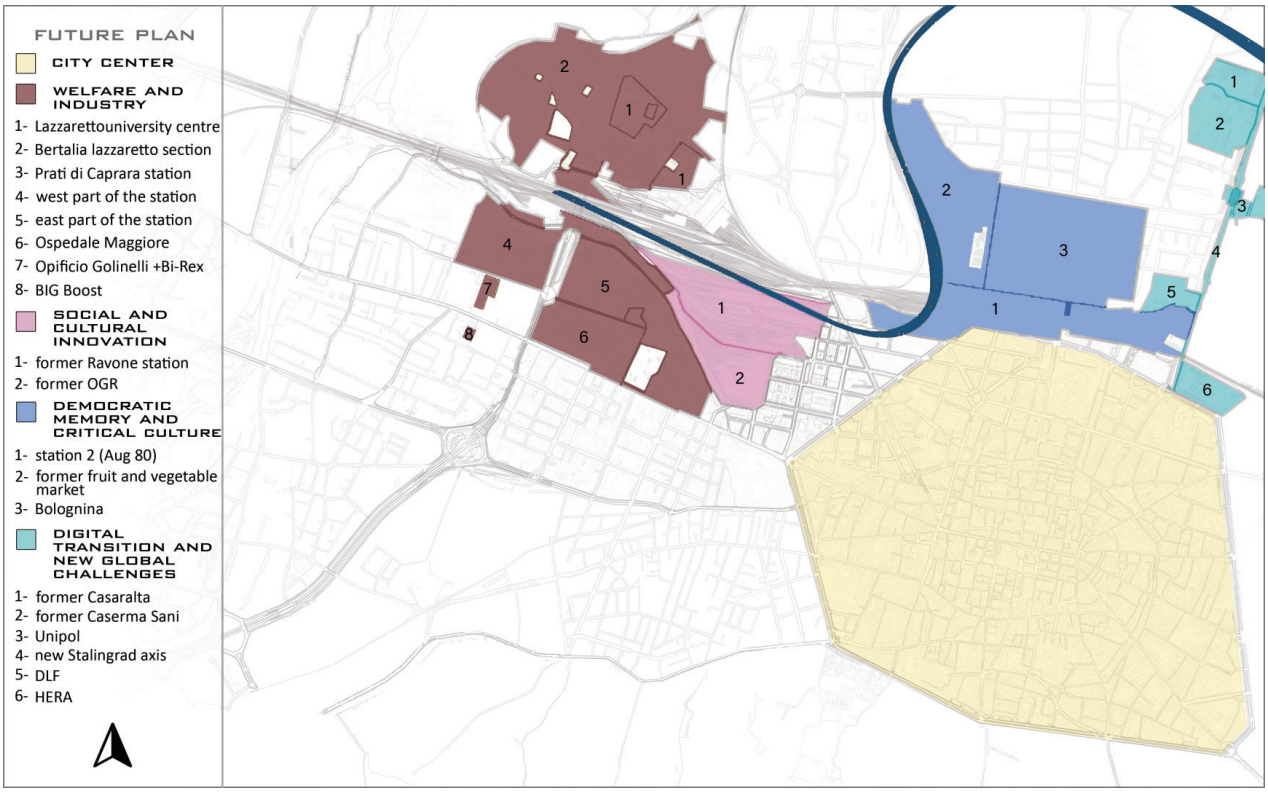


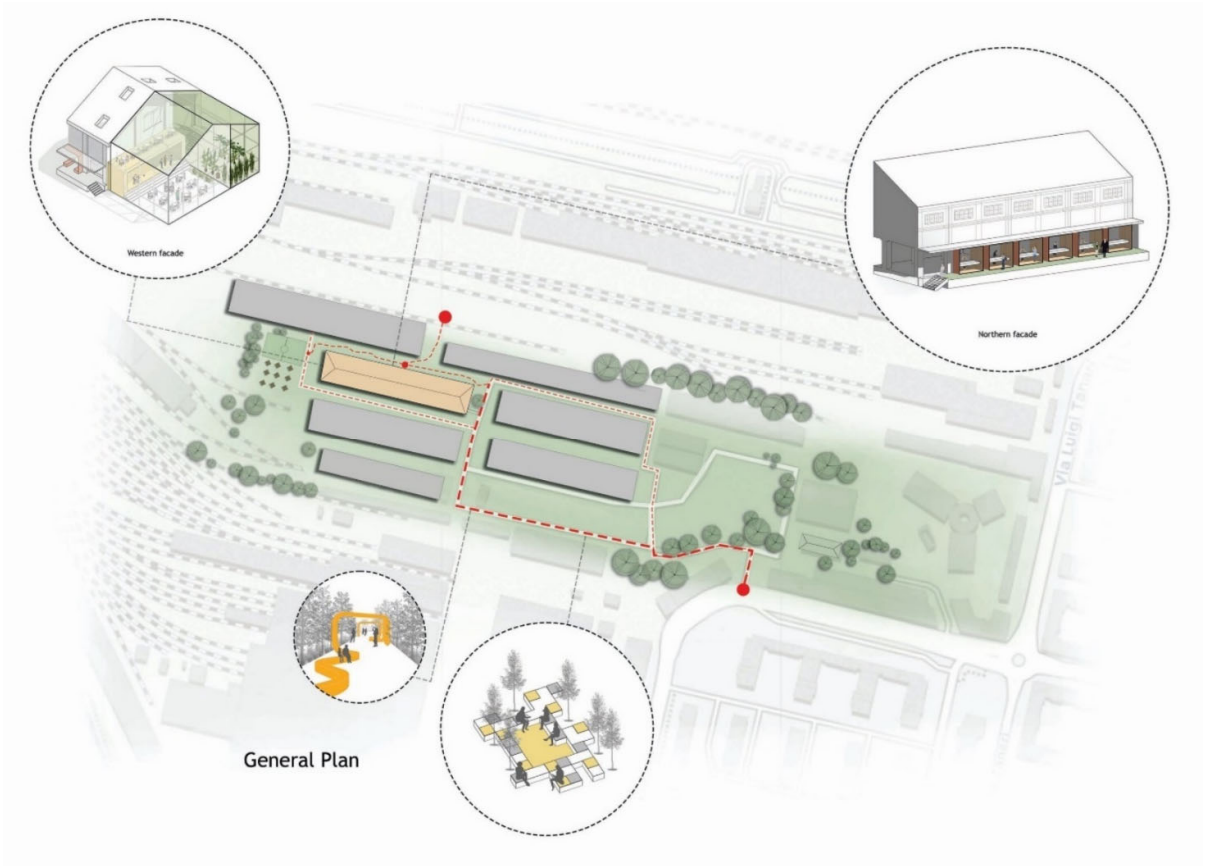
Figure 17: Future plan of the site



5.2 General Plan

The general plan illustrates the accessibility of the site, emphasizing a vibrant and inviting route designed to lead visitors to the main focus of the project: an old, unused shed slated for redevelopment. This plan incorporates various design elements that enhance the journey from the entrance to the building, making it more engaging and welcoming. Features such as landscaped pathways and strategically placed seating areas create a dynamic atmosphere that encourages exploration and interaction.

Figure 18: General plan of the site



5.3 Design strategies for the building

The design strategy for the building emphasizes flexibility, adaptability, and sustainability, responding to the specific environmental challenges of its location near a university campus and future dormitory. The goal is to enhance the livability of the area while reducing its ecological footprint.

The spatial design incorporates modular elements to create flexible spaces that can be reconfigured as needed. By using furniture and movable partitions instead of permanent walls, the building can adapt to various functions such as study areas, social spaces, or community activities. The integration of functional boxes within the building's columns adds aesthetic and practical value, serving as workshops, display areas, or seating. These features maximize space utilization and promote dynamic interactions throughout the building.

A key feature of the building is the solar greenhouse, which plays multiple roles in the sustainability strategy. It functions as a thermal buffer, capturing heat in winter and cooling in summer, thereby reducing energy consumption. The greenhouse also aids natural ventilation through the stack effect, minimizing the need for mechanical systems during transitional seasons.

The design allows for seasonal adaptability, enabling various uses throughout the year. In winter, the greenhouse offers a warm, well-lit space for community gatherings and gardening workshops. In summer, its operable facades open up to create an indoor-outdoor area for events like farmers' markets and exhibitions. In spring and fall, the space can be used for exhibitions, food festivals, or educational programs focused on sustainable living.

Community engagement is a central element of the design. The greenhouse supports urban agriculture, offering community gardening spaces that promote local food production and education. The building also serves as a living laboratory for sustainability, hosting workshops and classes on energy efficiency and urban farming. Its flexible spaces and greenhouse create an inviting social hub that fosters interaction among students, residents, and various community groups.

By integrating these strategies, the design creates a dynamic, sustainable space that adapts to changing needs while promoting community engagement and environmental responsibility. The solar greenhouse serves not only as a practical energy-efficient solution but also as a symbol of the project's commitment to sustainability and community-centered design. This approach enhances the building's performance while also positioning it as a unique destination that could drive further urban regeneration in the surrounding area.

Figure 19: Schematic design (plan view)

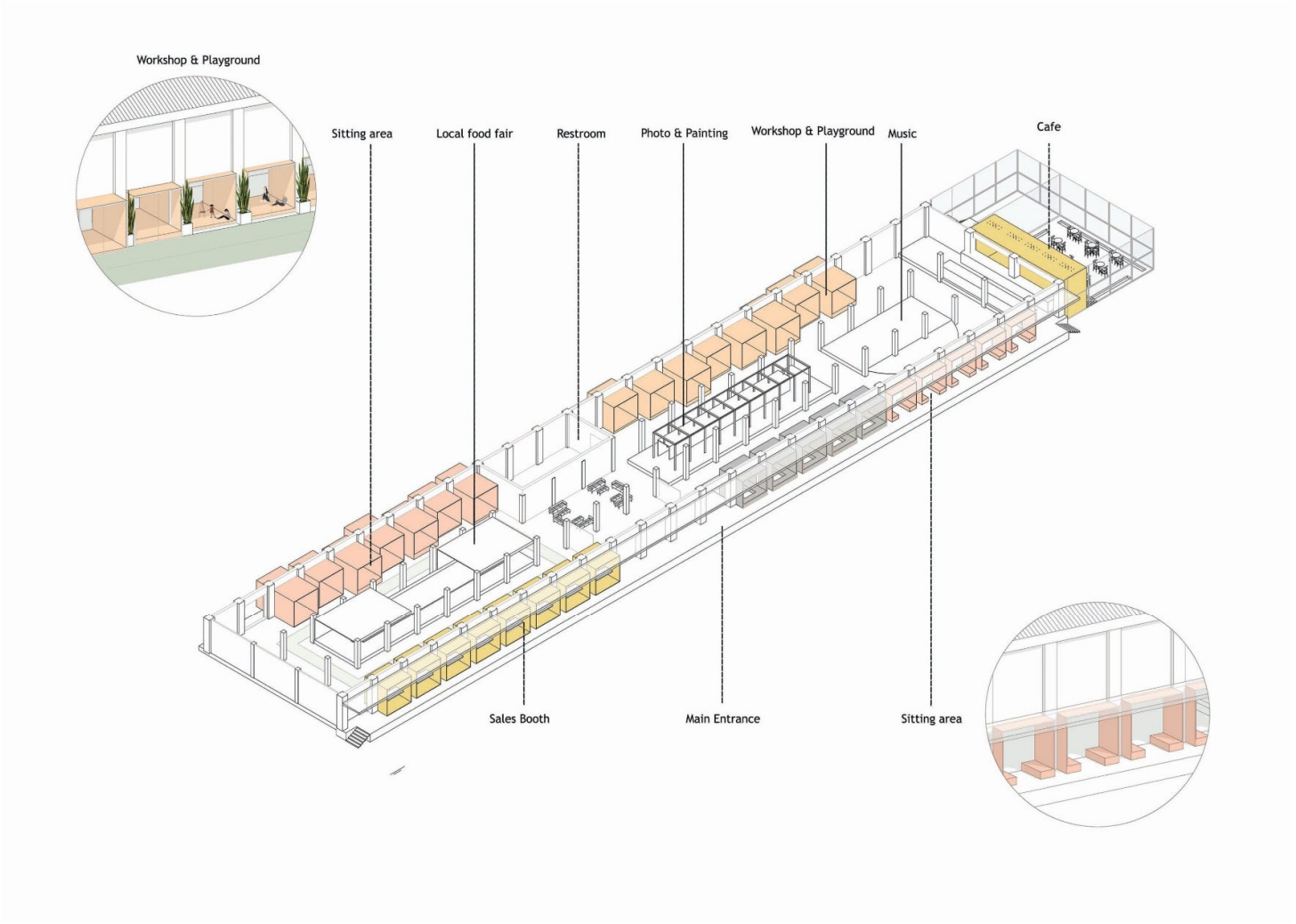


Figure 20: Schematic design (facade view)

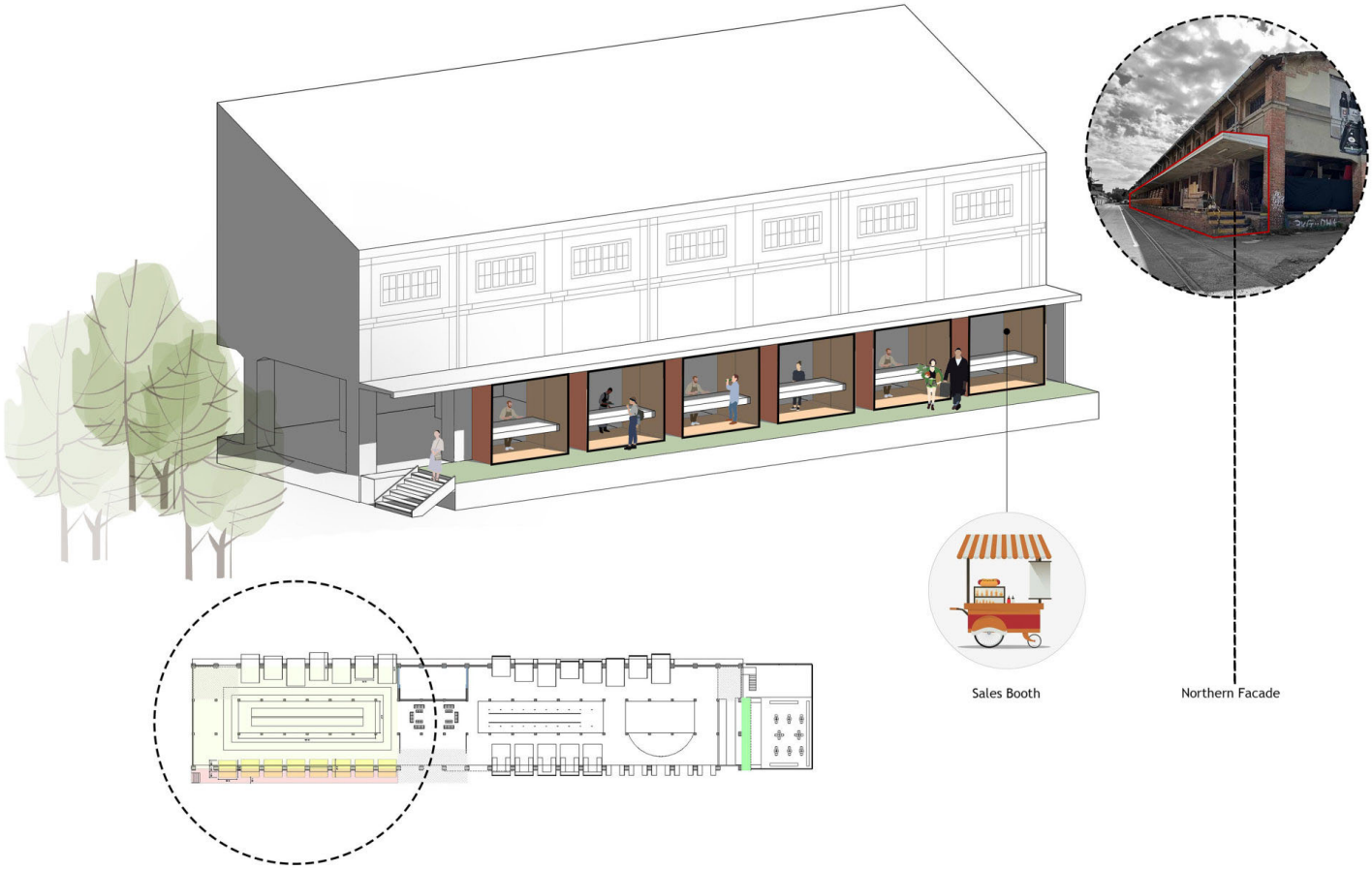


Figure 21: Schematic design (interior view)

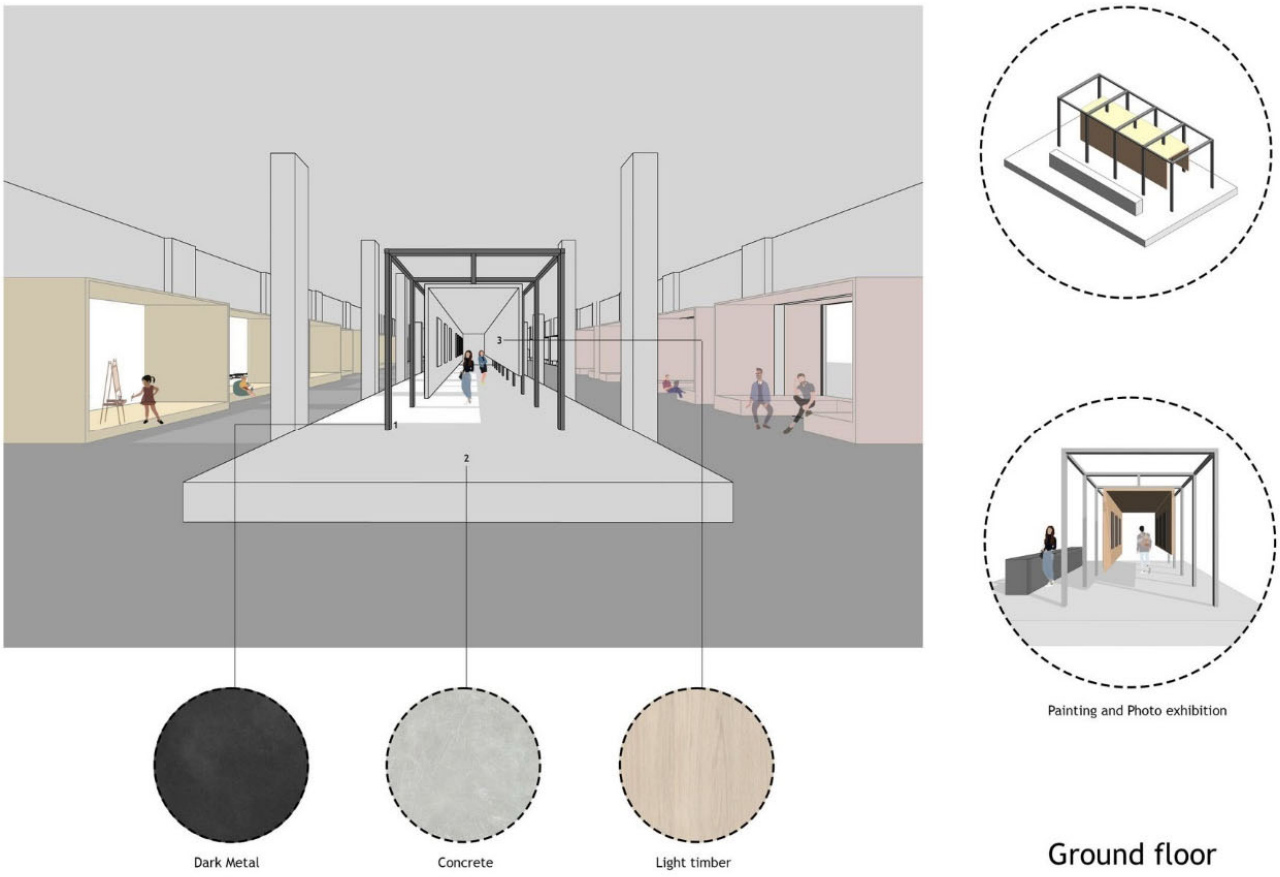
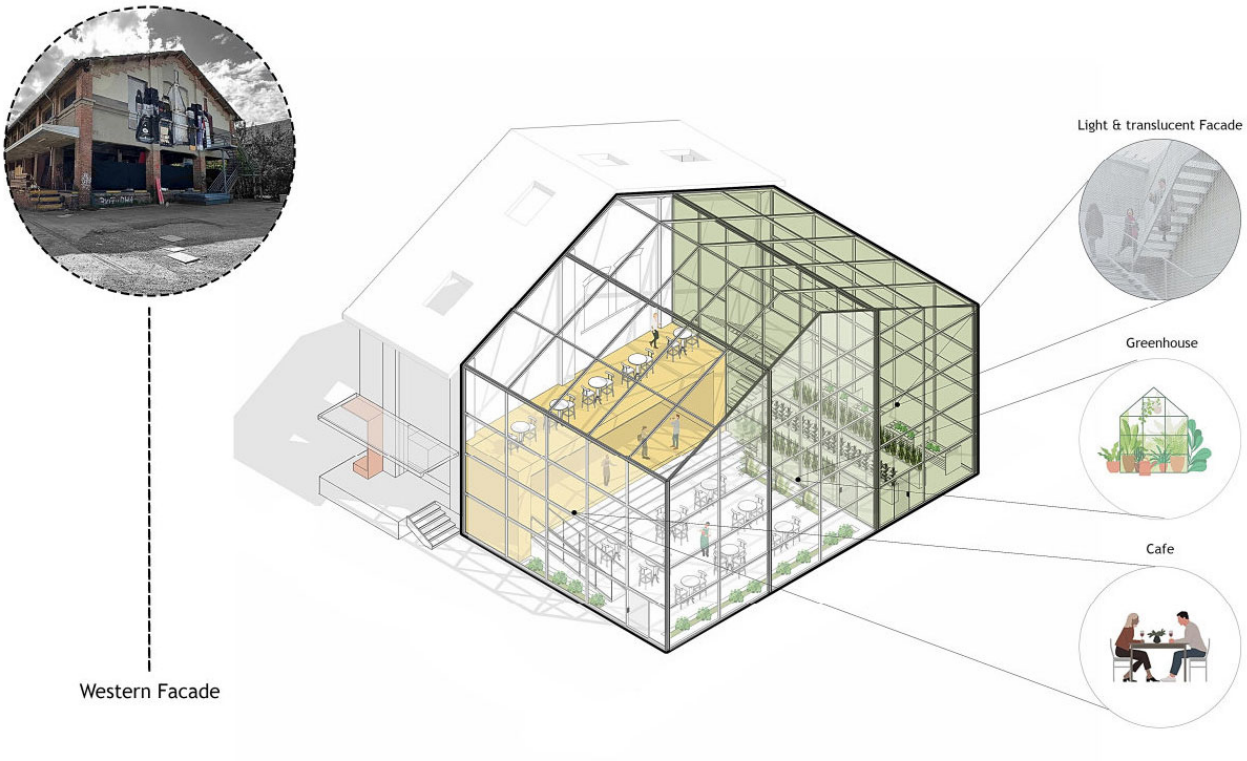
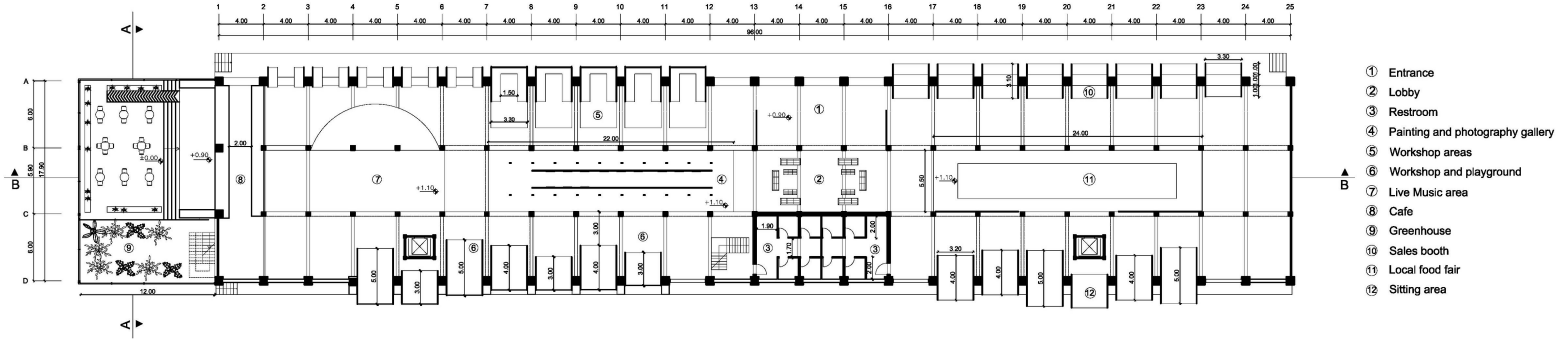


Figure 22: Schematic design (western view)



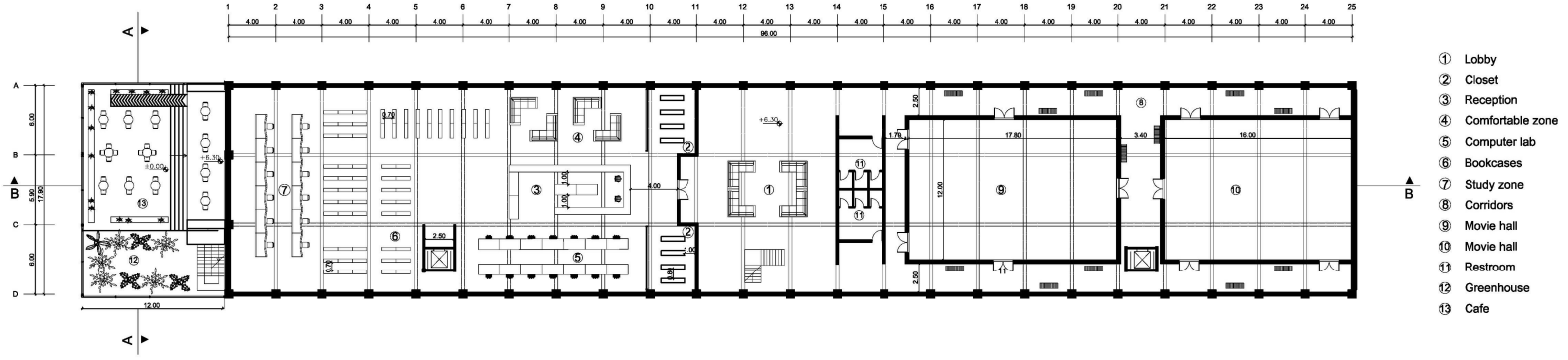
5.4 Architectural drawings of the designated building

Figure 23: Ground floor plan



Ground floor Plan
Sc 1.100

Figure 24: First floor plan



First floor Plan
Sc 1.100

Figure 25: Northern facade

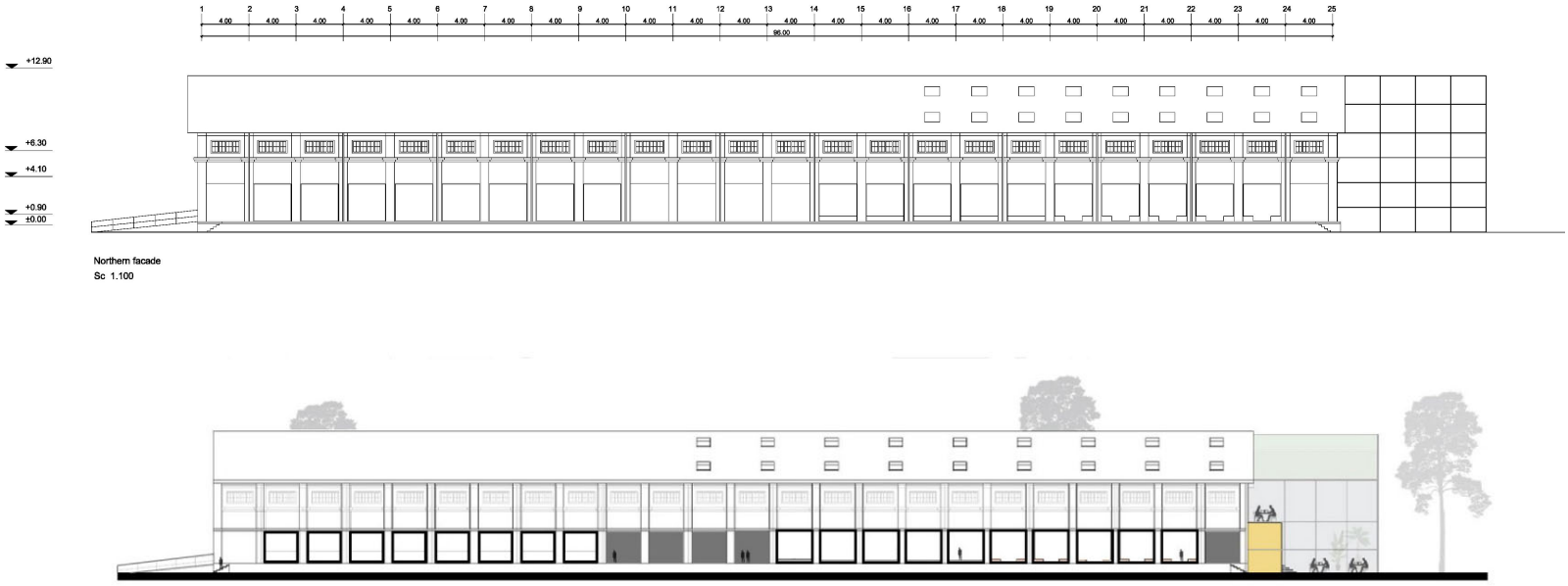


Figure 26: Southern façade

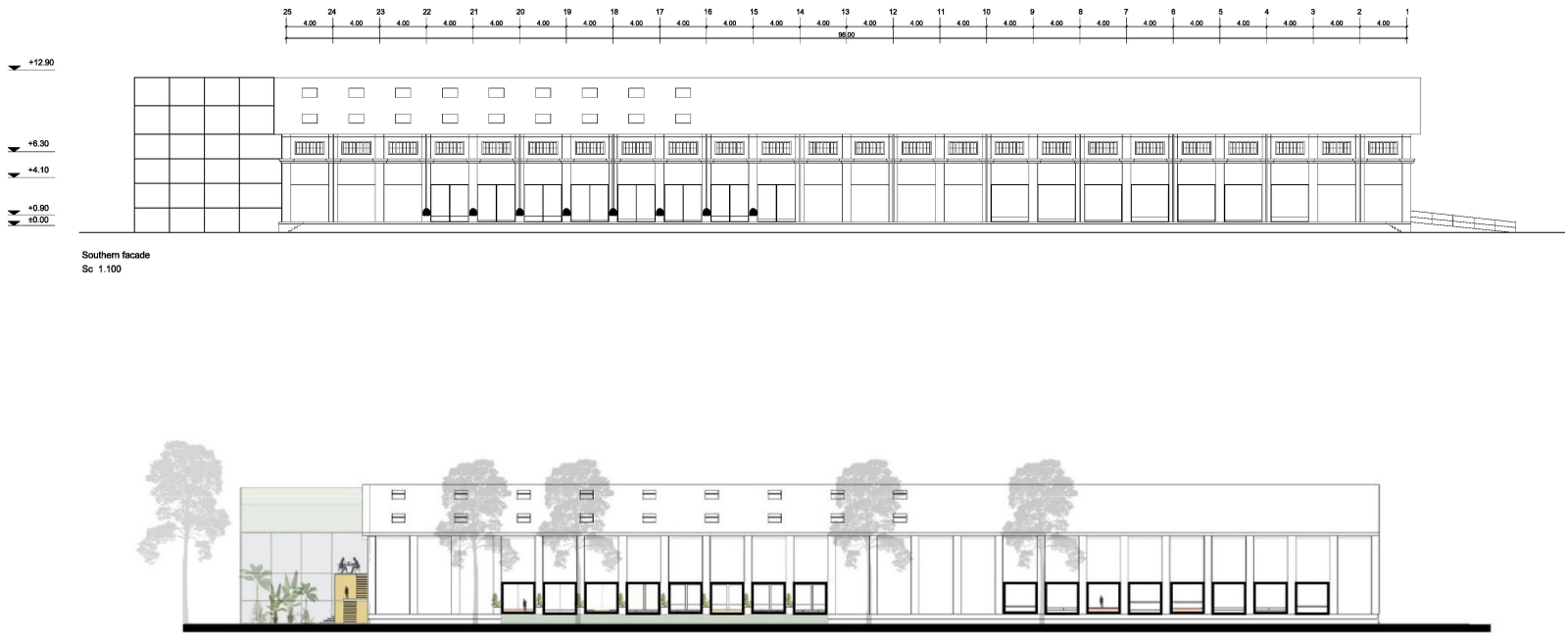


Figure 27: Eastern façade

Eastern facade
Sc 1.100

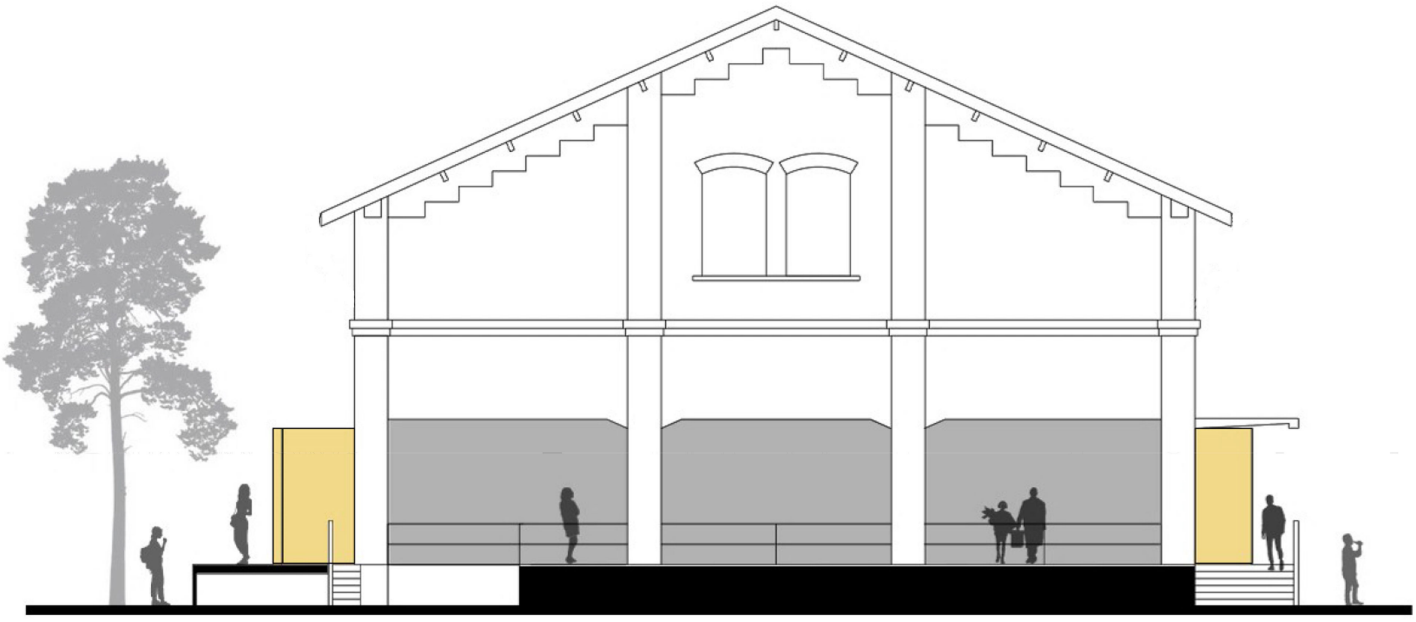
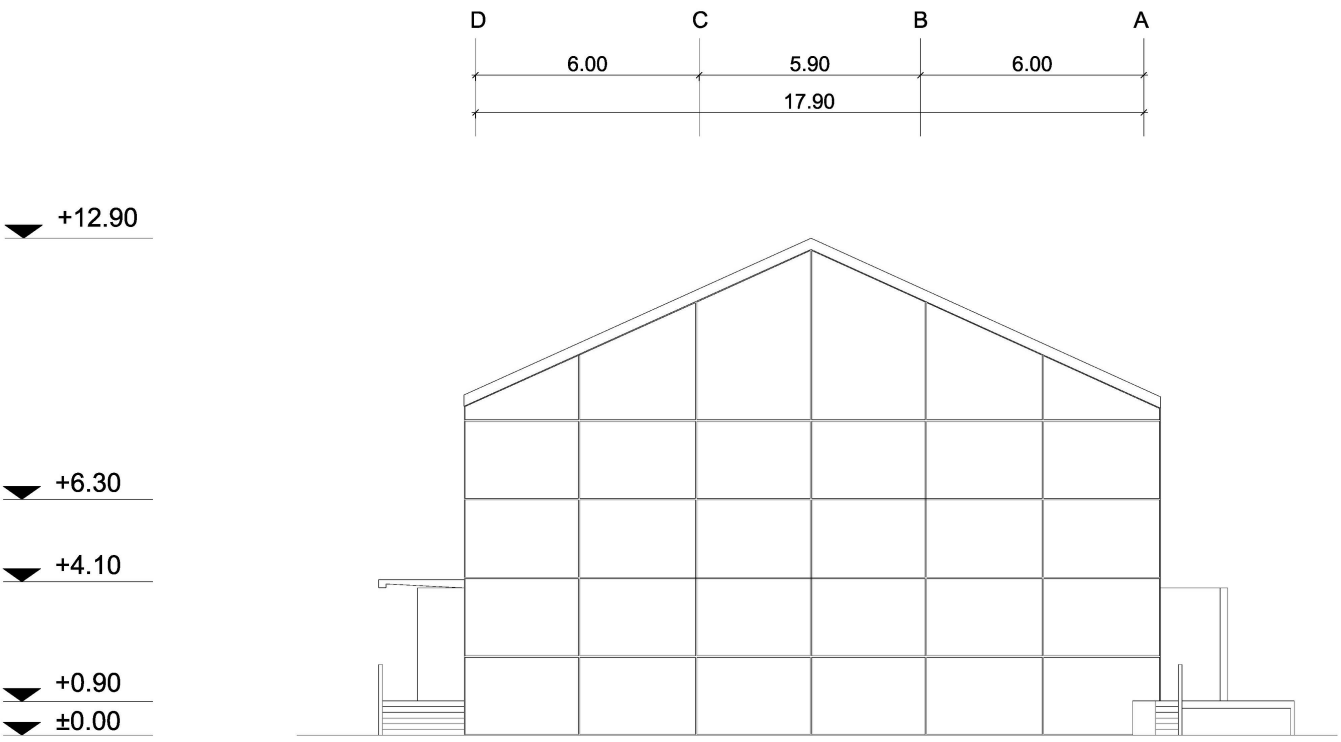


Figure 28: Western facade



Western facade
Sc 1.100

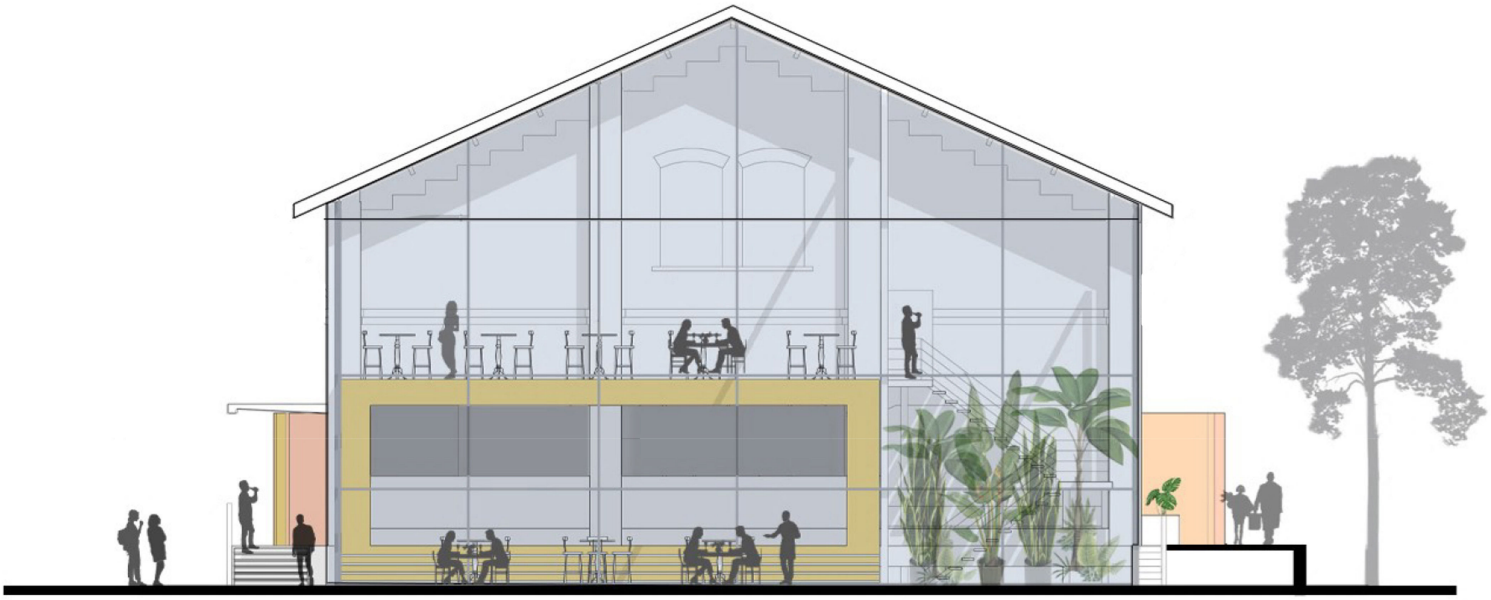


Figure 29: Section A-A

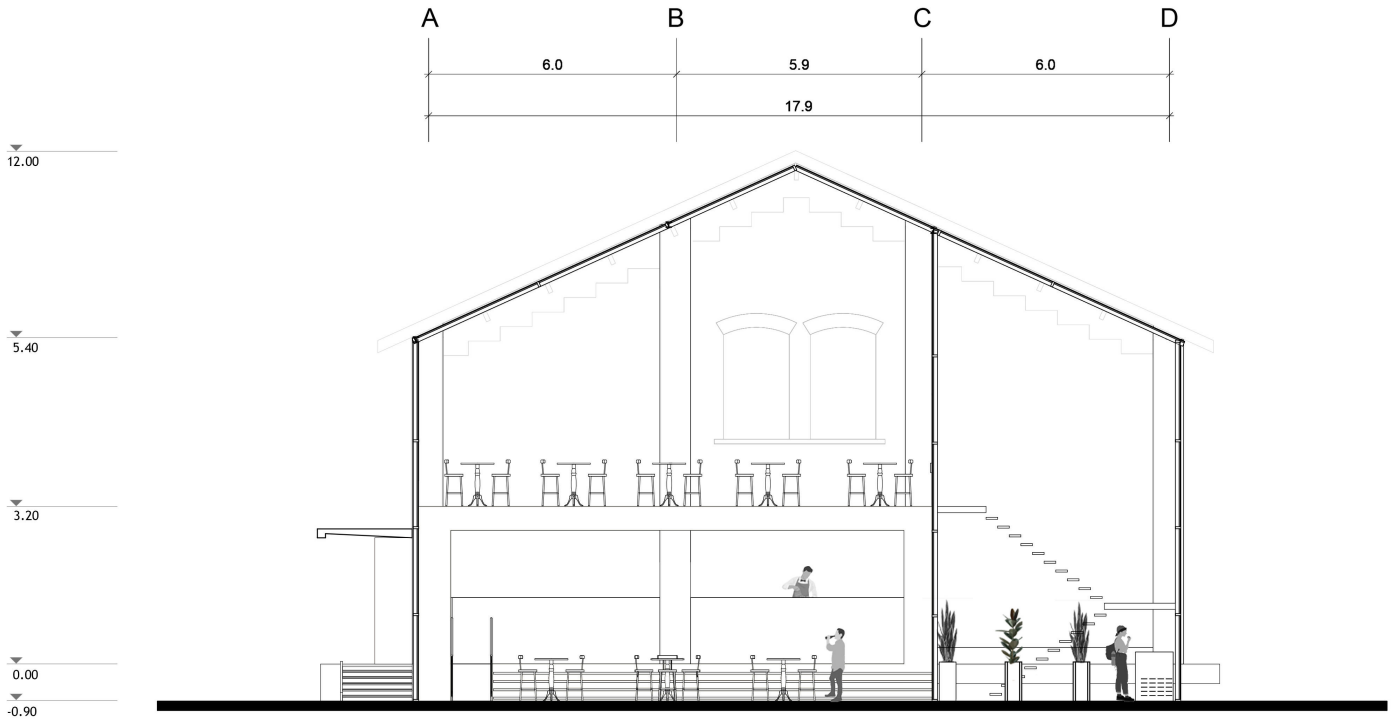
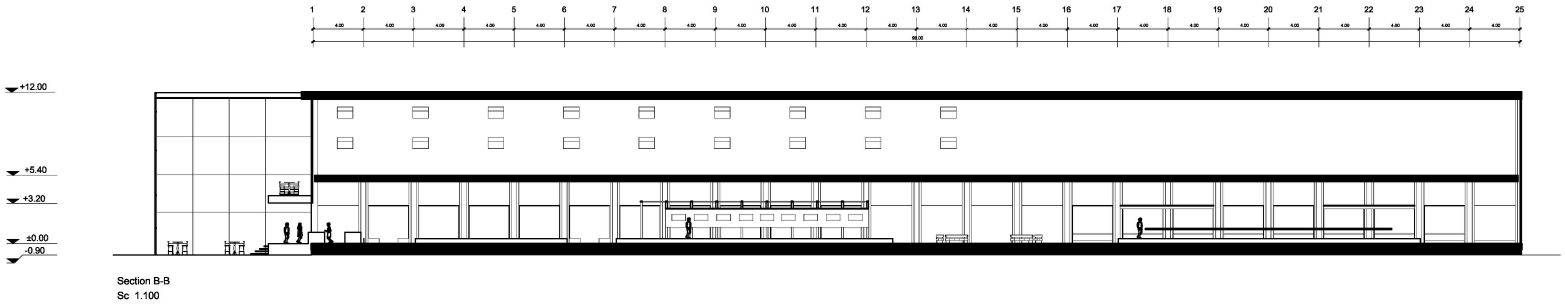


Figure 30: Section B-B



5.5 Green house

The integration of a greenhouse in this revitalization project serves as a cornerstone of the design, bridging sustainable architecture with community engagement. Attached to the repurposed building and connected to a coffee shop, this greenhouse is not merely an aesthetic addition but a multifunctional space that addresses several key objectives. It enhances the building's energy efficiency by acting as a thermal buffer, potentially reducing heating needs. The greenhouse also creates a unique social space, fostering community interaction and providing a tranquil environment for visitors to the coffee shop. By combining the coffee shop with the greenhouse, the design creates a unique "third place" where people can socialize, relax, and connect with nature in an urban setting. The inclusion of urban agriculture elements further enhances the space, promoting local food production and offering educational opportunities about sustainable practices.

Figure 31: Ground floor plan

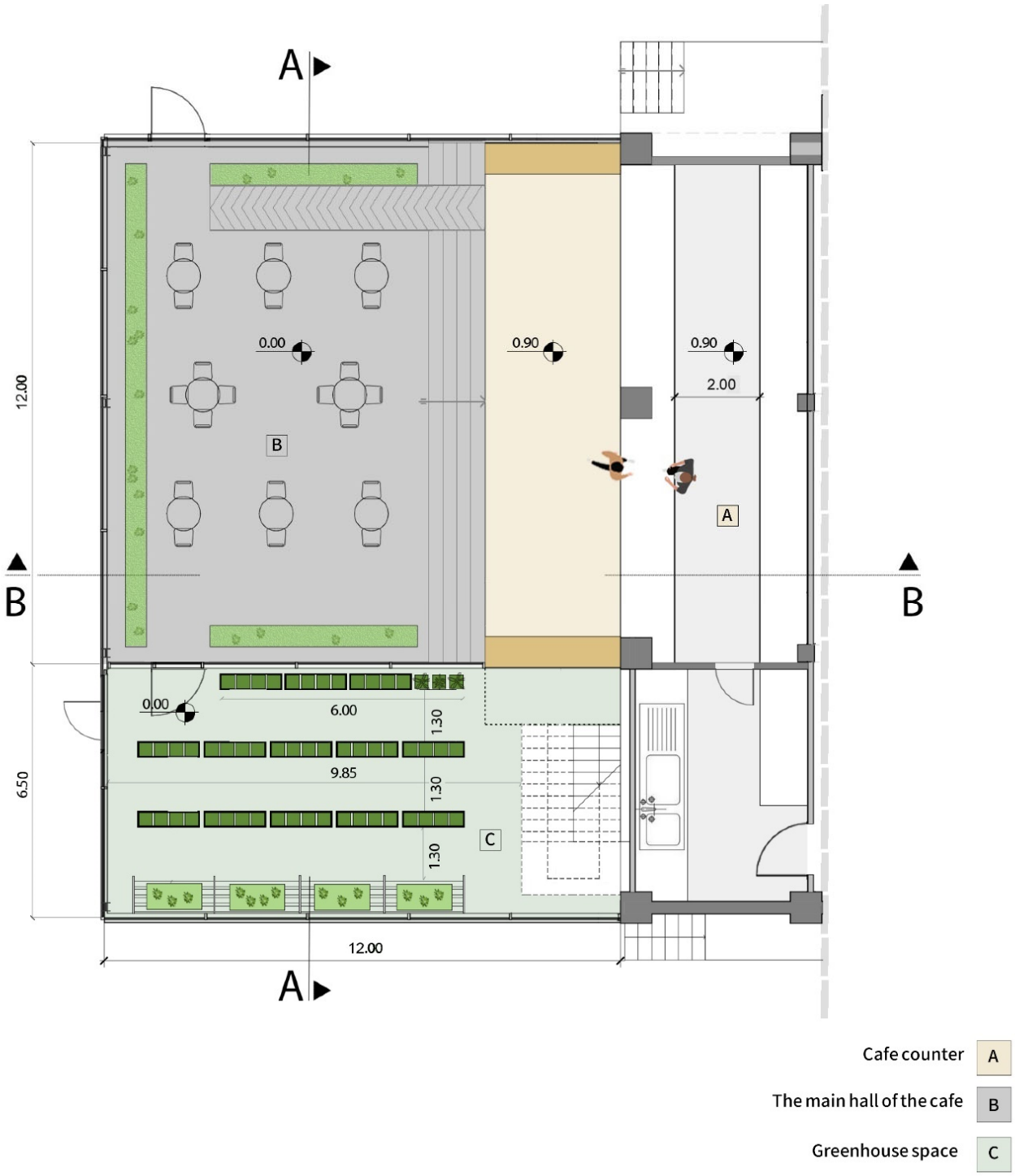


Figure 32: First floor plan

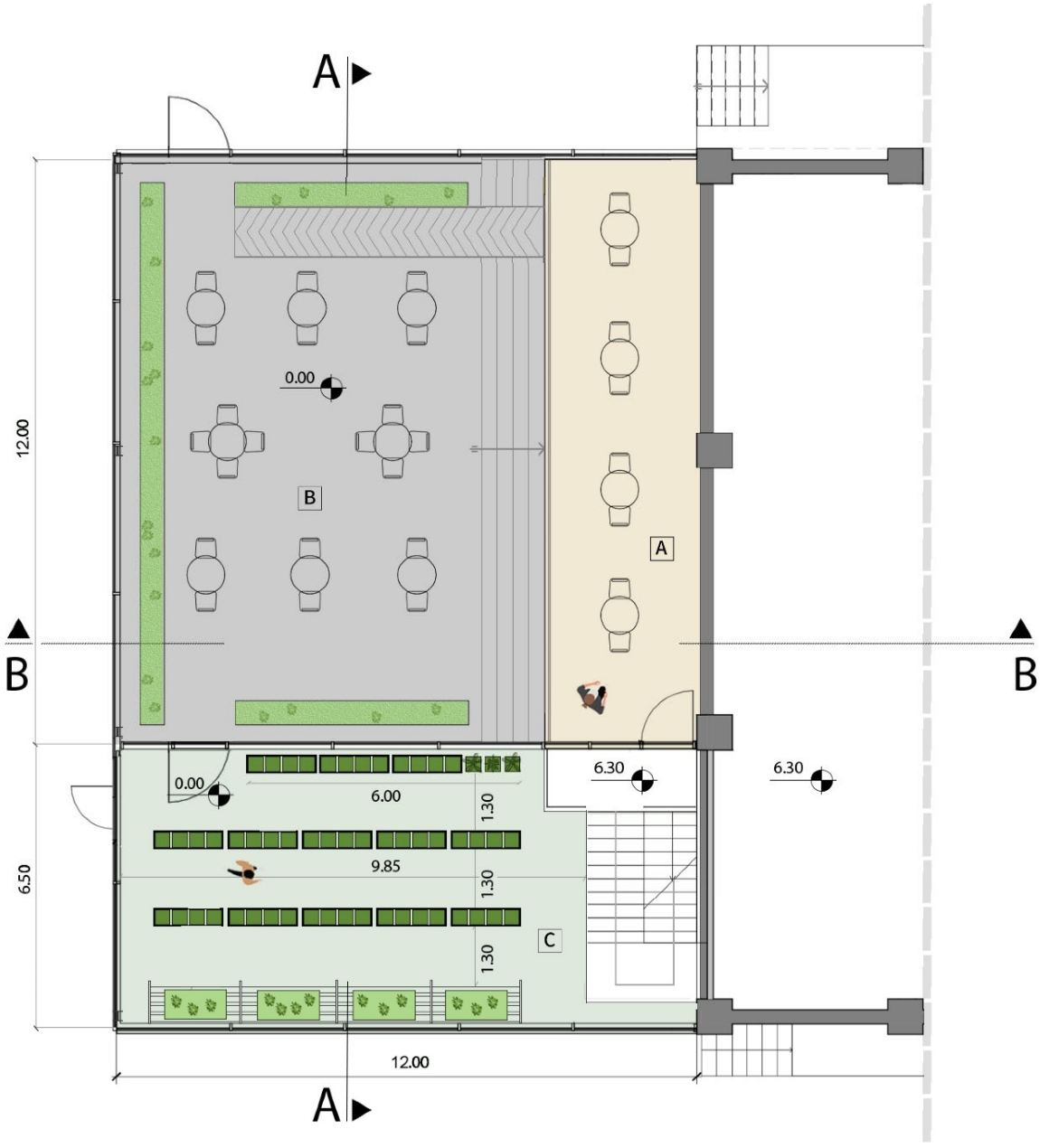


Figure 33: Perspective and glass walls of the green house

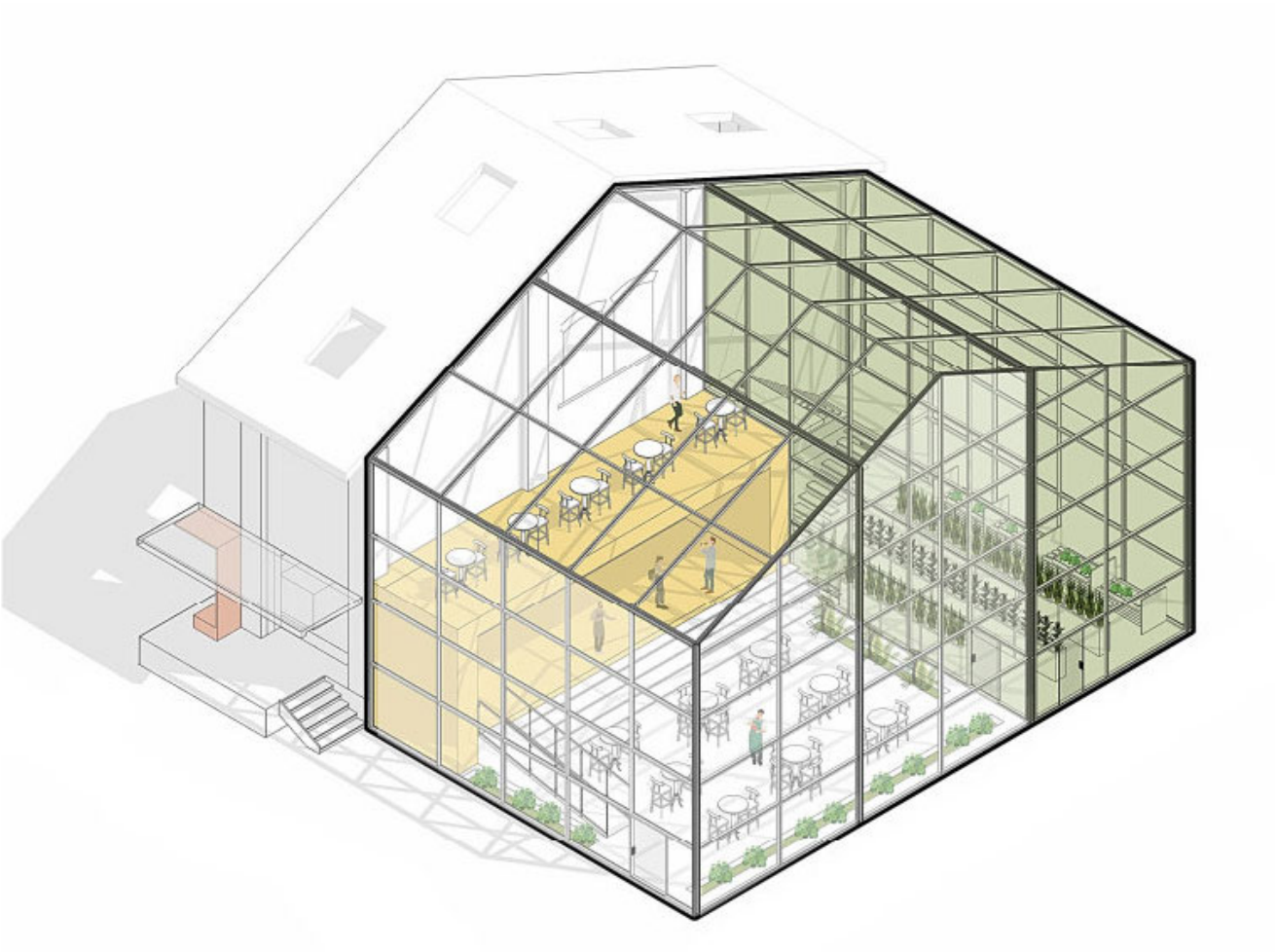


Figure 34: Functions in warm seasons

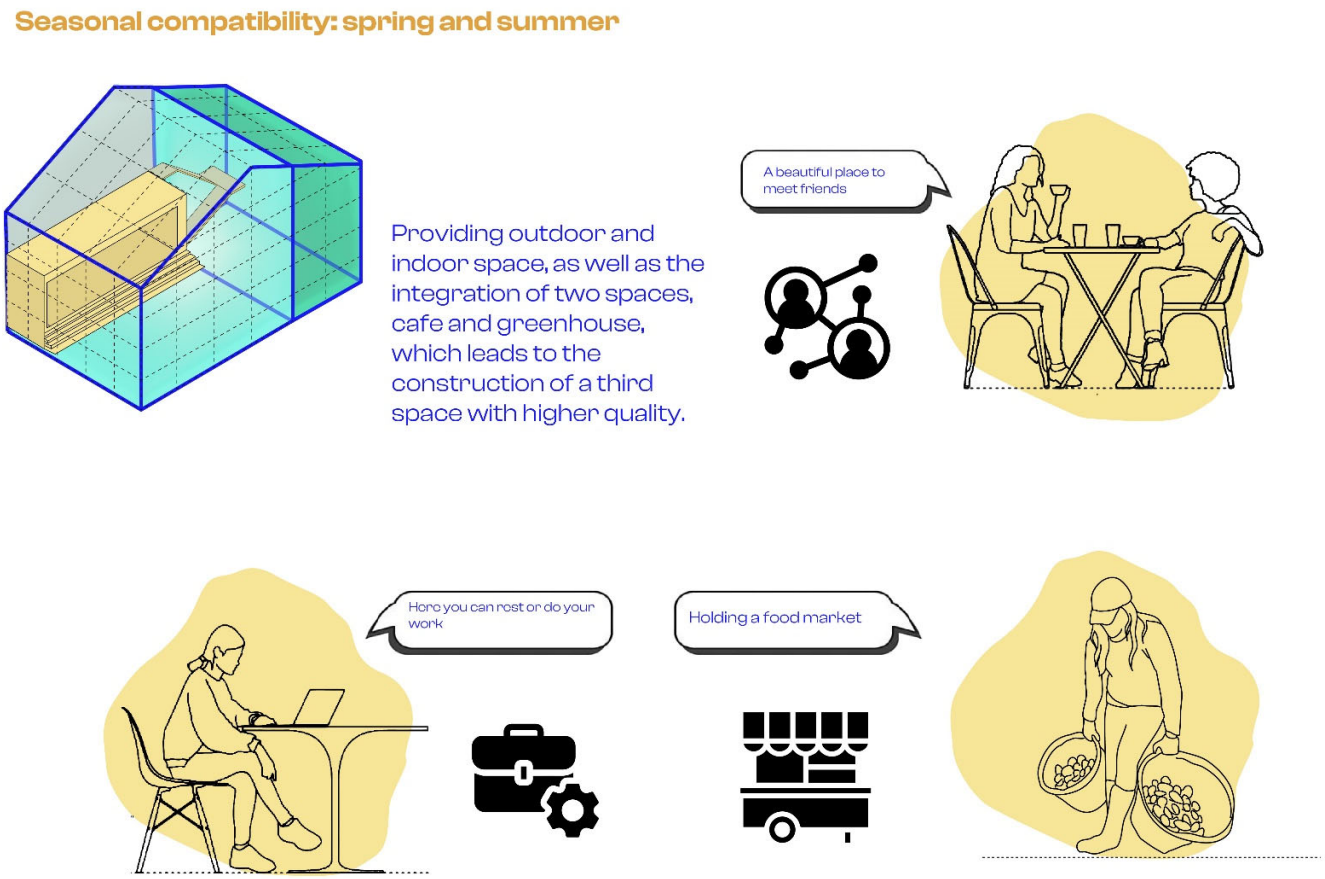
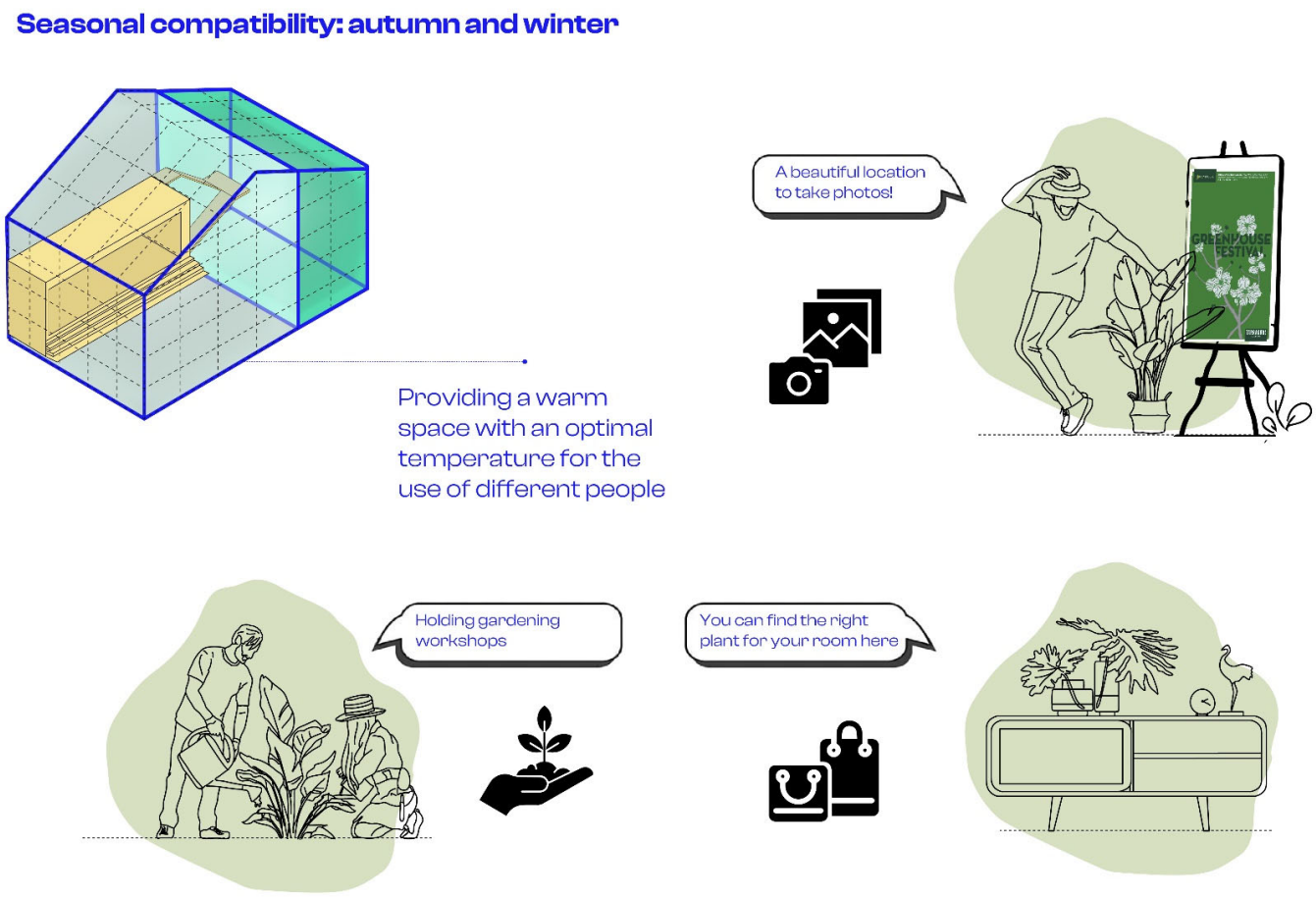


Figure 35: Functions in cold seasons



5.5.1 Detail design

Figure 36: Section B-B

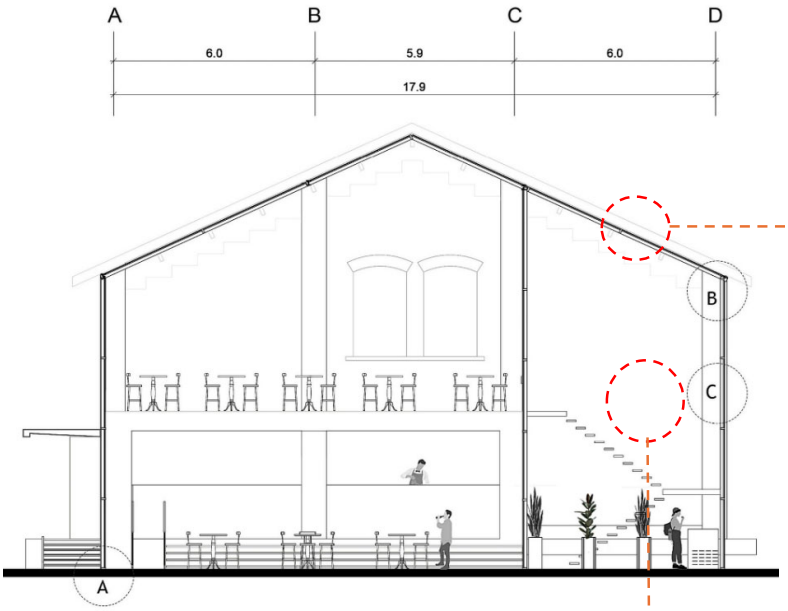


Figure 37:Pop up Window Det.

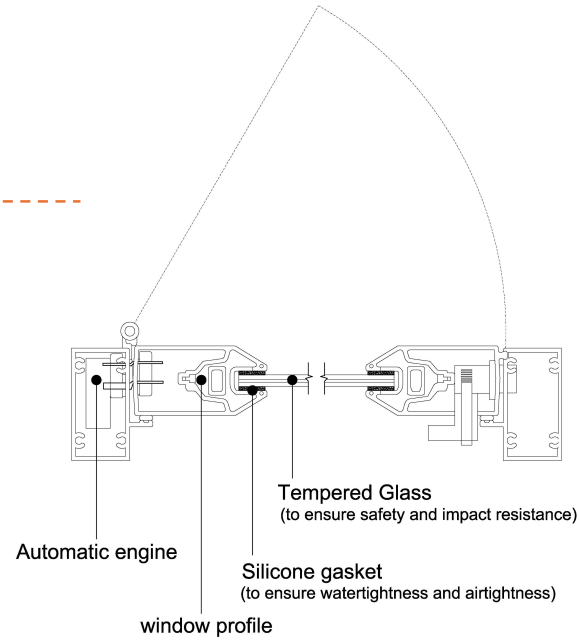


Figure 38: Wall section

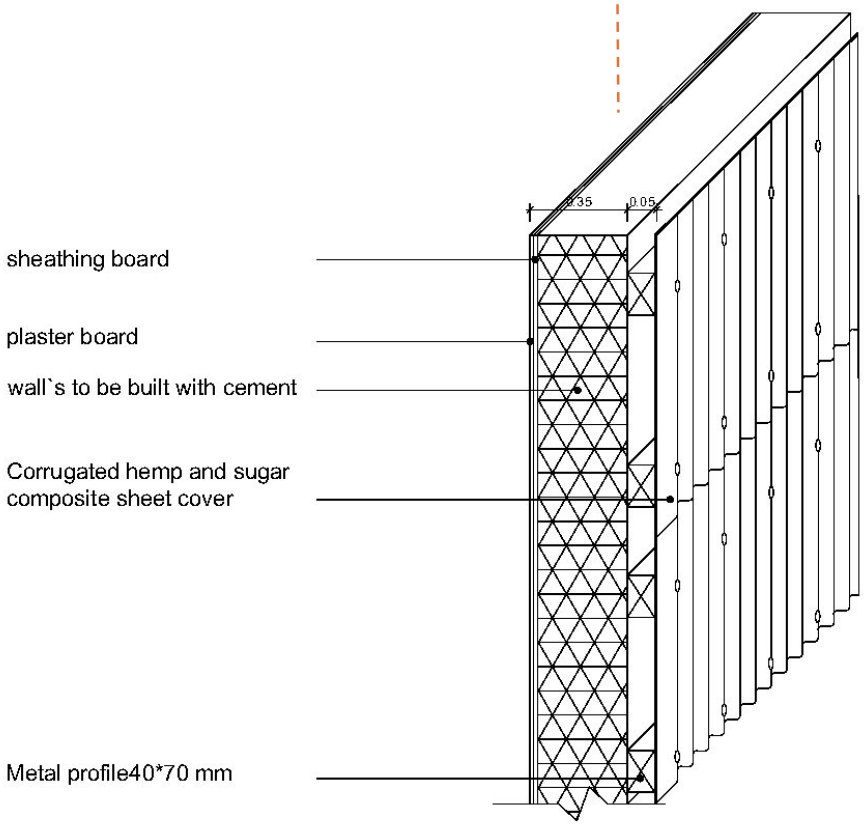


Figure 39: Detail A

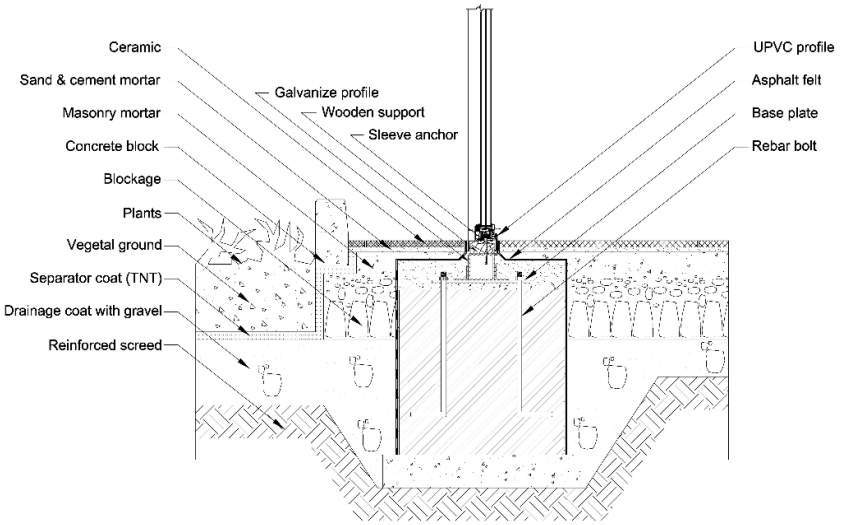


Figure 40: Detail C

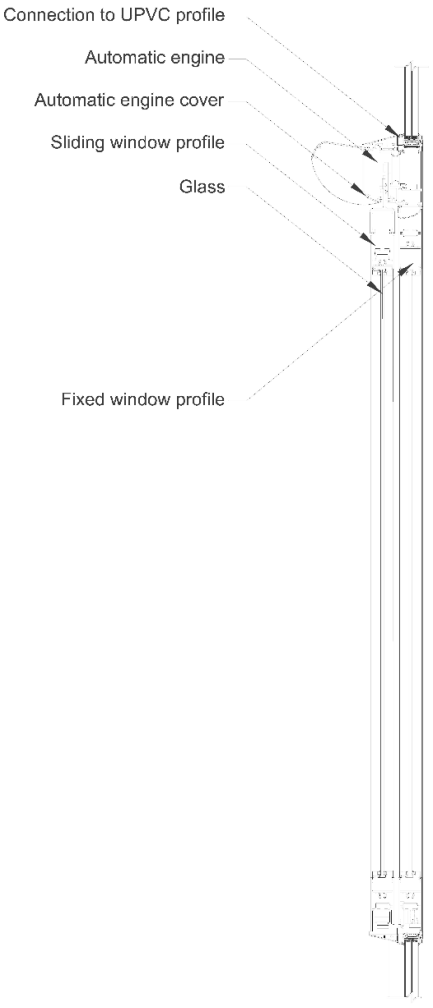
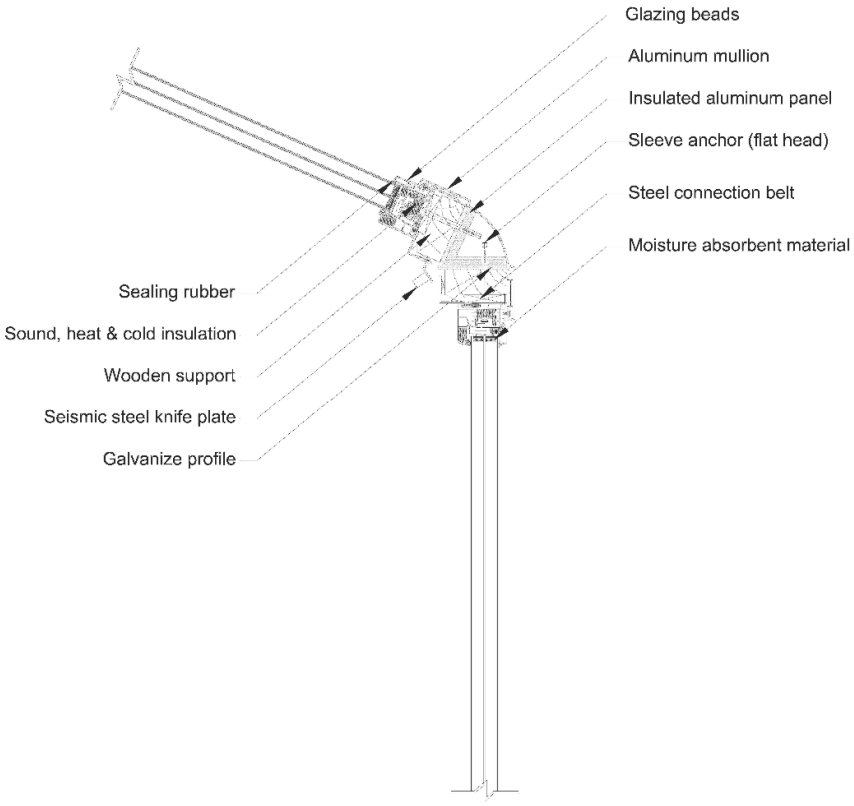
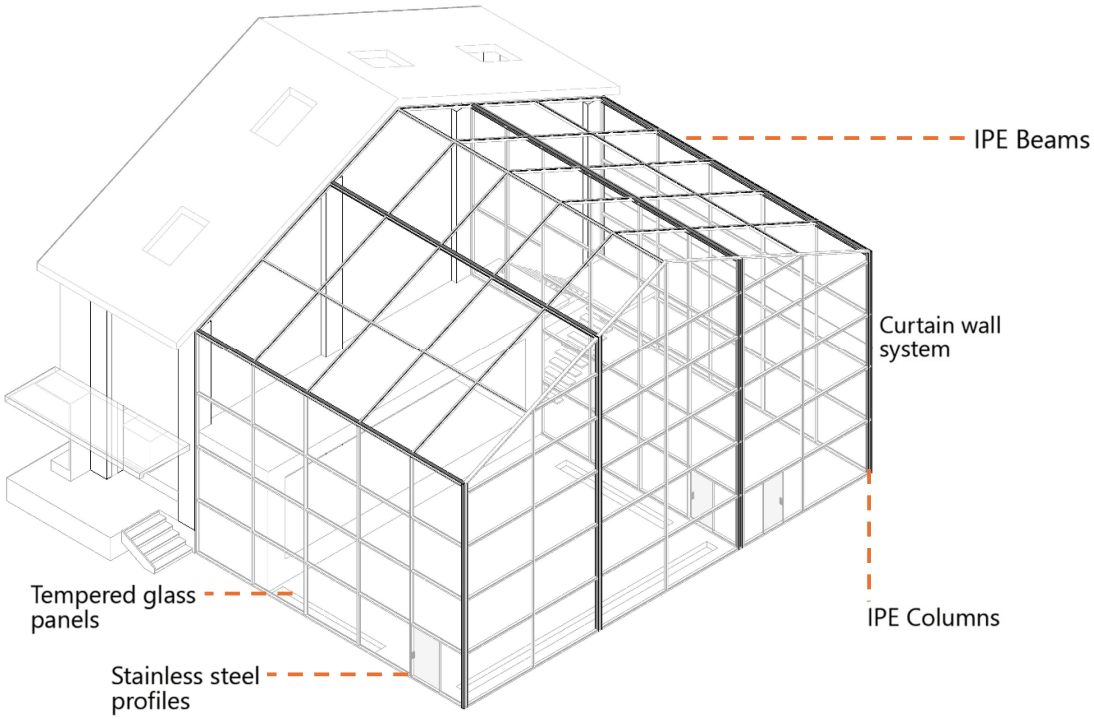


Figure 41: Detail B



5.5.1.1 Structural system



5.5.2 Plants

In selecting plants for the ornamental greenhouse combined with a café, it is essential to consider both aesthetic appeal and functionality. The chosen plants should not only enhance the visual environment but also provide practical benefits, such as fresh produce and aromatic herbs for café use (Epic Gardening, 2023). Additionally, the compatibility of the selected species with the specific irrigation system must ensure optimal growth and maintenance, contributing to a sustainable and vibrant greenhouse ecosystem (TNAU Agritech Portal, n.d.; Gardening Know How, 2021).

- **Ornamental Plants:**

Geraniums: These cheerful, low-maintenance flowers offer stress-reducing properties and are perfect for greenhouse cultivation (Garden Buildings Direct, 2021).

Petunias: Ideal for brightening up the greenhouse with lovely pastel colors and easy to grow (Garden Buildings Direct, 2021).

Ficus varieties: Ficus audrey, Ficus benjamina, and Ficus elastica (rubber tree plant) can add a striking tropical feel to the greenhouse (Epic Gardening, 2023).

- **Edible Plants (for cafe use and visual appeal):**

Herbs: Basil, mint, rosemary, and thyme are excellent choices. They're aromatic, visually appealing, and useful for the cafe (Epic Gardening, 2023).

- **Unique Additions:**

Epiphyllum crenatum: This plant produces stunning, fragrant flowers that can fill the greenhouse with a delightful scent (Tea Break Gardener, 2019).

- **Foliage Plants:**

Caladiums: Their colorful foliage can add visual interest to shaded areas of the greenhouse (Gardening Know How, 2021).

5.5.3 Irrigation system

- **Ornamental plants:**

Micro-irrigation is an efficient method well-suited for greenhouse applications. For a small greenhouse, it provides precise water delivery, improving water use efficiency and crop productivity. Key components include a water source, pumping devices, filtration systems, pipes, control valves, and emission devices (TNAU Agritech Portal, n.d.).

Suitable micro-irrigation systems for this size include:

Drip Irrigation: Delivers water directly to the root zone, offering precise watering and reduced disease risk, but requires maintenance (ErfGoed, n.d.).

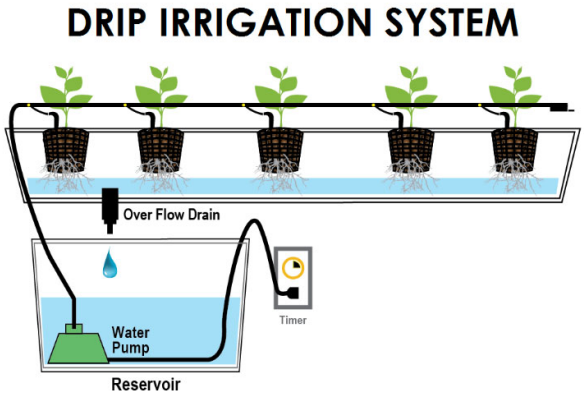
Micro-sprinklers: Spray water over a wider area, suitable for various soil types (Water Irrigation, n.d.).

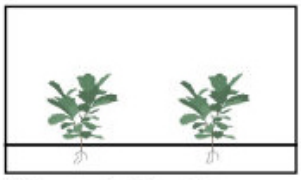
Foggers: Create a fine mist for humidity control and cooling.

A combination of these methods might be optimal, such as using drip irrigation for ground-level plants and micro-sprinklers or foggers for hanging baskets or taller plants.

Considering incorporating smart technologies for automated water delivery based on factors like soil moisture and temperature. Water quality, filtration, and potential for water recycling or rainwater harvesting are also crucial considerations for system efficiency and sustainability (Proksch, 2017).

Figure 42: Schematic of micro irrigation system



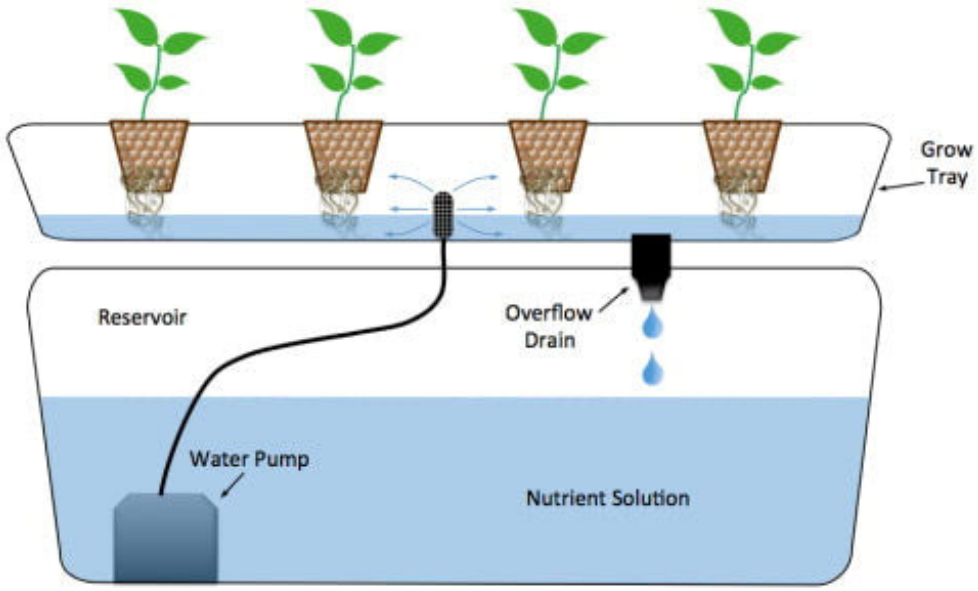


Irrigation efficiency	Water use (gallon/h and l/h)	Evaporation losses	Installation cost
80-90%	5-45 GPH 20-180 l/h (system with low flow rate)	Low	Low

- **Edible Plants:**

The ebb and flow system is a highly effective hydroponic method for cultivating edible plants, particularly in greenhouse environments. This system operates by periodically flooding the plant roots with a nutrient-rich solution and then draining it away, which provides essential water, nutrients, and oxygen to the roots. This cycle promotes rapid growth and high yields, making it ideal for fast-growing edible crops such as leafy greens, herbs, and even fruiting plants like tomatoes and peppers (Drottberger et al., 2023). The ability to control nutrient delivery and water availability allows for optimal plant health and quality. Additionally, the ebb and flow system is water-efficient, using less water than traditional soil methods, which aligns with sustainable agricultural practices (Mougeot, 2006). This method not only enhances the productivity of urban agriculture but also serves educational purposes, demonstrating innovative growing techniques in community gardens and urban farming initiatives.

Figure 43: Schematic of ebb and flow system



5.5.4 Energy system

The schematic diagrams (figure 38 and 39) illustrate how a passive solar greenhouse utilizes solar energy and natural processes to regulate its internal environment and minimize energy consumption:

1. **Solar Radiation**:

Short Wave Radiation: Sunlight (short wave radiation) enters the greenhouse through transparent panels.
Ground Heating: The ground inside the greenhouse absorbs this solar energy and heats up.

2. **Heat Distribution**:

Warm Air Circulation: As the ground heats up, it warms the air inside the greenhouse. This warm air rises, creating a natural convection current that helps distribute heat throughout the greenhouse.
Long Wave Radiation: The heated ground emits long wave (infrared) radiation, which cannot pass through the glass and is thus trapped inside, maintaining warmth.

3. **Environmental Regulation**:

Air Temperature: The greenhouse uses fans, pad cooling systems, and mechanical cooling to regulate air temperature. Fogging systems can also be used to cool the air.
Air Humidity: Humidity levels are managed using the same fogging and cooling systems.
Air Velocity: Natural ventilation through pop-up windows and other openings ensures fresh air circulation, aiding in temperature and humidity control.

4. **Lighting**:

The lighting system can include indoor/outdoor screens, whitewash shading, and orientation adjustments to optimize light use and minimize excess heat or glare.

5. **Heat Utilization**:

The excess heat generated within the greenhouse can be utilized to heat the entire building, showcasing an integrated approach to energy use and conservation.

6. **Natural Processes**:

- **Ventilation**: The diagram emphasizes natural ventilation through pop-up windows, allowing warm air to escape and fresh air to enter, further stabilizing the interior climate.

Figure 44: schematic design for the energy system I

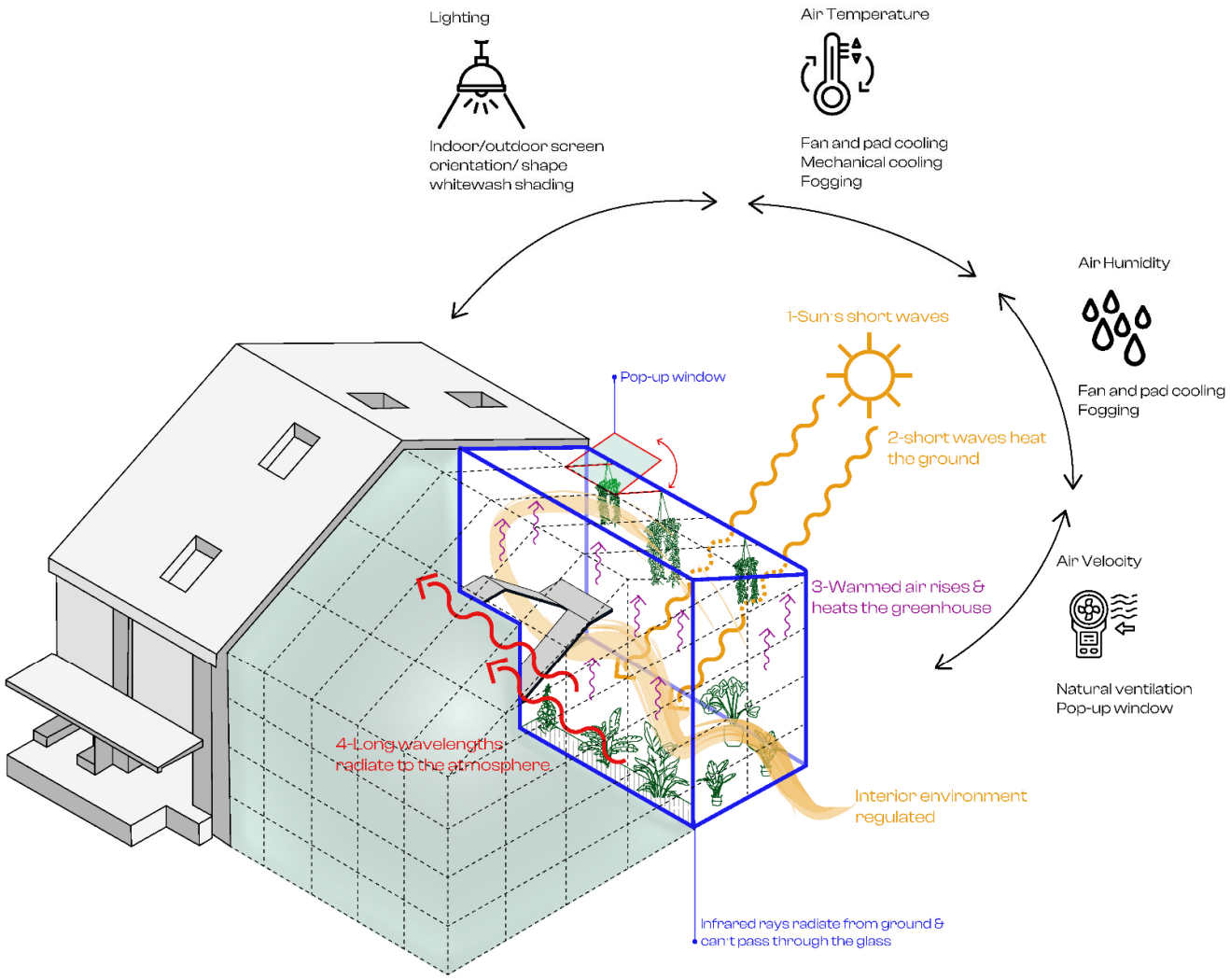
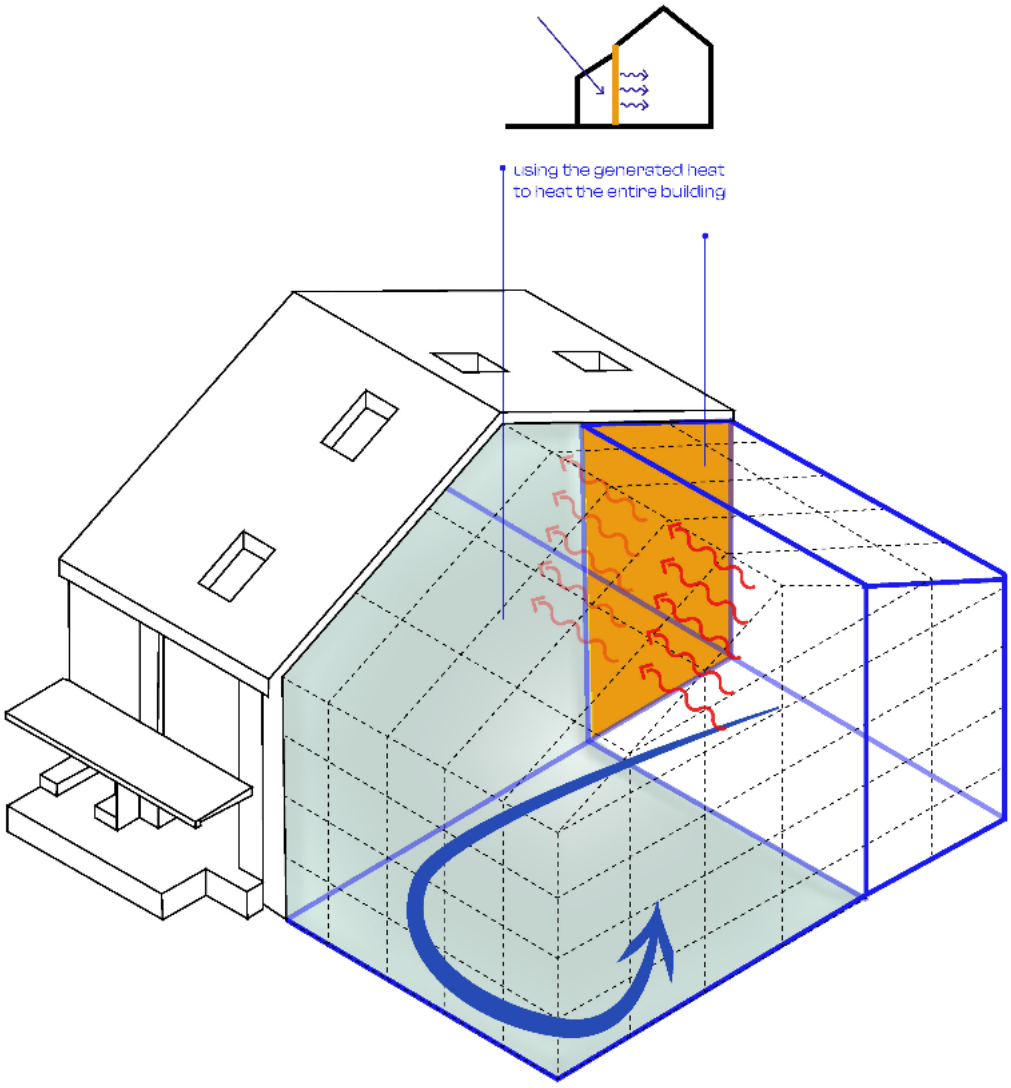


Figure 45: schematic design for the energy system II



5.6 Conclusion and Contribution

The revitalization of the former Ravone railway yard, with the adaptive reuse of the 'Temporanea' warehouse and the integration of a solar greenhouse, presents a significant case study in sustainable urban regeneration. This project not only breathes new life into a post-industrial site but also sets a precedent for how adaptive reuse and bioclimatic design can address contemporary urban challenges while fostering environmental sustainability and social inclusivity.

One of the primary contributions of this thesis is the demonstration of how passive energy strategies, such as the use of a solar greenhouse, can play a transformative role in urban regeneration. By utilizing natural processes like solar radiation and ventilation, the greenhouse contributes to the energy efficiency of the entire complex, reducing the reliance on mechanical systems and lowering the building's carbon footprint. This integration of renewable energy systems with traditional architectural design highlights a path forward for cities aiming to achieve net-zero energy goals.

Moreover, this project underscores the potential of adaptive reuse in preserving industrial heritage while meeting modern urban needs. The reuse of the 'Temporanea' warehouse retains the historical and cultural significance of the site, allowing for the conservation of Bologna's industrial past. By combining this heritage with innovative design elements like the solar greenhouse, the project creates a dialogue between the past and future, embodying the evolving identity of urban spaces in the 21st century. This approach not only minimizes environmental impact by avoiding new construction but also leverages the embodied energy of existing structures, making it a model for future regeneration projects.

A central aspect of this work is its emphasis on community-centered design. The integration of social spaces with urban agriculture creates a multifunctional environment where residents can engage in community activities, learn about sustainable practices, and participate in local food production. This community-oriented approach fosters social cohesion by creating shared spaces that cater to diverse groups, from students to local residents. The inclusion of urban farming also addresses issues of food security and promotes local, sustainable food systems, contributing to the resilience of urban communities.

The project also aligns with the principles of the circular economy by prioritizing the reuse of materials and promoting sustainable resource management. The solar greenhouse not only enhances the building's energy performance but also serves as an educational tool, teaching visitors about sustainable living and passive energy strategies. This dual function as both a

functional space and a site for learning reinforces the project's role in advancing urban sustainability and resilience.

From an architectural perspective, the design successfully blends historical industrial aesthetics with contemporary sustainable technologies. The use of glass for the greenhouse structure not only facilitates passive solar energy capture but also creates a visually striking contrast with the existing warehouse, symbolizing the fusion of heritage and innovation. This careful balance of old and new demonstrates how architecture can serve as a bridge between different eras, contributing to the cultural and historical continuity of urban spaces.

In conclusion, the revitalization of the Ravone railway yard serves as a comprehensive model for sustainable urban regeneration. By integrating adaptive reuse, bioclimatic design, and community engagement, this project addresses key urban challenges while promoting environmental stewardship and social well-being. Its interdisciplinary approach offers valuable insights for future projects in urban development, architecture, and sustainability, emphasizing the importance of innovation, heritage conservation, and community participation in shaping the cities of tomorrow.

The contributions of this thesis extend beyond the specific context of Bologna. The strategies employed here can be adapted to other cities facing similar challenges, providing a replicable model for transforming abandoned or underutilized industrial sites into vibrant, sustainable urban spaces. By demonstrating how architecture can contribute to a more sustainable and inclusive urban future, this project advances the discourse on urban regeneration and serves as a touchstone for future efforts in the field.

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