

Education, Teaching and Practice
In a Changing World

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INTRODUCTION

Education, Teaching and Practice in a Changing World

The SOCB International Conference brought together educators, researchers, practitioners, policymakers, and emerging professionals to examine a defining question of our time: how must architectural education and professional practice evolve in response to rapid technological, environmental, and social change? Under the theme “Technology, AI, Robotics, Green Infrastructure, and 3D Printing in a Changing World,” the conference created a space for critical reflection on both the opportunities and responsibilities accompanying innovation.

Across the presentations, technology was considered not simply as a collection of new tools, but as a force capable of reshaping how knowledge is produced, shared, tested, and applied. Artificial intelligence, virtual reality, robotics, digital modelling, and collaborative platforms are transforming educational environments and professional workflows, while green infrastructure and regenerative approaches are expanding the role of design in addressing climate resilience, biodiversity, public health, and social equity.

At the same time, the conference resisted the assumption that technological advancement is inherently progressive. Questions surrounding ethics, accessibility, affordability, employment, cultural sensitivity, and the relationship between human judgement and automated systems remained central. The discussions demonstrated that innovation becomes meaningful only when it responds to real social and environmental needs.

The diverse contributions also revealed the importance of connecting global technological developments with local knowledge and lived experience. From architectural education in India and virtual exchanges between Palestine and the United States to climate-responsive public spaces in Greece, green infrastructure in Brazilian favelas, housing in the United Kingdom, and heritage practices in Tunisia, the conference demonstrated that there is no single model for responding to change.

Instead, education and practice must become more adaptive, collaborative, and critically engaged. The future professional is not simply a user of technology, but an interpreter, mediator, and responsible decision-maker. Ultimately, the conference positioned education as a vital instrument for preparing designers to work across disciplines, cultures, technologies, and scales while maintaining a clear commitment to ethics, sustainability, equity, and human well-being.

EDITORIAL NOTES

The presentations gathered under the theme “Education, Teaching and Practice in a Changing World” offer a broad and compelling picture of a profession undergoing fundamental transformation. Across different educational systems, cultural contexts, technological environments, and geographic conditions, a common question emerges: how can architectural, urban, and landscape education prepare future professionals for a world in which the conditions of practice are changing faster than ever before?

What becomes evident through these contributions is that the challenge is not simply to introduce new technologies into existing educational models. The deeper task is to reconsider what should be taught, how knowledge is produced, how professional judgement is developed, and what responsibilities designers carry toward society and the environment. Technology may alter the tools of practice, but education must continue to shape the values, critical thinking, and ethical awareness that determine how those tools are used.

Prof. Rajiv Mishra’s reflections provide an important foundation for this discussion by returning to the fundamental relationship between architectural education and professional practice in India. His emphasis on briefing, contextual understanding, sustainability, innovation, constructional logic, and disciplinary fundamentals demonstrates that technological advancement does not diminish the importance of foundational knowledge. Instead, it makes that knowledge more significant. As design processes become increasingly digital, students must still understand materials, construction, climate, culture, people, and place. His perspective reinforces the value of connecting academic learning with professional realities while ensuring that local knowledge and social responsibility remain central to architectural education.

Dr. Elham Haasani expands this conversation by positioning artificial intelligence as a potential instrument for resilient urban regeneration. Rather than treating AI simply as a visualization or production tool, her work explores its capacity to support urban analysis, morphological studies, scenario development, and iterative decision-making. Concepts such as urban acupuncture, community-engaged urbanism, and climate-responsive approaches, including desert urbanism, demonstrate how technological intelligence can be combined with local knowledge and stakeholder participation. The significance of this approach lies in understanding regeneration as an ongoing process rather than a fixed intervention. Data, communities, designers, and institutions can participate in a continuous cycle of analysis, testing, feedback, and adaptation.

Dr. Manju Pundir’s work similarly examines the educational potential of immersive and digital technologies. Her pilot studio integrating virtual reality and artificial intelligence addresses a longstanding challenge within architectural education: the distance between theoretical knowledge and embodied experience. Immersive technologies can create new opportunities for students to explore space, collaborate across geographical boundaries, and understand design through experience rather than representation alone. The proposed compendium further extends this work by considering how experimental educational models can become transferable frameworks for future capacity building.

The Design Futures Exchange developed by Prof. Philip Horton and Dr. Marc J. Neveu demonstrates another dimension of technological transformation through Collaborative Online International Learning. By connecting students in Palestine and the United States through sustained virtual exchange, the initiative illustrates how digital platforms can create meaningful opportunities for intercultural learning. Its focus on trauma-informed and child-centred architectural responses within

refugee contexts adds an important social dimension. Technology becomes valuable not because it eliminates distance, but because it can create conditions for dialogue, empathy, and shared learning across different lived realities. Such experiences also develop intercultural competence and digital literacy, both of which are increasingly important within a globally connected profession.

Landscape Architect Isabella Bohan extends this ecological perspective through Landscape Information Modelling, or LIM. Her work demonstrates how digital technologies can support a more evidence-based understanding of landscape and urban systems. By incorporating microclimatic information, socio-environmental indicators, and habitat-creation strategies, LIM provides a framework for understanding cities as interconnected living systems. The Hereford Station Transport Hub pilot project illustrates the potential of this approach to move landscape design beyond intuition alone toward measurable ecological outcomes. It also expands the professional role of landscape architects, positioning them as active stewards of environmental resilience and planetary health.

The ethical dimension of technological change is addressed directly by Prof. Moritz Elbert in his examination of artificial intelligence within design education. His position avoids simplistic interpretations of AI as either a threat or a solution. Instead, the emphasis falls on the frameworks surrounding its use. Transparency, responsibility, critical judgement, and ethical awareness must develop alongside technical competence. This is particularly important in education because students are not merely learning how to operate new technologies. They are also learning how to make decisions about when, why, and under what conditions those technologies should be used.

Questions of equity become particularly visible in the research of Prof. Angélica Tanus Benatti Alvim and Prof. Ester Carro, who examine green infrastructure in Brazilian favelas. Their work demonstrates that environmental inequality is also spatial inequality. Where access to vegetation, open space, shade, ecological infrastructure, and environmental services is limited, communities can experience disproportionate exposure to climate and environmental risks. Their proposal to transform residual urban spaces into micro-green infrastructures demonstrates how relatively small interventions can support broader processes of social and environmental inclusion. Participatory processes and shared governance are essential to this approach because infrastructure becomes more meaningful when communities participate in shaping and maintaining it.

Dr. Sana Malik brings the discussion into the complex territory of housing, sustainability, and affordability in the United Kingdom. Her research challenges the tendency to treat sustainable housing as a universal category with a single definition. Environmental performance is important, but housing must also respond to affordability, cultural expectations, community needs, accessibility, and changing patterns of occupation. Sustainability therefore becomes a socially embedded concept rather than a purely technical standard. Her work reinforces the need for housing policies and design strategies that acknowledge diversity rather than imposing a single model of what sustainable living should mean.

Dr. Anwar Hamrouni provides a particularly valuable perspective on heritage through the concept of “alter-patrimonialisation” and the Tunisian practice of oukalisation. His research challenges the idea that heritage is necessarily defined by formal designation, preservation, and institutional control. The spontaneous occupation and adaptation of abandoned communal buildings demonstrates that heritage can also emerge through everyday use, memory, conflict, and collective appropriation. This understanding transforms heritage from a static object into a living process. Built fabric acquires meaning through the communities that inhabit, adapt, remember, and negotiate it.

Taken together, these contributions reveal a profession that is moving toward greater interdisciplinarity and technological complexity while simultaneously returning to fundamental questions of human responsibility. AI, VR, LIM, robotics, digital collaboration, and advanced modelling are expanding the possibilities of design education and practice. Yet none of these technologies can independently determine what constitutes a meaningful, equitable, or sustainable environment.

The most important transformation, therefore, may not be technological at all. It may be pedagogical. Future professionals must learn to work with technology without becoming dependent upon it, to interpret data without losing sensitivity to lived experience, and to pursue innovation without abandoning ethics. They must be capable of moving between digital systems and physical realities, global knowledge and local conditions, environmental performance and social need.

The conference ultimately presents education as an active form of preparation for uncertainty. Rather than training students only for the profession as it exists today, education must equip them to question, adapt, collaborate, and respond to conditions that are still emerging. This requires curricula that bring together technology, environmental responsibility, cultural understanding, construction knowledge, social engagement, and critical reflection.

In this changing world, architecture, landscape, and urbanism cannot remain fixed disciplines. Their methods must evolve, but their underlying responsibility remains constant: to create environments that support human dignity, ecological resilience, cultural continuity, and collective well-being. The future of practice will depend not simply on how effectively professionals use new tools, but on how thoughtfully they choose to use them.

The conference therefore becomes more than a discussion of emerging technologies. It becomes a conversation about the kind of professionals, institutions, and communities we want to cultivate. Education is not simply preparing the next generation to enter a changing profession. It is helping shape the values and capacities through which that profession will respond to the future.

COLLABORATIVE ONLINE INTERNATIONAL LEARNING (COIL): BETWEEN PALESTINE AND THE US

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INTRODUCTION

We live in a moment that is marked by the rapid politicization of seemingly all events. From election results to the status of foreign leadership, every global event is understood through multiple “truths” often with very local ramifications – an event thousands of miles away has an impact on local gas and grocery costs, for example. The ability to empathize, or even sympathize, with the “other” has become increasingly difficult as our political divides deepen. Study abroad programs offer the opportunity for students to experience another culture and may have the ability to develop empathy. Beginning with the Rome Prize at the Ecole des Beaux-Arts over two centuries ago, study abroad programs are a constant in architectural education. In the programs, students typically travel to another place to see a new context, language, and culture to, ideally, see their world from another perspective. This paper sets out to describe and contextualize an ongoing virtual exchange program between An Najah National University (NNU) in the West Bank and Arizona State University (ASU) in Tempe, Arizona.

WHAT is Virtual Exchange?

At many universities, a semester spent abroad is an integral part of the student experience.¹ As the name implies, almost all study abroad programs involve some duration of travel and time spent in another country. The intentions of programs vary – from language skills, to tourism, to volunteer work. The *Building Futures Exchange*, between Architecture programs at An Najah National University and Arizona State University is one of over 100 virtual exchange programs supported by the J. Christopher Stevens Virtual Exchange Initiative (JCSVEI) over the past 10 years. The Stevens Initiative was launched in 2015 to continue the legacy of U.S. Ambassador to Libya, J. Christopher Stevens, who studied abroad in Europe and served as a Peace Corps volunteer in Morocco. These experiences shaped his view of the world, fueled his curiosity, and prepared him to be a good-willed diplomat who earned the respect of people wherever he served. JCSVEI, sponsored by the U.S. Department of State and administered by The Aspen Institute, has aimed to make similar experiences available to an unprecedented number of young people through virtual exchanges that connect youth in the United States to students in the Middle East and North Africa (MENA) region.

Virtual Exchange, however, is not unique to the JCSVEI. Since 1988, iEARN (International Education and Resource Network) has worked with organizations in over 140 countries to include over

50,000 educators and over 2 million youth participants.² Most significantly, the first ever virtual exchange through iEARN linked twelve schools in the US with twelve schools in the USSR prior to the collapse of the Soviet Union. Soliya, the Connect Program, was established in the wake of 9/11.³ The pilot program sought to connect students from ten universities in the US and Arab worlds with the intention of creating a platform of understanding intended to ease growing tensions between the two regions. Since that time over 75,000 students have participated. Roughly the same number of students have participated in the JCSVEI since its establishment in 2015. ASU and NNU have run two exchanges since 2017, which have included over 1650 students.

HOW does the *Building Futures Exchange* work?

The Virtual Exchange between ASU and NNU began in 2017 and was a relatively small-scale studio-based exchange. Students at each university collaborated on a project in the Balata Refugee camp in the West Bank. Funding for the three-year exchange was cut short during the first Trump Administration. In 2021 the Biden Administration restored funding and faculty from ASU and NNU applied and received additional seed funding for two years. After planning to pursue a larger scaling-level grant, we were approved for one additional year of funding. In 2025, the second Trump Administration again cut funding to the Stevens Initiative, thus halting the program in Summer 2026.

Beginning in 2022, the second iteration of the exchange includes two semesters with different approaches to the same goal of exchange. In the fall semester, students enrolled at ASU in ARC 111, an introductory course on the built environment, are paired with first- and second-year students at NNU on a weekly Zoom call. These meetings bring together more than 450 students at our two universities synchronously. While these meetings begin and end collectively, the core of these meetings are smaller breakout room conversations with the same peers each week. The breakout room conversations in those weekly synchronous meetings are peer dialogues in response to a weekly series of asynchronous videos that each student makes in response to common prompts about their respective experiences in the built environment where they live and study.



Figure 1. Screenshot from a typical Zoom call. (Image by author.)

In the second semester, students at both universities collaborate on an upper-level architecture studio. The studio meets twice per week, and features desk crits, pin ups, reviews and other hallmarks of a typical studio course. While the conceptual framework for the studio as a virtual exchange is relatively unique, and might suggest that student work be exclusively digital, sketching, model-making, printed presentation materials, and other physical features of architectural education are still very present within the *Building Futures Exchange* studio. The current project for the *Building Futures Exchange* studio is the design of a kindergarten for a refugee camp in Nablus. Refugee camps in Palestine are informal settlements, not unlike favelas in Brazil or townships in South Africa. While the history and living conditions in the refugee camps begin difficult conversations, the program of kindergartens casts a focus toward a constructive future.

Empathy is a critical part of design thinking, and it is also a critical component to COIL (Collaborative Online International Learning) experiences. One way that we ask our students to empathize for both purposes is to share pictures and stories from their own experiences as kindergartners. While cultural differences between life in the U.S. and in Palestine exist, there is also a lot of common ground to be found in early childhood development, activities-based learning, and sharing ideas about moments for play and imagination. Students at ASU, whose semester starts weeks before their peers, are tasked with assembling their pictures and memories into a Welcome Board shared with our colleagues via Miro. These photographs and memories help the students (re)adopt the mindset of a 5-year-old, recall the experiences that were most important to them at that age, learn more about one another, and to share those with our colleagues in Palestine.



Figure 2. Welcome Board of Kindergarten portraits of ASU students (Image by author.)

Miro is one of several collaborative whiteboard spaces that became very popular during the SARS-CoV-2 (COVID-19) pandemic. It is a project space that allows teams of students to share a project space, and exchange images, sketches, references, and dialogue both synchronously and asynchronously. These tools have been a game-changer for asynchronous collaboration as well as for Virtual Exchange. When paired with synchronous, video-conferencing capabilities of platforms like Zoom, students can present their work to one another, give feedback to one another, sketch simultaneously, and experience iterative and cyclical collaborative design processes despite hours of time zone, and thousands of miles, of separation. Advancements in Virtual Reality (VR) and Immersive Learning Experiences was one of our focuses during their visit. ASU is host to Dreamscape Learn, which uses VR and storytelling to create immersive, experiential learning environments. Dreamscape Learn courses are being designed to be accessible to students anywhere in the world, but the fully immersive experiences can only be had within the Dreamscape pods on an ASU campus. Before entering, participants put tracking sensors on their hands and feet, along with slim computers in backpacks, and virtual reality goggles, sensors, and speakers on their heads. Once inside the Dreamscape pods, participant locations are constantly tracked throughout the pod, while the fully immersive experience is supported by vibrating floors, fans, misters, interactive handheld devices and (still in-development) “smell engines.”

Through grant support from JCSVEI three of our faculty colleagues, and seven of their students from NNU, were able to travel from Palestine to Arizona for a week in September of 2024. The seven students who were able to travel from NNU were the winners, selected by a panel of outside critics, of a design competition held at the end of their architecture studios during the Spring of 2023. While visiting ASU, our guests from NNU were able to “break the fourth wall” of our large, fall lecture courses by coming into the lecture hall and talking with our students directly. After first introducing themselves and answering questions as a panel on the lecture hall stage, the students and faculty from NNU spent time in the audience having smaller group discussions, not unlike our breakout rooms conversations on Zoom.



Figure 3. NNU students in ARC 111, in person. (Image by author.)

During their visit to ASU, the NNU students also presented their design projects, in English, to an audience of students and faculty from both universities, as well as some guest critics. Presenting students from NNU wore formal, traditional clothes during their presentation and students from ASU learned about cultural differences in higher education, and formal classroom etiquette. The visit also gave our program managers from The Aspen Institute an opportunity to perform a site visit for our program, and to interview students and faculty from both universities.



Figure 4. NNU students presenting their architecture projects. (Image by author.)

Outside of leadership meetings, and informal cultural tours of ASU and the surrounding city, the faculty and students from NNU were also provided with tours of local architecture and construction management offices. The ASU campus also provided numerous lessons on climate adaptation, old and new, such as the courtyard of our teachers College whose courtyard supports exotic palms and fruiting trees from Southeast Asia as part of the campus arboretum, and net-zero designed Student Pavilion which recycles water from its cooling system to support vegetation under a canopy of photovoltaic panels. Students from NNU re-joined their faculty for the most important of these leadership meetings, as they were invited to meet with the President of Arizona State University, Dr. Michael Crow. They brought with them a representative gift of collaboration from the University President of An Najah National University, Dr. Abdel Naser Zaid. During the trip we learned that Dalia Zaid, one of the visiting students, is Dr. Zaid's daughter.



Figure 5. NNU campus visit. (Image by author.)

And, though the friendships and collegial bonds that we have formed over the years with our colleagues from An Najah National University did not require a traditional travel experience, sharing meals together certainly has added depth and richness to our partnership.



Figure 6. Faculty from NNU enjoying some local tacos. (Image by author.)

HOW is the *Building Futures Exchange* meaningful?

Study abroad programs offer many benefits, but there can be drawbacks. Programs vary in duration, in focus, and type of immersion. Additional costs associated with travel is always an issue. Short term study abroad (STSA) programs typically attract more white male students than other demographics. Excessive drinking and lack of language skills can encourage students to live in a foreign “bubble.” And, the majority of STSA programs simply cannot scale to become accessible to a more diverse cohort of students. The duration of the *Building Futures Exchange* (now going on three years) allows for students to get to know each other over the course of a much longer and lower stakes interaction. Synchronous and asynchronous digital interaction is within the realm of our digitally native students. The result of this is that when students are able to travel, even for a short duration, the time spent on ground allows for new discoveries and in person interactions, all of which is built upon a much more solid foundation of conversations and experiences.

The *Building Futures Exchange* revealed something else that was quite unexpected. In each of the virtual exchange programs described at the beginning of this paper, students are assessed across a range of learning outcomes. For the *Building Futures Exchange*, outcomes are assessed using the Intercultural Knowledge and Competence VALUE rubric developed by the American Association of Colleges and Universities (AAC&U).⁴ The rubric focuses on three areas: Knowledge (Cultural Self-Awareness and Cultural Worldview), Skills (Empathy and Verbal and Nonverbal Communications, and Attitudes (Curiosity and Openness). Upon successful completion of the semester’s activities, each student receives a Collaborative Online International Learning (COIL) digital credential.

JCSVEI works with a third-party, objective auditor, RTI, to collect standardized survey data from all participating students year-over-year. In Year 1 of our exchange, our outcomes were relatively poor in categories surveyed for increased professional interest, increased job skills, and increased soft skills compared to our cohort. Our team made several changes to both semesters of Exchange activities from Year 1 to Year 2, focused on improved student experience. We did so without focusing on these survey metrics, but Year 2 outcomes improved by 20 percentage points or more across each of these categories. Not only did our Year 2 outcomes improve significantly compared to our outcomes the previous year, but our Year 2 outcomes beat the cohort average for the year. So, while we were not primarily focused on the VALUE rubric, students were gaining soft skills as well as job-related skills and demonstrated increased professional interest.

CONCLUSION: VIRTUAL EXCHANGE IN CRISES

There is a curious connection between the establishment of Virtual Exchange programs during times of global political crises. Be it the Cold War, 9/11, and the unrest in the Middle East. The JCSVEI is particularly focused on this region and has certainly been affected by the politics, both in the West Bank and in Washington. There was a moment in the current exchange, just after October 07, 2023 where we thought the exchange would pause if not end. The resiliency of the students and faculty from NNU to continue the exchange was remarkable. Even more so was the deepened commitment from students in the West Bank to ramp up the conversation to go beyond the built environment and to talk about real issues that they face in everyday life. I can’t claim that Virtual Exchange programs will solve all our political crises, we do believe, however, that it is an important first step in trying to better understand very complicated issues from multiple perspectives, both locally and globally.

Acknowledgment

This program would not have been possible without the invaluable support of the J. Christopher Stevens Virtual Exchange Initiative (JCSVEI), sponsored by the U.S. Department of State and administered by The Aspen Institute. We thank all the staff in the Aspen Institute who have been incredibly and consistently supportive. Our students at ASU continue to show up and are open to learning about a part of the world that many know very little about. The project has been supported by incredible Research Assistants, including Mohammad Alrajhi and Athoub Alrayyes. Finally, the faculty and students from An Najah National University have not only become friends, but they have also demonstrated an incredible resolve and resiliency in ways that we, writing this from serene Arizona, cannot fathom.

NOTES

¹ See Marina Iskhakova and Andrew Bradly, "Short-Term Study Abroad Research: A Systematic Review 2000-2019." *Journal of Management Education*, 46, no.2 (2021): 383-427, for a review of short-term study abroad (STSA) programs.

² For more information see the iEARN website, accessed January 6, 2023, <https://www.iearn.org>.

³ For more information see the Soliya website, accessed January 6, 2023, <https://soliya.net/connect-program>.

⁴ For more information see the AAC&U website, accessed January 6, 2023, <https://www.aacu.org/value/rubrics/value-rubrics-intercultural-knowledge-and-competence>.

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LEARNING THE LAND DIGITALLY – LANDSCAPE INFORMATION MODELLING

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INTRODUCTION

Cities have long been at the heart of human progress. Urbanisation has concentrated opportunity and innovation, yet cities remain bound to fragile ecological systems. Rising temperatures, flooding, and biodiversity loss reveal that planetary boundaries are shifting faster than urban infrastructures can adapt.¹

With 2.5 billion additional urban dwellers projected to be under ecological strain by 2050, as planetary boundaries continue to be breached², the UN Sustainable Development Goals call for resilient, nature-based urbanism.³ The New Urban Agenda reinforces this through nature-based and regenerative approaches.⁴ Yet implementation remains slow, as most cities are still shaped through mechanistic rather than ecological frameworks. The challenge is no longer whether cities can grow, but how they can adapt.

Technology defines the pulse of urban life. Every building, streetlight, and transport system generates data; sensors track air quality, heat, and movement; satellites visualise entire districts in real time.⁵ Despite this unprecedented visibility, the digital revolution has improved efficiency but not adaptability, it optimises the built environment while leaving ecological processes largely unseen.

This concern nonetheless presents an opportunity. If environmental data, microclimate simulation, and species behaviour could be integrated into design workflows, cities might begin to operate as responsive ecological networks.⁶ Digital models could be used to simulate ecological benefit which influences biodiversity and comfort, transforming landscapes into measurable performance.

This chapter argues that Landscape Information Modelling (LIM), a digital framework integrating environmental datasets, species-level information, and climatic simulations, can transform design from intuition-led practice to evidence-based ecological accountability.

The framework was tested through the Hereford Station Transport Hub pilot in the UK, LIM was implemented through collaboration among landscape architects, ecologists, and engineers. The case study demonstrates how digital modelling can evolve intuition-led design into evidence-based practice, fostering multispecies thinking and improving ecological literacy.

Within the framework of Spatial and Climatic Adaptation Strategies, and aligned with the UN SDGs, Paris Agreement, and COP28 Global Stocktake, this chapter argues that digital tools can transform cities from inert systems of extraction into adaptive ecological networks, where every design act becomes an accountable contribution to planetary resilience.⁷

THEORETICAL AND POLICY CONTEXT

McHarg's *Design with Nature* (1969) conceived cities as living systems where ecology and resilience are co-produced. Contemporary ecological urbanism extends this framing, yet most projects still rely on visual precedent rather than quantifiable performance. Global frameworks, including the UN SDGs (11, 13, 15), Paris Agreement, and Kunming-Montreal Biodiversity Framework, now mandate measurable ecological outcomes. LIM operationalises these policy commitments by embedding ecological indicators within digital design workflows, translating targets into site-specific evidence.

McHarg's ecological planning method has been critically extended by Corner's *Recovering Landscape* (1999) and Mostafavi & Doherty's *Ecological Urbanism* (2010), yet these remain largely conceptual. Recent scholarship on digital ecological design has begun operationalising these frameworks. Steiner et al. (2019) in *Urban Resilience* argue that digital modelling must accommodate ecological uncertainty rather than Cartesian precision. Nature-Based Solutions (NbS) literature provides performance metrics (cooling, infiltration, habitat units) that align directly with LIM's indicator logic.⁸ However, Frantzeskaki et al. (2019) caution that NbS implementation remains hindered by "disciplinary silos between ecology, engineering, and design", precisely the gap LIM addresses through interoperable modelling.

Technological Advancement in City Building

Urbanisation has always been mediated by technology, from irrigation canals to satellites (Jacobsen & Adams, 1958). Today's digital infrastructures expand this lineage through their capacity to measure and simulate performance of urban life. Sensor networks, satellites, and remote monitoring provide continuous data on microclimate, air quality, and mobility flows, e.g. presenting an opportunity to integrate ecological intelligence, as another dataset, into the same systems already governing the city infrastructure.

Redirecting this computational power toward nature-based simulation, modelling how wetlands filter pollutants or how canopies affect microclimate, can transform digital technology from representation to transformation, enabling cities to act as adaptive ecological networks.

Within digital twin and urban informatics scholarship, Kitchin (2014) *The Data Revolution* critiques techno-deterministic smart city narratives, while Batty (2018) distinguishes between predictive and exploratory urban models. LIM aligns with the latter: its function is not to forecast but to generate informed scenarios. Gabrys (2016) *Program Earth* further argues that environmental sensing must remain "speculative and provisional", a methodological stance LIM adopts through its emphasis on indicative rather than absolute outputs.

Existing Digital frameworks

Over the last two decades, three digital frameworks have transformed spatial practice within city building:

- Geographic Information System (GIS) – maps and analyses spatial data across topography, land use, and demographics to inform evidence-based planning.⁹
- Building Information Modelling (BIM) – coordinates design, construction, and operation through data-rich 3-D models.¹⁰
- Digital Twins – extend BIM into real time by linking models to live sensor data, simulating performance under changing conditions.¹¹

Together they revolutionised project delivery and asset management but share a critical omission: they model built form, not living matter. Vegetation, soils, and hydrology remain simplified or excluded, leaving ecological performance largely invisible within the digital city.

This is where LIM emerges. It extends the logic of Nature-Based Solutions (NbS) by embedding measurable outcomes directly into design processes. Rather than post-hoc assessments, LIM makes ecological effects; canopy cooling, runoff reduction, carbon sequestration, or maintenance cost savings, computable parameters, translating policy commitments into site-specific design evidence and action.

METHODOLOGY: LANDSCAPE INFORMATION MODELLING (LIM)

The methodology presented in this chapter reflects both the conceptual evolution and prototype testing of Landscape Information Modelling (LIM), a digital framework designed to embed ecological intelligence within design workflows. LIM developed as an extension of BIM & GIS, integrates environmental datasets, biological variables, and spatial simulations into a single interoperable environment, enabling designers, ecologists, and engineers to make data-informed decisions that account for the behaviour of living systems.

Unlike building models and Digital Twins, which simulate real-time performance of built assets through live sensor integration, LIM operates as a design-phase framework that foregrounds ecological variables typically omitted or simplified in conventional models. Where Digital Twins optimise operational efficiency (energy, traffic, maintenance), LIM quantifies biological performance: carbon sequestration, evapotranspiration, habitat connectivity, and stormwater retention. The two frameworks are complementary rather than competitive: LIM generates ecological baselines and design scenarios that could later feed into a Digital Twin for post-occupancy validation. However, LIM's core innovation lies in making ecological intelligence computable at the point of spatial decision-making, rather than retrofitting environmental assessments after design lock-in. Its iterative workflow of testing, feedback, and adaptation aligns design intent with measurable ecological outcomes such as temperature regulation, carbon sequestration, and biodiversity value (Figure 1).

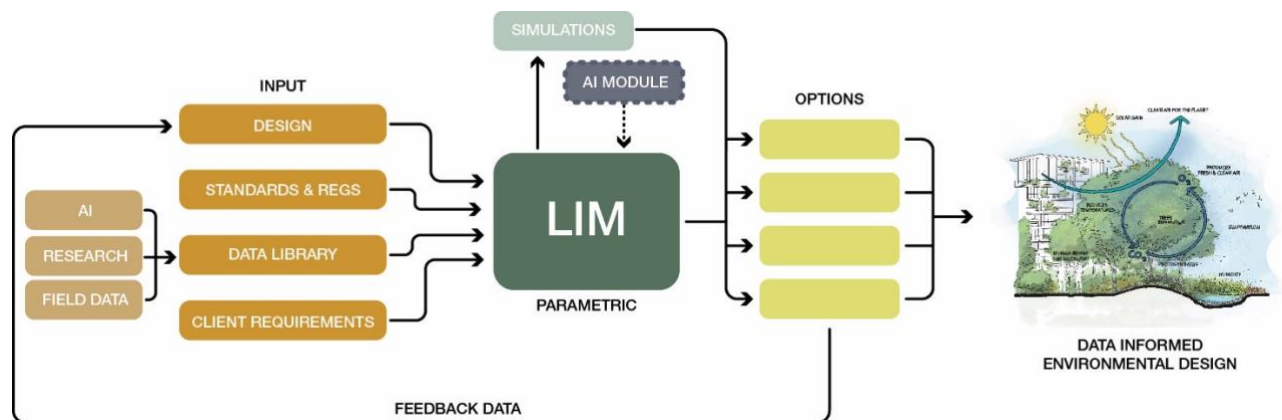


Figure 1. Illustrated process of LIM (Source diagram developed by the author)

The framework was iteratively developed by the landscape team at WW+P and later tested through the Hereford Station Transport Hub pilot in the UK within a collaborative multi-disciplinary setting, where LIM was applied as a decision-support tool in real time, translating ecological intent into operational design intelligence.

Core Components of LIM

LIM operates through embedded data drawn from open-source databases, field studies, research, and professional practice. This information is stored in a data library which, together with regulations, project requirements, and design input, forms the LIM framework from which simulations and design options are generated and iteratively refined.

Data Inputs:

LIM integrates microclimate simulations, socio-environmental statistics, cost-saving metrics, and species-level ecosystem-service databases to model ecological performance. Microclimate inputs map temperature, humidity, wind, and solar exposure, while socio-environmental data link site conditions with indicators such as air quality, accessibility, and exposure to green space. Species databases, including i-Tree, support plant selection, habitat creation, and pollinator diversity.¹² Economic metrics estimate maintenance and resource-use savings. Because some ecological datasets (e.g., soil carbon, root systems) remain incomplete, LIM treats outputs as indicative rather than absolute, enabling adaptation as new science emerges.

Digital Workspace:

At its core, LIM functions as a collaborative workspace linking IFC (Industry Foundation Classes) and CityGML (format for storing digital 3D geospatial models) standards for interoperability with BIM, GIS, and digital-twin environments.¹³

Parametric and simulation tools operate within this shared space, where geospatial, climatic, and biological datasets converge.

Scenarios and Simulations:

LIM enables 3D modelling and performance-based scenario testing, allowing designers to evaluate alternative planting palettes, soil compositions, and surface materials under site-specific conditions. The workflow follows four stages:

- Baseline assessment — modelling existing conditions.
 - Scenario generation — simulating alternative options.
 - Performance analysis — comparing outcomes (temperature, carbon, runoff).
 - Design feedback — refining proposals based on results.
- This process brings ecological reasoning to the front end of design.

Calculations:

LIM employs environmental simulation, parametric modelling, and performance analysis in Revit, chosen for its industry-standard BIM capabilities and interdisciplinary compatibility.¹⁴ Interoperability ensures ecological metrics inform mainstream design decisions. Ecological data are currently dispersed; values are therefore aggregated from multiple sources and combined through formulas such as wastewater-treatment cost savings. In the pilot project, water-use data from Hereford Council were applied to rain-garden capture models informed by soil-retention data. Tree-ecosystem performance values from i-Tree were compiled at project scale.¹⁵

At a strategic level, LIM provides a digital backbone for asset management and monitoring. Future integration of IoT sensors (soil moisture, temperature, air quality) will enable real-time feedback, post-occupancy validation, and continual recalibration, evolving LIM from a design-phase tool into a living, adaptive landscape digital twin.

Methodological Principles

Ecological Performance as Design Intelligence

LIM translates ecological parameters into quantifiable design drivers. Each choice, species, material, or soil composition, is assessed for measurable environmental impact, turning ecological reasoning into a creative, performance-oriented process.

Adaptive and Collaborative Modelling

Because ecological systems evolve, the model remains open-ended, incorporating new datasets, behavioural insights, and maintenance regimes over time. This iterative adaptability mirrors the resilient character of living systems. By consolidating spatial and ecological information within a single platform, LIM fosters genuine interdisciplinary collaboration.

Measurable Co-Benefits

Simulations quantify option-specific co-benefits such as cooling, air filtration, carbon capture, and psychological well-being. Expressed through ecosystem-service indicators or carbon-equivalent values, these metrics strengthen the economic and policy case for nature-based interventions.

Criteria for Selection of Ecological Indicators

Ecological indicators were selected according to three criteria: (1) alignment with policy targets (UN SDGs, UK Biodiversity Net Gain, local planning requirements); (2) computational feasibility within Revit and i-Tree ecosystems; and (3) site-specific relevance to Hereford's diagnosed deficits (urban heat, flooding, fragmented habitat). Indicators excluded, such as noise attenuation or soil carbon, were either irrelevant to the brief, lacked reliable open-source data, or required laboratory analysis beyond the pilot's scope. This pragmatic selection logic means LIM outputs are contextual rather than universal; different bioclimatic regions would require recalibrated indicator sets.

Application of Methodology

In Hereford, LIM was applied by a small team of 3 landscape architects and 1 digital designer. It provided a replicable workflow for integrating environmental data into design, enabling comparative scenario testing that informed both species selection and material specification.

From the resulting datasets it emerged, how small-scale species decisions, for example, substituting Acacia trees with Washingtonia palms, produce measurable shifts in ecosystem performance (Figure 2).

LIM also enhanced stakeholder dialogue through visualisation, allowing non-specialists to understand environmental outcomes and strengthening evidence-based approval processes.



Figure 2. Acacia vs Washingtonia Palms (Source diagram developed by the author)

More broadly, LIM demonstrated that digital systems could operationalise ecological thinking, translating sustainability rhetoric into spatially verifiable outcomes.

Limitations and Reflexivity

Despite its promise, LIM operates within a field of partial knowledge. Ecological datasets remain uneven in resolution with many unknown variables, below-ground carbon, species resilience, or long-term maintenance behaviour, which prevents precise modelling.

LIM simulations carry three inherent constraints. First, species-level performance data (i-Tree) derives from mature specimens under optimal conditions; transplant shock, disease, and maintenance variability introduces unmodelled divergence. Second, below-ground processes, root-soil interaction, mycorrhizal networks, carbon sequestration rates, remain partially unknowable within current ecological science. Third, microclimate simulations assume static boundary conditions; they do not account for future climate scenarios beyond 25-year horizons (yet). LIM therefore functions as a comparative rather than absolute tool: its value lies in ranking design alternatives (Tree A vs. Tree B) rather than forecasting precise outcomes.

Integrating living systems into digital environments demands shared understanding: technology cannot replace ecological expertise; it can only amplify and structure it. Hence, LIM functions under critical adaptability, framing outputs as indicative guidance rather than deterministic prediction. Its value lies in making uncertainty visible, enabling designers to negotiate complexity with awareness rather than assumption.

CASE STUDY: HEREFORD STATION TRANSPORT HUB

The Hereford Station Transport Hub (HSTH) served as LIM's pilot application. Situated in Hereford, UK, the site forms part of the Edgar Street Grid Regeneration Programme, a long-term initiative to revitalise the city's transport and civic infrastructure while protecting its heritage assets. The agenda was to transform the Grade II-listed Hereford Railway Station and its forecourt into a multi-modal interchange integrating bus, taxi, cycle, and pedestrian movement with new public realm and landscape interventions.

The design challenge was twofold: to create a functional transport gateway for the twenty-first century while protecting heritage landmarks and to re-establish the station as a civic landmark within a rapidly changing climate. The brief demanded sensitivity to the historic setting while addressing pressing ecological issues such as urban heat accumulation, surface water management, and biodiversity connectivity.

LIM was introduced as a decision-support framework and enabled the design team, comprising landscape architects, ecologists, engineers, and local authorities, to visualise and quantify the environmental consequences of design choices in real time.

Baseline Assessment

The first stage of the project involved developing a comprehensive baseline model of the existing site. Using GIS data, micro-climate mapping, and biodiversity surveys, the team mapped surface materials, user movement, vegetation cover, air temperature, and carbon accumulation (Figure 3 & 5). Baseline assessment revealed a tarmac forecourt functioning as an urban heat sink (55°C surface temperature), impermeable surfaces exacerbating flooding, and fragmented vegetation providing minimal ecological benefit.



Figure 3. Biodiversity baseline mapping (Source diagram developed by the author)

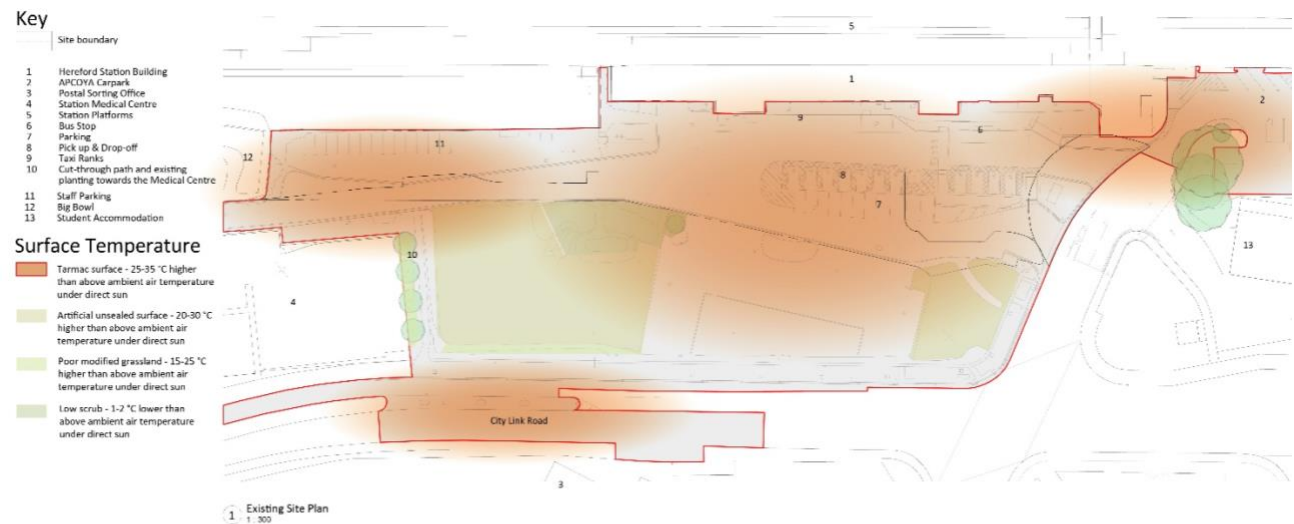


Figure 4. Urban heat baseline mapping (Source diagram developed by the author)

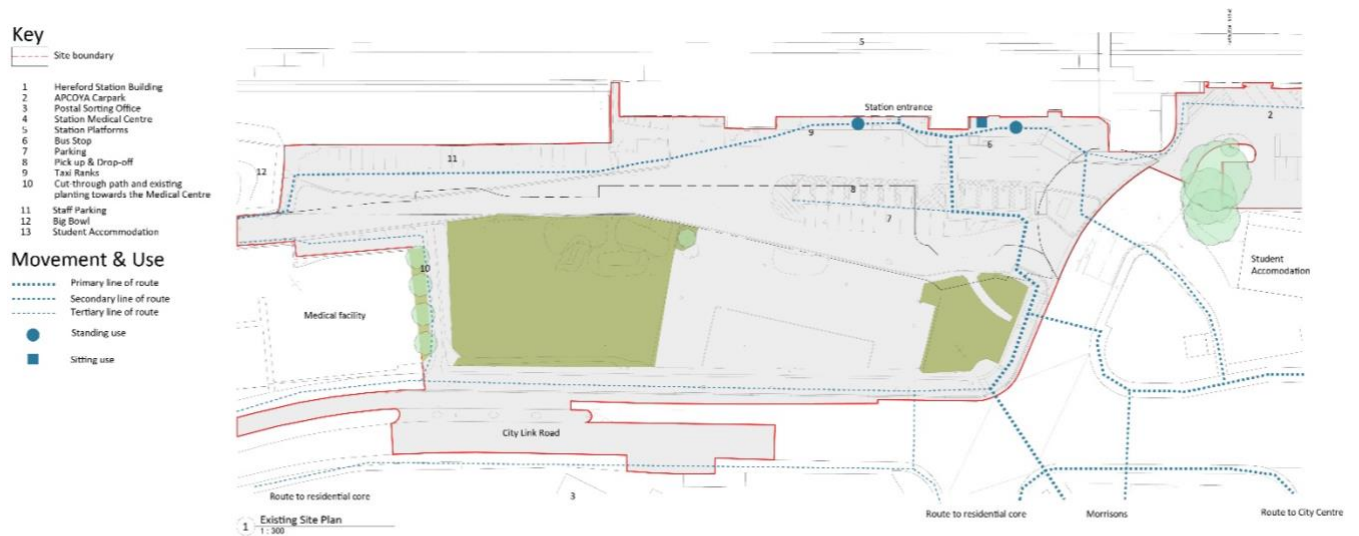
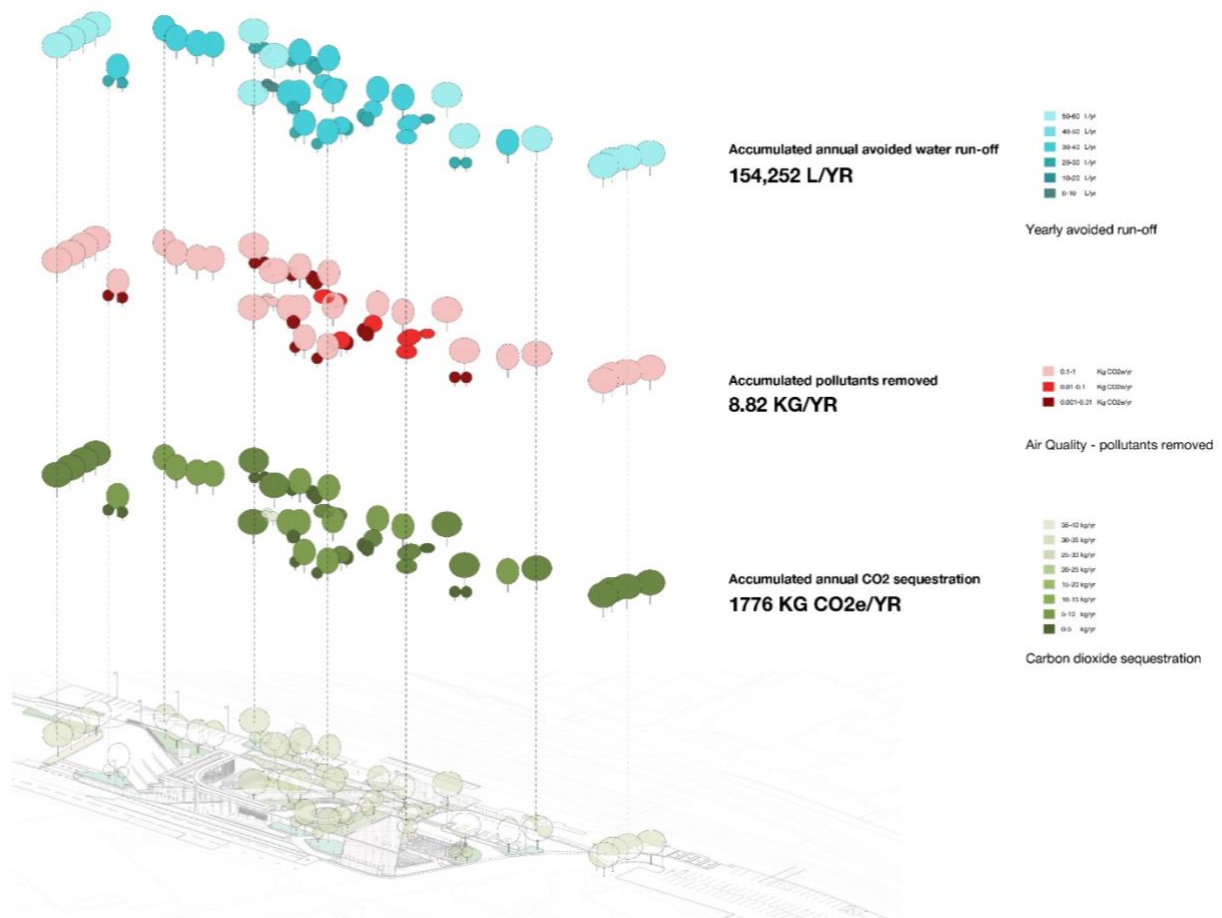
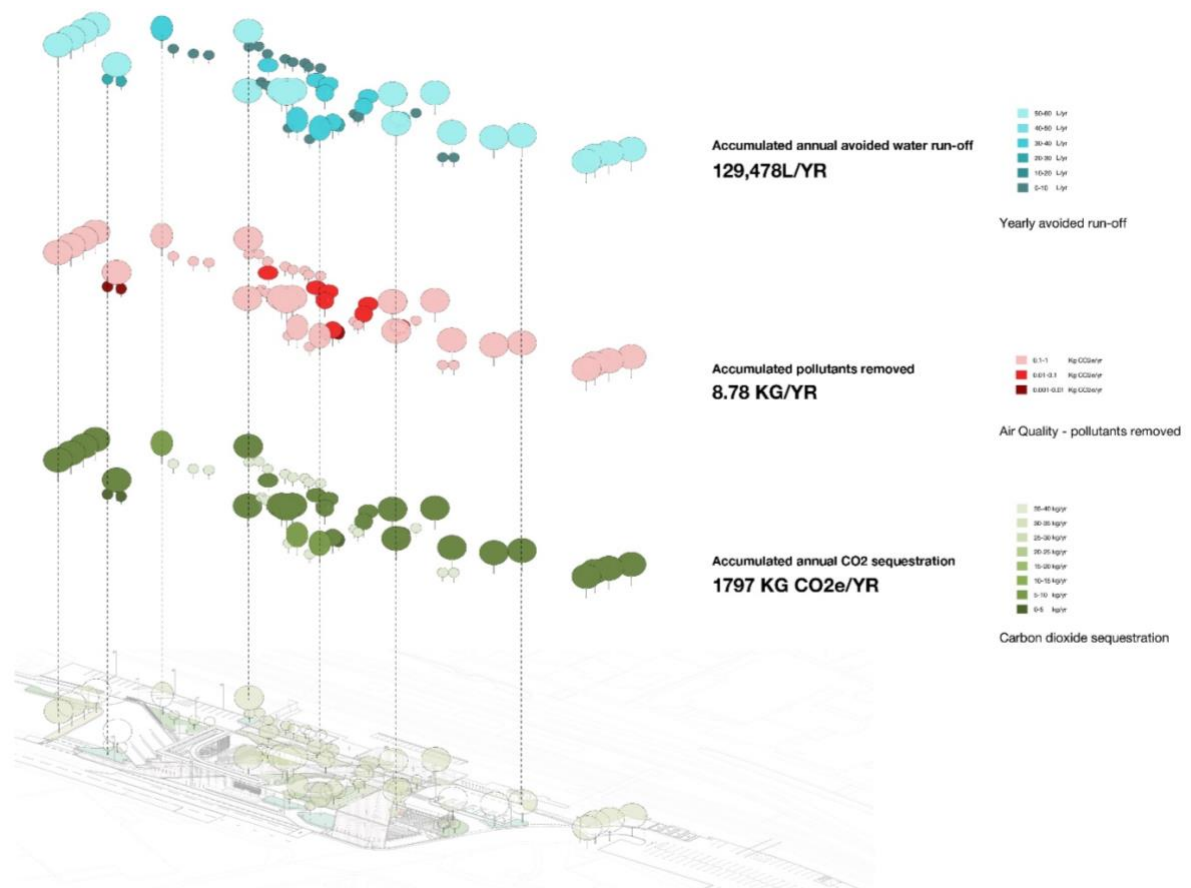


Figure 5. User movement mapping (Source diagram developed by the author)

The baseline assessment data formed the foundation for scenario modelling, defining both the environmental deficits to be addressed and the parameters for evaluating potential design strategies.

Scenario Modelling and Design Integration

LIM enabled the project team to simulate multiple design configurations and quantify their ecological performance. Each simulation tested variations in tree species, soil depth, surface material, and drainage strategy, allowing measurable comparison of outcomes such as carbon sequestration, evapotranspiration, and water retention.



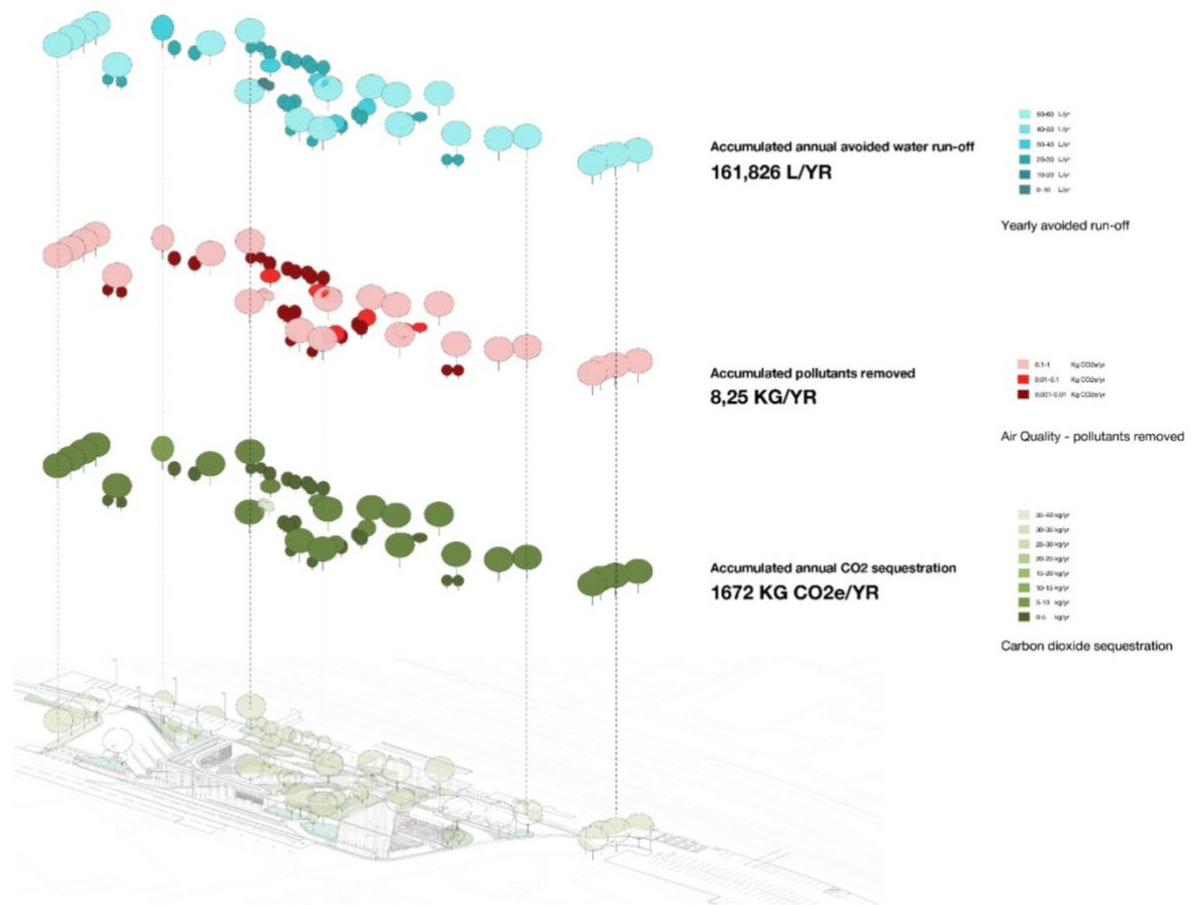


Figure 6. Tree planting palette with highest carbon sequestration, pollution mitigation and water run-off avoided (Source diagram developed by the author)

The iterative process revealed several critical insights:

- **Species Selection:** Simulations compared over a dozen tree species for their carbon storage and shading capacity. *Alnus glutinosa* demonstrated the highest sequestration rates (approx. 28 kg CO₂/yr)¹⁶ (Figure 7), while *Quercus petraea* performed best for avoided water run-off (5m³/yr) and pollution mitigation (0.14kg/yr).¹⁷ A final mixed-species palette was adopted to balance biodiversity value, visual character, and long-term resilience (Figure 15).
- **Surface Materials:** Replacing impermeable tarmac with permeable paving, open softscape surfaces and vegetated raingardens reduced surface runoff by over 40 % under a 1-in-100-year storm event scenario. Demonstrating how soil moisture, shading, and surface permeability collectively influence thermal regulation and runoff attenuation (Figure 8).
- **Cooling Performance:** Tree canopy expansion and softscape surfaces were shown to lower local surface temperatures by 6–8 °C, directly improving pedestrian comfort in summer months (Figure 7).
- **Pollution Mitigation:** Increased vegetation cover improved particulate capture and reduced local CO₂ accumulation by an estimated 12 % compared with baseline conditions (Figure 6).

The workflow - baseline assessment → scenario simulation → ecological and health metrics → design feedback - established a replicable process for data-informed design refinement.

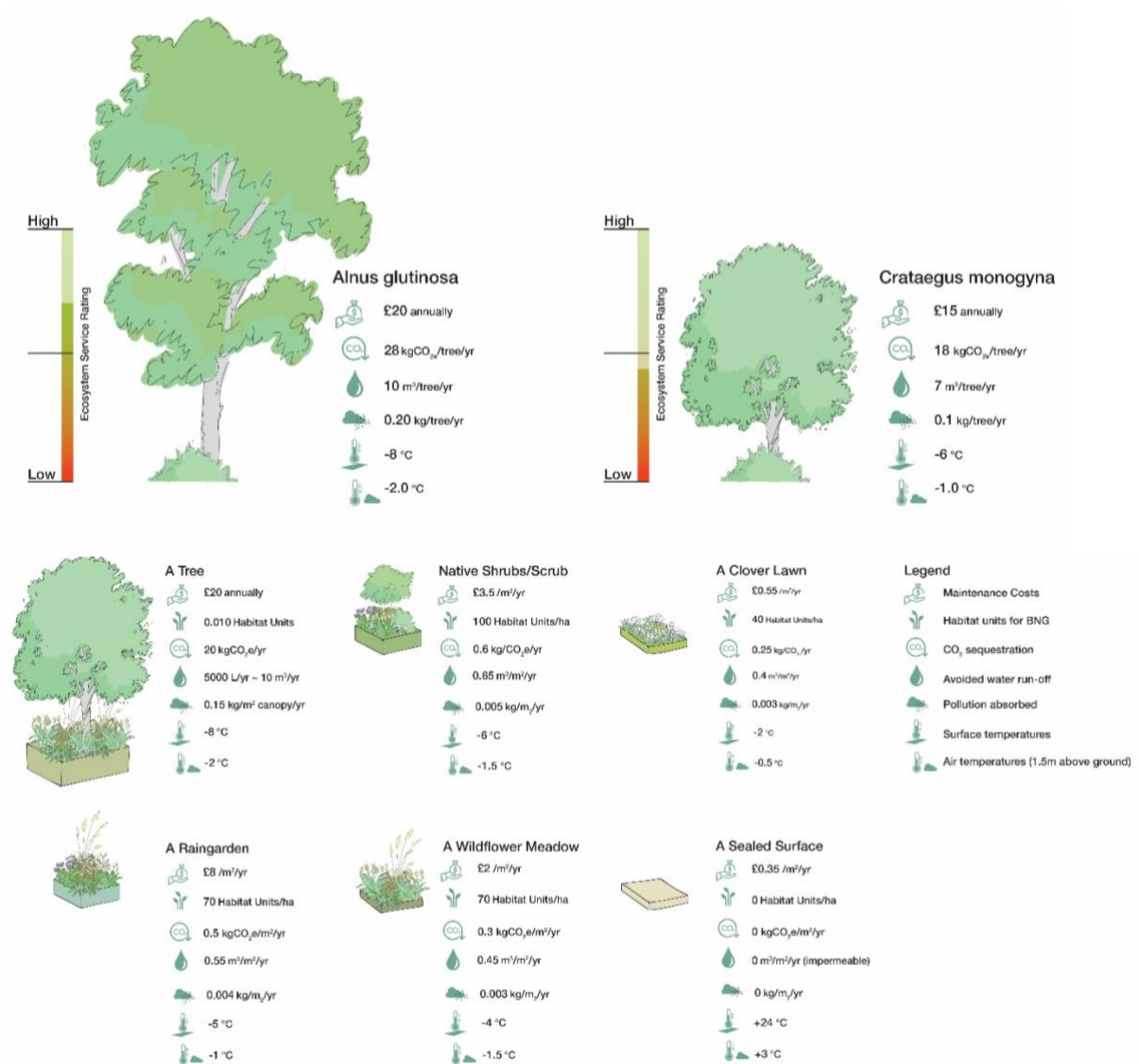


Figure 7. Tree species comparison of ecosystem services & vegetation surface types and their ecosystem service abilities. (Source diagram developed by the author)

Measurable Outcomes

LIM facilitated interdisciplinary collaboration by making ecological trade-offs visible: heat maps showed how tree placement protected pedestrian routes while preserving heritage views. Measured outcomes included +10% biodiversity gain, 1,115kg CO₂/yr sequestration, 105,800 L/yr runoff reduction, and £2,588 annual cost savings. Limitations included incomplete soil carbon data and absence of real-time monitoring, confirming LIM as a comparative design tool rather than predictive model.

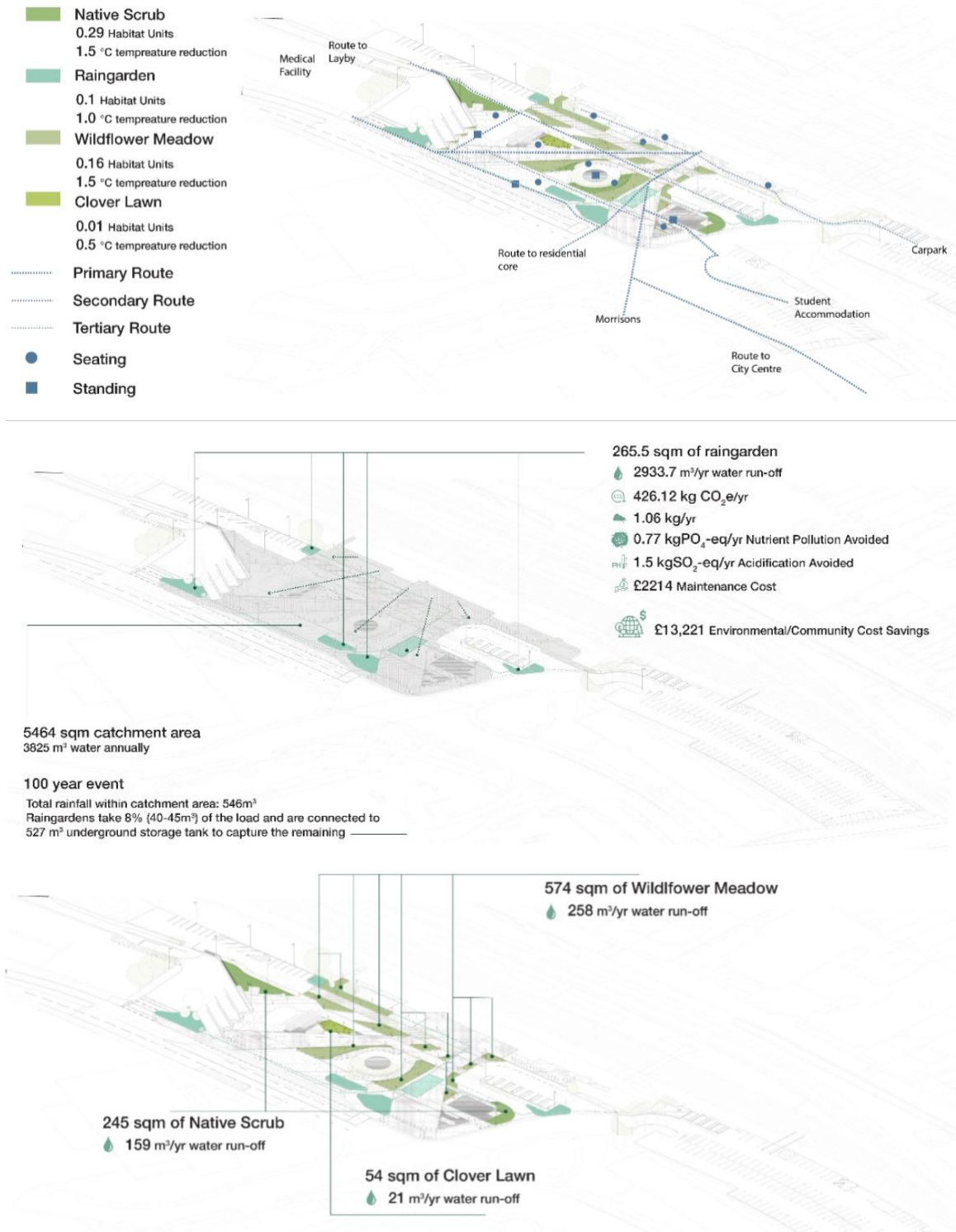


Figure 8. Proposal movement, temperature and biodiversity gain mapping, nature-based drainage proposal and the ecosystem services achieved and avoided water run-off due to additional softscape surfaces. (Source diagram developed by the author)

Stormwater Management

Through integration with hydrological simulations, LIM guided the placement of rain gardens, swales, and permeable paving, achieving a 40 % reduction in peak runoff and a 20 % improvement in infiltration rate. The system design also demonstrated an annual reduction of 3,825 m³ in surface water discharge, alleviating pressure on local drainage networks (Figure 8).

Carbon and Energy Performance

The model projected annual carbon sequestration of 1115 kgCO₂e/yr, primarily from the new tree canopy and improved soil structure (Table 2). This represented a net offset of 28 % of the landscape construction emissions over a 25-year period. Further, shading and evapotranspiration effects were shown to lower local mean radiant temperature, reducing building cooling demand by an estimated 4–5 % in adjacent structures.

Heritage Integration

One of the most delicate challenges was maintaining the visual integrity of the Grade II-listed station façade. LIM's tree growth simulations projected optimal canopy growth over 25 years, identifying placements that retained open sightlines while ensuring adequate shade and canopy cover (Figure 9). The outcome balanced heritage conservation with ecological enhancement, demonstrating resilience and preservation synergies.

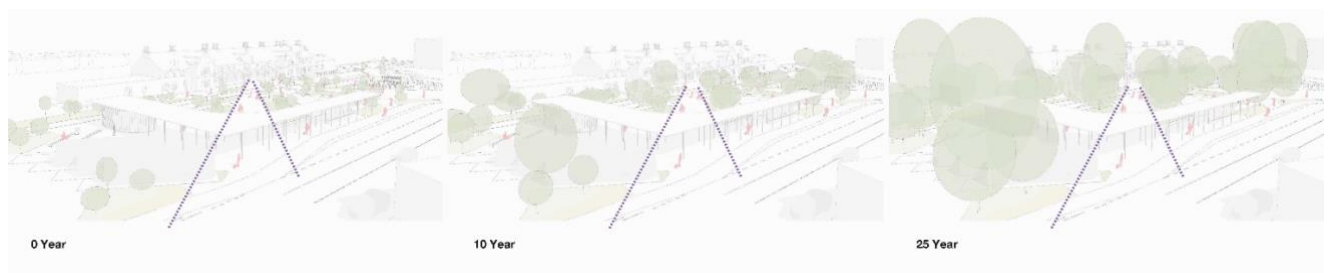


Figure 9. Tree species specific growth rate based on LIM data and simulations. (Source diagram developed by the author)

Public Realm and Accessibility

By overlaying environmental data with pedestrian movement patterns, the team reconfigured circulation to minimise conflict zones and enhance wayfinding. New shaded routes, seating areas, and cycle facilities improved the thermal comfort and inclusivity of the forecourt, transforming it from a car-dominated forecourt into a climate-responsive civic space (Figure 8). The approach demonstrated how climate and health data shape spatial configuration.

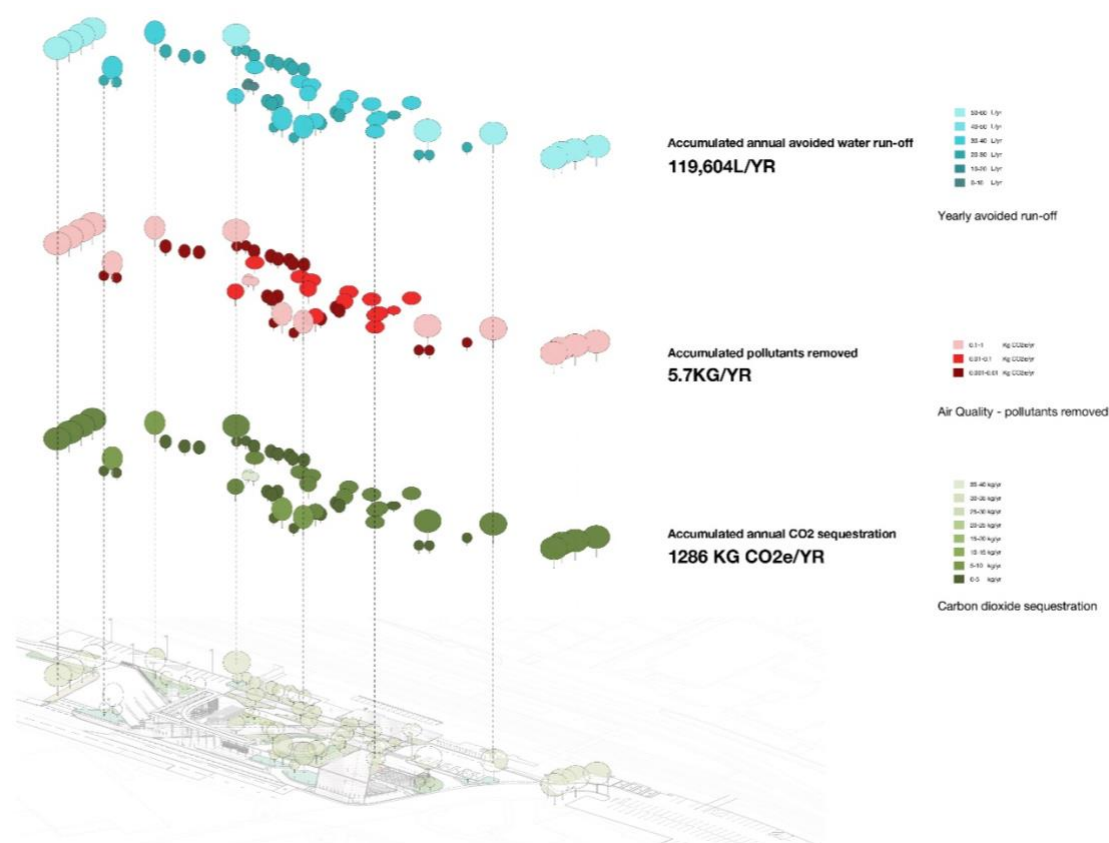


Figure 10.1 Final tree planting palette and the accumulated ecosystem services. (Source diagram developed by the author)

Cost Savings and predictions

Through maintenance predictions and savings, clear projections were provided for the client and stakeholders of what the design would require to be maintained and kept successful. It clarified opportunities to enhance the ecological value along with reducing cost (65-60%) for maintenance based on the choice and type of species and habitat implemented in the design (Table 1).

Planting types	Traditional Perennial & shrub bed	Wildflower Meadow	Mixed Native Scrub	Rain garden
Cost per sqm/yr	£10 - £20	£1.50 - £3.00	£2.00 - £5.00	£6.00 - £10.00
Hereford Softscape sqm	0	574	350	480
Annual Maintenance Cost for Hereford	£14,040 – £20,080 (1404 sqm)	£4,441 – £8,272		
Cost savings		65-60%		

Table 1. Maintenance costs for traditional planting types in comparison to alternative low-maintenance planting types. (Source table and data created by author)

Co-benefits

The application of Landscape Information Modelling (LIM) at the Hereford Station Transport Hub demonstrated how digital tools paired with environmental performance can turn ecological intent into quantifiable design action.

The LIM process led to a balanced planting palette, one that optimised ecological gain while remaining practical in terms of maintenance, heritage sensitivity, site considerations and cost (Figure 10 & Table 1).

Environmental KPIs	Ecosystem Services
Biodiversity	+10% Gain
Water run-off	105,800 L/yr Natural filtration
Carbon	1115 kg/yr sequestration
Air Pollution	5.61 kg/yr removed from the air
Oxygen generated	8930 kg/yr
Temperature	22% Reduction
Wind	42% Reduction
Cost Savings	£2588 annually

Table 2. Accumulated ecosystem services based on final landscape design (Source table and data created by author)

Challenges and Limitations

The Hereford pilot also exposed key limitations in operating digital–ecological modelling:

Data Resolution: Environmental data were incomplete and inconsistent. Soil carbon, subsurface hydrology, and species-level performance often required extrapolation from limited datasets, revealing the need for additional research through open, standardised ecological databases at the urban design scale.

- **Modelling Living Systems:** Vegetation behavior is inherently variable, with each plant responding differently to soil, microclimate, and transplant stress. LIM simulations therefore guide rather than predict outcomes; resilience depends on adaptive management and feedback, not fixed precision.
- **Real-Time Monitoring:** At the time of testing, LIM functioned as a design-phase tool. Future integration with IoT sensors (soil moisture, canopy temperature, air quality) will enable post-construction validation and ongoing recalibration.
- **Professional Upskilling:** Converting numerical outputs into design decisions requires ecological and digital fluency. The project exposed gaps in cross-disciplinary literacy, highlighting the need for stronger data skills among designers and greater ecological awareness across teams.

- **Site Constraints:** Conditions such as underground services, budgets, and maintenance capacity limited implementation of optimal ecological strategies. LIM clarified these trade-offs, supporting informed decisions rather than prescribing idealized solutions.

Collectively, these challenges reveal LIM's dual nature as both technical innovation and cultural shift. Its effectiveness depends on data infrastructure, institutional adaptation, and professional education progressing together.

Cases Study Conclusions

The Hereford Station Transport Hub represents the first operational test of LIM as a framework for designing with nature through technology. By quantifying environmental performance, it translated intangible sustainability goals into measurable design outcomes. The project revealed both the potential and the constraints of digital-ecological practice, showing that precision in data is less important currently than clarity in process and adaptability in intent.

Lessons from Hereford form the empirical foundation for understanding how LIM may be scaled across diverse bioclimatic and policy contexts, turning data into design, and design into living resilience. Furthermore, future aspirations lie in tracking performance from the Hereford pilot project when constructed to confirm the predicted values from LIM, but this is currently not available in the LIM format.

DISCUSSIONS, IMPLICATIONS AND FUTURE DIRECTIONS

LIM reframes landscape design as an evidence-based, accountable practice linking ecological performance to decision-making across building, community, and institutional scales. The framework strengthens design literacy around climate, health, and biodiversity while exposing limits in data quality and governance. Yet its most transformative implications lie not in technical refinement but in how it reshapes design pedagogy and professional identity, a dimension with profound consequences for architectural education and practice.

Building-level practice – From intuition to performance

At the building scale, LIM transforms landscape design from skill-based to evidence-based practice. Decisions on species, soil, and irrigation, traditionally guided by precedent, can now be tested through climatic and ecological simulation, anticipating failures that inflate carbon footprints through re-establishment.¹⁸

Yet ecological data remain incomplete, and biological systems resist full prediction.¹⁹ LIM therefore functions as a calibration tool, guiding rather than dictating design. The value lies in continual feedback between ecological intuition and digital reasoning, where modelling amplifies rather than replaces professional expertise.²⁰

Community-scale interventions – Climate-health visibility

LIM makes the relationship between environment and health legible. Heat exposure, air quality, and access to green space materially affect public well-being yet are rarely quantified in spatial planning.²¹ LIM translates these datasets into visual, place-specific evidence, reframing green infrastructure as public-health infrastructure. LIM translates these datasets into visual, place-specific evidence, reframing green infrastructure as public-health infrastructure. In Hereford, simulations revealed unequal heat exposure, enabling targeted adaptation for vulnerable communities. To remain equitable, LIM must integrate local knowledge and governance mechanisms that prevent digital divides between well-resourced and underfunded authorities.

Digital transformation – LIM as scalable infrastructure

Interoperability with BIM and GIS enables scaling from site to region, allowing both a single tree and a reforestation programme to be assessed using comparable metrics of cooling, ecosystem services, and biodiversity. However, digital progress without institutional capacity remains fragile. Embedding LIM requires shared literacy and governance so that technical modelling translates into ecological understanding.²²

Climate justice & data ethics

The integration of socio-environmental and health datasets introduces both ethical value and risk. LIM can map vulnerability, identifying where heat, pollution, and lack of green space intersect with social inequality, guiding interventions where they generate the greatest public benefit. This visibility, however, demands strong data ethics: information must remain transparent, anonymised, and accountable in use. Resilience cannot be reduced to metrics alone. Cooling capacity, pollution filtration, and psychological comfort are all valid forms of ecological performance. For these benefits to be equitable, institutional frameworks must guarantee fair access to data, representation, and decision-making.

Paradigm shift – Intuition to accountability

LIM signals a broader paradigm shift in the relationship between design, ecology, and technology. It positions design as an accountable act, where every decision leaves a measurable environmental trace. Creativity is reframed as exploration within evidence rather than beyond it. Yet accountability should not collapse into reductionism: quantification cannot replace cultural meaning or aesthetic judgment. LIM succeeds when precision coexists with empathy, treating data as a mode of care rather than control.

This shift redefines professional competencies. The landscape architect becomes less a stylistic author and more an ecological integrator: specifying not merely plant palettes but quantifiable performance targets (carbon/kg, runoff/m³, habitat units). This demands new liability frameworks: if a designed landscape fails to achieve modelled sequestration rates, where does accountability lie, with the modeller, the specifier, or the maintenance contractor? Professional bodies (LI, ASLA, IFLA) will need standards for evidence-based ecological design, including post-occupancy validation. The most effective practitioner will combine ecological intuition with computational fluency, a hybrid competency defining the digitally literate ecological designer.

Integration challenges & capacity priorities

The Hereford pilot revealed three priorities:

- Data reliability – stronger, standardised ecological datasets are essential.²³
- Institutional capacity – models should migrate within public agencies for continuity.²⁴
- Human expertise–LIM enhances human judgement; it does not automate it.

A fourth priority is pedagogical transformation. Professional fluency requires ecological numeracy—the ability to translate biological processes into computable parameters and interpret simulation outputs as design drivers rather than deterministic verdicts. Without curricular reform, LIM remains a specialist tool rather than a mainstream competency.

If achieved, digital environmental intelligence can become a global framework that transforms digital infrastructure to a system of regeneration, aligning computation with environmental care.²⁵ By merging computation with ecological insight, it invites a more accountable, adaptive, and empathetic approach to city-making, one that recognises data not as control, but as dialogue with the living systems that sustain us.

Scaling, interoperability, and public engagement

Following its UK pilot, LIM should be tested across arid, tropical, and alpine contexts, each requiring regionally calibrated datasets. Future development must deepen interoperability with IFC and CityGML, while IoT sensors (soil moisture, canopy temperature) will enable real-time feedback, transforming LIM from predictive tool to adaptive system.

Resilience depends on public understanding as much as technology. LIM's visual outputs turn data into dialogue; interactive dashboards can engage citizens in local climate action. Embedding LIM in academic curricula requires three pedagogical shifts: (1) data literacy, working with species databases, simulation tools, and parametric platforms alongside conventional drawing; (2) interdisciplinary collaboration as core, not elective; and (3) reflexive modelling, understanding what simulations cannot represent (below-ground carbon, species resilience), as professional judgment rather than technical afterthought.

Global Implications and Future Research

As climate instability grows, the ability to measure, model, and manage ecological processes across scales becomes essential.²⁶ LIM provides this foundation but raises critical research questions:

1. How can models remain context-sensitive yet comparable across regions?
2. How do we ensure common agreement on outputs (units) and universal comparable outcomes?
3. How can digital infrastructures expand without worsening inequality?
4. How can LIM literacy be democratised across design programmes worldwide, preventing a new digital divide between computationally resourced and under-resourced institutions?

Future research must link data science, ethics, and design, explore AI-assisted pattern recognition and predictive modelling while maintain human interpretation. The strength of LIM lies not in precision but in its ability to reveal relationships and dependencies, turning data into awareness.

Ultimately, LIM points to cities conceived as responsive ecosystems, where design, data, and life evolve together.

CONCLUSIONS

LIM shows how digital technology can become an instrument for implementation and integration of ecological intelligence in contemporary urban design processes. As cities face climate volatility and rapid urbanisation, LIM offers a bridge between design, science, and governance, transforming technology into a mediator between the built and the living. Through its methodology and Hereford pilot, LIM has proven that environmental data can guide spatial decisions with measurable outcomes, carbon sequestration, flood mitigation, and biodiversity gain, while recognising that designing with living systems requires interpretive skill and sensitivity.

By linking climatic models, species intelligence, and environmental data within one collaborative platform, LIM reframes digital design as ecological reasoning, uniting disciplines under a shared system of accountability. It supports Spatial and Climatic Adaptation Strategies by operationalising global policy frameworks such as the UN SDGs, Paris Agreement, and Kunming–Montreal Biodiversity Framework into practical, measurable design.²⁷ Equally, LIM decentralises ecological knowledge through transparency and interoperability, enabling designers, institutions, and citizens to share accountability for environmental outcomes.

Future progress will rest on three trajectories:

1. Scaling across bioclimatic regions.
2. Embedding real-time feedback and adaptive learning.
3. Fostering civic participation and ecological literacy.

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GREEN INFRASTRUCTURE AS A SOCIOSPATIAL JUSTICE STRATEGY: THE CASE OF JARDIM COLOMBO FAVELA, SÃO PAULO, BRAZIL.

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INTRODUCTION

In Brazil, approximately 17 million people live in slums and informal urban communities, which corresponds to about 8% of the national population.¹ These territories are characterized by dense, self-built occupation, precarious housing, a lack of urban infrastructure, and legal insecurity resulting from the absence of land regularization. More than a physical condition, the slum expresses a structural mode of urban space production marked by profound socio-spatial inequalities, which directly affect access to essential rights, services, and environmental goods.

In favelas, residual areas—such as alleys, stairways, valley bottoms, stream banks, and interstitial lands—often emerge as abandoned or underutilised spaces. These urban fragments, often converted into solid waste disposal sites, open sewers, or precarious occupations, reflect both the historical neglect of public authorities and the fragmentation of urban policies. In the context of climate change and public health crises, such spaces intensify socio-environmental risks, such as flooding, landslides, and the spread of disease, disproportionately affecting the most vulnerable populations.

Urban precariousness, however, cannot be understood as the result of the absence of the state, but as the product of a historically exclusionary model of urbanization that prioritizes economic interests and marginalizes significant segments of the population. As Milton Santos² argues, the contemporary city materializes social exclusion, producing inequalities that are simultaneously social and spatial. In this sense, favelas are not an anomaly of the urban process, but one of its structural expressions, formed by complex dynamics of self-construction, solidarity networks, and collective practices of territorial appropriations.³

As Ananya Roy⁴ points out, informality operates as a selective mode of urban governance, produced and regulated by the state and the market. It is in this context that residual spaces take on an ambiguous role: while they materialize processes of abandonment, stigmatization, and territorial control, they also reveal disputes, resistance, and latent potential for new forms of use and appropriation of space.

Recognizing these urban fragments as strategic territories, rather than mere voids, implies a change of perspective in urban and environmental planning. This change requires an approach capable of articulating socio-spatial justice, environmental justice, and the right to remain in the territory, especially in contexts of informality. It is from this understanding that green infrastructure emerges as a relevant strategy for the requalification of residual spaces, by integrating ecological, social, and urban functions in historically neglected areas.

In this context, this article analyses the experience of Fazendinha, located in the Jardim Colombo favela in São Paulo, Brazil, as a case study of the reinterpretation of a former residual space—previously used as an informal landfill, through green infrastructure and a shared governance model. The research seeks to demonstrate how community-based initiatives can operate as concrete strategies for socio-spatial justice, articulating environmental transformation, social protagonism, and new forms of urban space management in informal settlements.

METHODOLOGICAL APPROACH

This study adopts a qualitative and place-based research approach grounded in urban theory, environmental justice literature, and governance studies. The analysis is based on a case study of the Fazendinha initiative in the Jardim Colombo favela, combining document analysis, field observations, and empirical research conducted with residents as part of an ongoing doctoral research project. One of the authors is the founder and president of Instituto Fazendinhando and has been directly involved in the initiative since its early stages, acting as a practitioner-researcher. This positionality enabled direct engagement with community processes and access to project documentation, community archives, and field observations.

The research was approved in accordance with the ethical principles governing research involving human subjects, under CAAE No. 93823525.6.0000.0084, by the Research Ethics Committee of Mackenzie Presbyterian University. All interviews were conducted with the free and informed consent of the participants, ensuring the anonymity and confidentiality of the collected data.

RESIDUAL SPACES, GREEN INFRASTRUCTURE, AND SOCIO-SPATIAL JUSTICE AS SHARED LEARNING PROCESSES

Urban informality in Brazilian cities is marked by the coexistence of intense social life and deep socio-environmental vulnerability. In this context, residual spaces—often overlooked in public policies and planning practices, offer a privileged lens through which to understand how environmental degradation, social inequality, and fragmented governance materialize in everyday space. At the same time, these territories reveal possibilities for collective learning, engagement, and shared management, which are central to contemporary debates on education, participation, and socio-spatial justice in informal urban contexts.

Residual spaces in favelas are commonly associated with environmental degradation, recurrent flooding, accumulation of solid waste, and the absence of public care. In this article, such spaces are understood not merely as physical leftovers of urbanization—such as stairways, alleys, creek banks, and interstitial areas—but as territories where social, environmental, institutional, and cultural

processes intersect. Far from being only sanitary or technical problems, residual spaces reveal how unequal urbanization, limited state presence, and fragmented public policies shape lived experiences in informal settlements and structure everyday relations between population, territory, and nature.

In Brazilian cities, environmental degradation and informal or “insurgent” occupation have historically advanced together, particularly in ecologically fragile areas such as slopes, stream banks, and valley bottoms. This dynamic has intensified socio-environmental risks and urban vulnerability, especially where public regulation and infrastructure provision have been insufficient or discontinuous.⁵ In many cases, public interventions remain sectoral and short-term, implemented without sustained dialogue with residents and without a systemic territorial approach. As a result, such interventions tend to reproduce cycles of degradation, generating spaces that remain underused, deteriorate rapidly after implementation, or revert to abandonment.

This process is especially evident in favelas, where small squares, stairways, alleys, and transitional areas between informal settlements and formal infrastructure frequently become residual spaces—territories without a clear function, marked by neglect and stigma. In many cases, these spaces are simultaneously abandoned and excessively surveilled, reflecting logics of control rather than care. These dynamics operate in the interstices of segregated urban space, reinforcing territorial stigmatization and limiting the possibilities of social appropriation and collective use.⁶

At the same time, residual spaces should not be understood solely as expressions of deprivation. Precisely because they escape hegemonic logics of standardization, regulation, and technological control, they may also foster engagement, experimentation, and collective identification. Pereira⁷ highlights that these fragmented and emotionally charged spaces can generate new participatory situations, becoming places of encounter, shared use, and symbolic re-signification. Their marginal condition, rather than being an obstacle, can create opportunities for social mobilization and alternative forms of urban practice.

Reframing residual spaces in this way makes it possible to connect them to broader questions of socio-spatial and environmental justice. These spaces materialize unequal access to rights, infrastructure, and environmental quality, revealing how injustice is embedded in territory.⁸ From this perspective, residual spaces are not empty or neutral voids, but concrete expressions of territorial, environmental, and social injustices that directly affect the daily lives of populations who inhabit them. Justice, in this sense, must be understood as situated, linked to specific places, histories, and power relations.

The notion of spatial justice, as articulated by Soja,⁹ provides an important framework for understanding these dynamics. Spatial justice is closely linked to the right to the city and to struggles over how rights, resources, and opportunities are distributed and negotiated in space. It encompasses not only distributive justice, related to the fair allocation of public goods and environmental benefits, but also procedural justice, embedded in the ways decisions are planned, negotiated, implemented, and managed.¹⁰ Residual spaces thus become key arenas where distributive and procedural dimensions of justice intersect through everyday practices, disputes, and forms of resistance.

The increase in inequality, socio-spatial fragmentation, and lack of access to public goods represents a serious threat to urban sustainability, particularly when sustainability is understood in its social,

economic, and environmental dimensions.¹¹ In this context, the way urban space is managed can either reproduce or counteract inequalities. Participation, transparency, and the inclusion of multiple voices in decision-making processes emerge as essential conditions for more just urban policies, especially in territories historically excluded from institutional planning arenas.¹²

Environmental justice further reinforces this argument by drawing attention to the unequal distribution of ecological risks, which disproportionately affects vulnerable populations in peripheral and informal territories. According to Mendes and Siqueira,¹³ justice constitutes a fundamental mechanism for structuring social order, ensuring dignified living conditions through legal instruments that guarantee rights and protections. Environmental justice, in this sense, highlights how exposure to environmental hazards is socially produced and unevenly distributed, transforming risk into a central dimension of socio-spatial inequality.

Within this broader framework, green infrastructure emerges as a strategic tool to operationalize the principles of socio-spatial and environmental justice in informal settlements. Green infrastructure can be understood as an approach that positions natural systems as essential urban infrastructure, capable of providing fundamental environmental services such as water regulation, temperature control, soil stabilization, biodiversity support, and improvements in air and environmental quality. As Firehock¹⁴ defines, it is “green because it is part of the natural environment and infrastructure because it provides the basic services that we all need for a healthy life.” Unlike conventional gray infrastructure, green infrastructure operates through networks of interconnected open and vegetated spaces, integrating ecological processes with social use and everyday practices.

In contexts marked by socio-spatial vulnerability, such as favelas, the absence of green areas, limited tree cover, and insufficient ecological infrastructure intensify exposure to flooding, extreme heat, landslides, and pollution. These conditions reveal how environmental degradation disproportionately affects marginalized populations and reinforces the interconnection between socio-spatial injustice and environmental inequality. In many cases, what remains are fragmented and degraded open areas—residual spaces that, although frequently neglected in maintenance and stewardship policies, hold significant potential for transformation.

The incorporation of green infrastructure into residual spaces allows these fragments to become elements of ecological reconnection, environmental recovery, and social inclusion. By transforming residual areas into vegetated spaces, water infiltration zones, community gardens, or small-scale ecological corridors, green infrastructure redistributes environmental benefits and mitigates ecological risks in territories historically excluded from urban investments. In this sense, green infrastructure functions as a concrete mechanism of distributive justice, expanding access to environmental goods such as shade, improved microclimates, flood protection, and healthier living conditions.

At the same time, the effectiveness of green infrastructure in informal settlements depends on participatory processes of planning, implementation, and management. This dimension highlights its role as a mechanism of procedural justice, as decisions regarding the use, care, and transformation of residual spaces become opportunities for negotiation, collective learning, and the recognition of local knowledge.¹⁵ Green infrastructure thus cannot be reduced to a technical solution; it must be understood as a socio-ecological and educational process.

From this perspective, the incorporation of green infrastructure into residual spaces fosters shared learning processes. Participation in design, implementation, and everyday management enables the circulation of knowledge, strengthens local capacities, and promotes co-responsibility among residents, civil society organizations, and public actors. Shared governance emerges as a necessary condition for sustaining these transformations over time, recognizing community leadership and supporting the co-production of space.

By understanding residual spaces as fragmented and historically neglected territories, but also as places capable of fostering engagement and collective action, it becomes possible to reinterpret them beyond their condition of urban obsolescence. Their re-signification through green infrastructure strategies opens pathways that combine environmental transformation with social inclusion, reinforcing the role of participation, education, and shared governance in the pursuit of socio-environmental justice.

In light of this debate, it is essential to observe how these principles can be operationalized in concrete contexts of urban informality. More than technical solutions, such interventions require institutional and social arrangements capable of dealing with territorial complexity, socio-environmental vulnerability, and local power dynamics. It is at this point that shared governance becomes central, and the experience of Fazendinha, in Jardim Colombo, offers a concrete example of how residual spaces, green infrastructure, and socio-spatial justice can be articulated in practice.

SHARED GOVERNANCE AND THE RE-SIGNIFICATION OF A FORMER LANDFILL: THE CASE OF FAZENDINHA

It is understood that the requalification of residual spaces in favelas, with the aim of transforming them into green infrastructure, requires the adoption of new governance models capable of addressing the social, environmental, and territorial complexity of these contexts. Among these models, shared governance stands out, as it recognizes the central role of the community as a protagonist in processes of urban transformation. This management arrangement presupposes the active participation of residents from the project conception through the stages of implementation, management, and maintenance of spaces, establishing a logic of co-responsibility among public authorities, the private sector, civil society, and the local community. Shared governance enables interventions to be conceived beyond the short term, taking into account their long-term sustainability, mechanisms of ongoing care, and the strengthening of local capacities for stewardship and appropriation of spaces.

“Shared governance seeks to bring together both institutions and the community itself. Its creation requires reflection on how these actors are organized—public institutions at different scales and sectors of action, private entities, and community organizations—present and active within the territories, consolidating mechanisms of social, financial, and institutional management and assigning responsibilities and obligations to territorial agents. This process consists of creating groups of organizations that work collectively as a network, whose main strength lies in the involvement of partners in decision-making processes that affect the implementation and planning of local interventions, as well as in their flexibility and responsiveness to the needs of the territory and its population. It is a model that, in order to be effective, demands commitment and effort from its participants, with resources and time dedicated to its operation—hence the importance of strong articulation with the community, adherence to timelines, and the delivery of tangible outcomes that confer credibility to the actions”.¹⁶

The involvement of stakeholders in local affairs has increasingly gained prominence in discussions on urban governance. When addressing this involvement, it is necessary to understand how interactions

among stakeholders function within governance systems. Wachhaus argues that governance determines who has influence, who makes decisions, and how decision-makers are held accountable. Therefore, the greater the participation of different stakeholders in planning and decision-making processes, the stronger the evidence of collaborative governance.¹⁷

“Cities that implement collaborative strategies have the capacity to build public policies based on the contributions of different viewpoints and social actors, accurately identifying local problems and improving public investment. Moreover, they develop the ability to think in the long term, grounded in principles of transparency and shared responsibility in the structuring of sustainability policies. Finally, the chart shows that collaborative governance enables citizen empowerment, transforming the city into a public space for social participation.”¹⁸

The experience of Fazendinha takes place in this context, located in the Jardim Colombo favela in São Paulo, Brazil, in an area of approximately one thousand square meters, characterized by a pronounced topographic slope, with about 18 meters of difference between the lowest and highest points of the terrain. Until 2017, the site functioned as an open-air landfill, associated with environmental degradation, irregular waste disposal, and insecurity for the surrounding residents. The transformation of this space began through a bottom-up community mobilization, led by the residents themselves, initially coordinated by a group of volunteers, which later became consolidated as the Instituto Fazendinhando, a non-profit social organization. This movement allowed the recognition of the site’s potential as a space for social interaction and collective gathering, which was fundamental for re-signifying the use of the area and breaking with the historical pattern of neglect and invisibility of open spaces in favelas. (Figure 01)



Figure 01. Beginning of the community workdays in 2018 at the Fazendinha former landfill, located in the Jardim Colombo community, in São Paulo, Brazil. Source: Author’s archive.

The transformation of Fazendinha did not occur in a linear manner nor without conflicts. In the initial stages, dialogue with the public authorities proved challenging, both due to institutional bureaucracy and the absence of formal channels for listening to community demands. Nevertheless, through community-organized collective work efforts, with support from external volunteers and civil society actors, cleaning, terrain management, planting, and small-scale green infrastructure interventions were initiated. Cultural, recreational, and educational activities played a central role in this process, functioning as strategies for community engagement and consolidating the community's presence in the space, ensuring its continuous occupation a condition essential for the sustainability of the project.

As illustrated in the diagram below, this process can be understood as a continuous cycle of territorial transformation, structured around space activation, practical experimentation, collective construction and governance, educational processes, and ultimately its consolidation and continuity. Rather than a linear sequence, it is a dynamic process shaped by trial, adjustment, and collective learning over time.

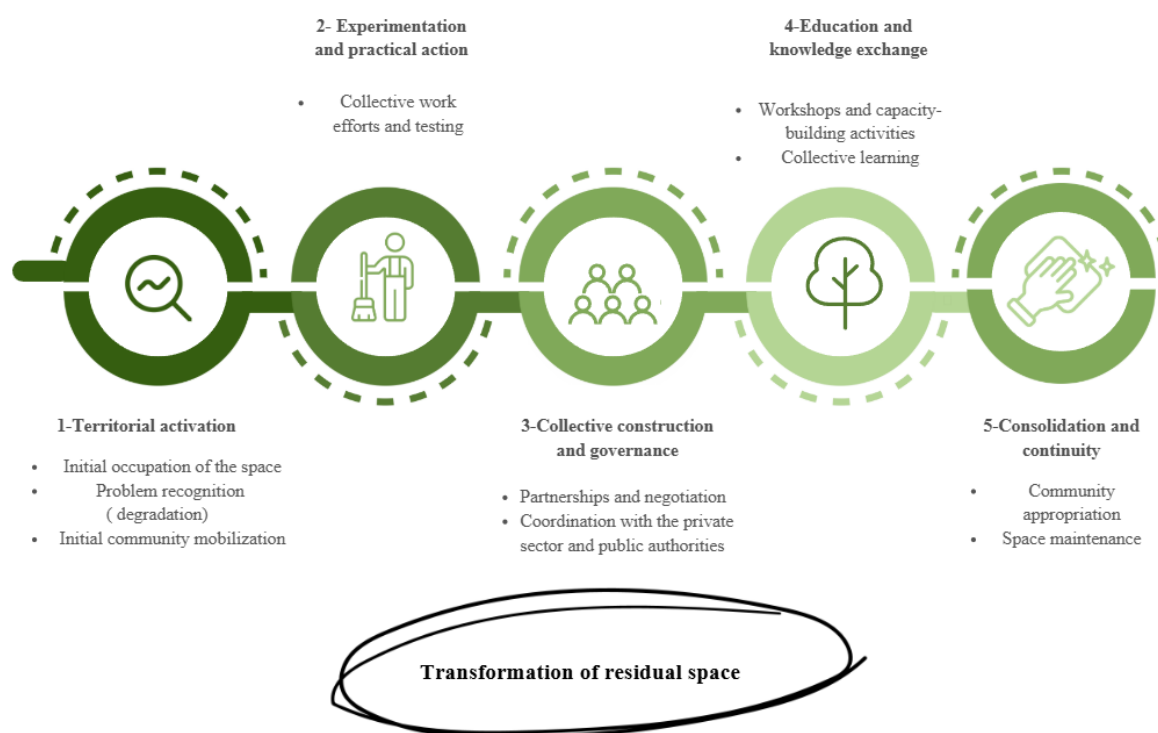


Diagram 01. Iterative Cycle of Residual Space Transformation: The Fazendinha Case
Source: Prepared by the authors.

As the process matured and the local organization strengthened, it became possible to advance in the construction of a shared governance model, involving residents, civil society organizations, the private sector, and gradually, the public authorities. Continuous dialogue and the daily practice of collective management consolidated trust among local actors and also strengthened institutional relations with the São Paulo municipality, expanding the possibilities for long-term public support. Currently, Fazendinha operates as an open, ungated space freely accessible to the community, hosting a variety of activities and establishing itself as a rare and vital green area within the dense urban fabric of the Jardim Colombo favela. The space hosts cultural events, environmental workshops, educational activities, and community gatherings, significantly increasing local use and strengthening residents' sense of belonging and collective stewardship. In a context marked by the scarcity of public green

spaces in favelas, Fazendinha has become a breathing space in the heart of the territory, fostering everyday encounters and environmental awareness. (Figure 02)



Figure 02. Cultural activities at Fazendinha, Jardim Colombo, São Paulo, Brazil, 2023.

Source: Author's archive.

The continuous use of the area and its open character are sustained through the ongoing stewardship carried out by Instituto Fazendinhando, which assumes responsibility for the maintenance and programming of activities in close collaboration with the residents. Importantly, the architectural and landscape project collectively designed by the community was incorporated into the municipal urbanization plan, signaling institutional recognition of bottom-up planning processes. Furthermore, the actions developed in Fazendinha have begun to reverberate throughout the territory, inspiring new initiatives and contributing to the formation of a network of community green infrastructures.

CONCLUSION

The experience of Fazendinha shows that the transformation of residual spaces in favelas occurs gradually, shaped by attempts, adjustments, and ongoing dialogue over time. It is not a linear process, but a collective construction that depends on the continuous presence of the actors involved. Along this path, shared governance takes shape through the relationships established within the territory. Residents, organizations, private initiative and, progressively, public authorities become part of this process, which requires continuity, negotiation, and adaptation to local dynamics. Educational processes develop within this context, closely linked to the practices carried out in the space itself. Workshops, collective work efforts, and activities create opportunities for the exchange of different forms of knowledge and help expand residents' participation and autonomy. At the same time, the continuity of these processes depends on the recognition and investment of public authorities, both in supporting these initiatives and in valuing insurgent practices already taking place in.

NOTES

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² Milton Santos, *A urbanização brasileira*, 5th ed. (São Paulo: Edusp, 2009).

³ James Holston, *Insurgent Citizenship: Disjunctions of Democracy and Modernity in Brazil* (Princeton: Princeton University Press, 2009), accessed May 25, 2025, <https://antropologiadeoutraforma.wordpress.com/wp-content/uploads/2014/03/holston-james-insurgent-citizenship.pdf>.

⁴ Ananya Roy, "Urban Informality: Toward an Epistemology of Planning," *Journal of the American Planning Association* 71, no. 2 (2005): 147–158, <https://www.wiego.org/wp-content/uploads/2019/09/Urban-Informality-Roy.pdf>.

⁵ A. T. B. Alvim and E. S. Bessa, "Assentamentos precários e meio ambiente: um breve olhar para as intervenções nas cidades brasileiras," in *Anais do 4º Encontro da Associação Nacional de Pesquisa e Pós-Graduação em Arquitetura e Urbanismo (ENANPARC)* (Porto Alegre: PROPAP/UFRGS, 2016).

⁶ Clemente Herrero Fabregat, "Aproximación a la geopolítica orgánica, cibernética y cognitiva," *Brazilian Journal of International Relations (BJIR)* 3, no. 3 (2014): 391–418, accessed March 15, 2025, https://www.marilia.unesp.br/Home/RevistasEletronicas/BJIR/mfo274_aproximacion_geopolitica_organica.pdf.

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¹¹ Rocco, "Spatial Justice", 17.

¹² Rocco, "Spatial Justice", 16-25.

¹³ Luís Marcelo Mendes and Jerônimo Tybusch Siqueira, "A justiça ambiental como instrumento no combate à distribuição desigual do risco ecológico em sociedades ditas periféricas," *Revista de Direito e Sustentabilidade* 3, no. 2 (2017): 71–89, accessed October 17, 2025, <https://doi.org/10.26668/IndexLawJournals/2525-9687/2017.v3i2.2534>.

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OUKALISATION: AMBIANCE AND THE NEGOTIATION OF CITIZEN HERITAGE.

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INTRODUCTION

The urban landscape of the Maghreb is defined by a profound contradiction where a vast built heritage recognized for its historical value exists in a critical state of decay. This paradox is highlighted by recent societal debates such as the potential demolition of the Hotel du Lac in Tunis, an iconic figure of Brutalist architecture. When official policies create a structural vacuum, social praxis takes over through forms of spontaneous appropriation by populations in situations of social vulnerability. This process of oukalization¹ is not merely a response to housing needs but represents complex socio-spatial and temporal dynamics that challenge dominant institutional heritage paradigms. These occupied spaces produce an architecture of the common that escapes traditional regulatory norms while proposing alternative modes of living through the reinterpretation of space.



Figure 1. Current state of historic buildings in Tunisia. (Hamrouni, 2020)

THEORETICAL FOUNDATIONS: CHRONOTOPY AND AMBIENT MEDIANCE²

To understand the Oukala, this research employs a multidisciplinary approach combining architecture, anthropology, and heritage studies. The concept of chronotopy³ is particularly fertile for analyzing how these spaces articulate diverse temporalities within a single configuration. In the oukala, this involves the superposition of the long time of the heritage building, the short time of precarious occupation, and the cyclical rhythms of daily domestic life.

Furthermore, the notion of ambient mediance describes how these spaces produce unique atmospheres that mediate the relationship between occupants and their environment. This mediance is a generative process of identity and belonging that transforms an illegal occupation into a perceived legitimate appropriation. Additionally, the concept of affordance reveals how these buildings offer specific action possibilities that are only activated through non-conventional usage.

METHODOLOGY AND TYPOLOGICAL DIVERSITY

The research is built upon an innovative methodology of participatory immersion and ethnographic observation conducted over a two-year period. The study focuses on three representative sites: Burj Toukebri in La Manouba, the former school on Rue du Tribunal in the Tunis Medina, and Villa Zodiac in Bou Argoub. Investigation tools included participatory mapping, commented walks, and mental maps to capture resident expertise without imposing pre-constructed analytical frameworks. This analysis revealed five principal configurations of oukalization based on the interaction between architectural type and appropriation gestures. Predisposed architectures like traditional courtyard houses require only minor transformations because their inherent organization distinguishes private and common zones. More dynamic adaptations occur in patio buildings where functions evolve from commercial storage on the ground floor to residential use on upper levels. In buildings originally designed for public use, such as the school on Rue du Tribunal, large classrooms are converted into family units while vast collective spaces like refectories are reinvested for community life. Standard residential buildings without such predispositions often undergo radical and sometimes destructive interventions to allow for collective housing. Finally, in ruins like Burj Toukebri, oukalization involves a phase of structural consolidation where extensions are often built outside the original structure to respect the integrity of the starting fabric.

RESEARCH METHODOLOGY AND IMMERSIVE APPROACH

Our research is fundamentally grounded in the immersive moment and direct contact, here and now, through encounters with a wide range of profiles and the various logics of oukalisierung observed. To this end, it was essential to construct our investigative approach on a cross-reading of the different levels of involvement and investment of the oukaliseurs, as well as on fragmented pieces of information found sporadically within the existing literature and filmographic documentation.

Immersion enabled us to identify the dynamics to be examined and to deepen the empirical foundation of our case studies. We also chose to diversify our study sites in search of recurring patterns and similarities in use, maintenance, and processes of heritagisation. This was conducted through an incremental approach, allowing for progressive advancement in analysis and the deployment of our findings.

Between the school on Rue du Tribunal located in the heart of the medina, the Bùrj Toukebri situated in Manouba, and the Zodiac Villa in Bou Argoub, we sought to trace the phenomenon of oukalisierung through its displacement, territorial evolution, and exportation, beyond the walls of the medina, in

order to examine a wide range of contextual data, cross-reference them with different architectural typologies, and identify the corresponding operational modes.

The immersion unfolded in five phases and aimed to progressively construct an ambient-based reading of the “trajective” and sensitive data collected. We thus adopted a hybrid posture, simultaneously that of observer, companion, facilitator, and at times provocateur or instigator. We also deliberately relied on simple and ordinary analytical tools in order not to distort the actions and behaviors of occupants within their environment.



Figure 2. Burj Toukebri : One of the three study sites. (Hamrouni, 2020)

The analytical protocol implemented was adapted to the different situations encountered and modified according to emerging data or contextual circumstances. As a result, we sought to remain flexible and adaptable, avoiding the imposition of a predefined direction on the observational process. “Immersion thus became a fundamental step [in the construction of an affective bond] with neighborhood inhabitants”. While this choice proved both relevant and compelling in light of the specificity of our research object, it later revealed itself to be complex to manage and analyze.

ESTABLISHING CONTACT AND BUILDING TRUST

The initial contact constituted a critical moment within our immersive approach. Our first encounters with the oukaliseurs were marked by apprehension, misunderstanding, mistrust, reserve, and ambivalent doubt, tempered by a strong sense of hospitality. Reception therefore occurred progressively, until trust was established. Throughout our visits, we were repeatedly questioned regarding our real motivations, fields of interest, expectations, and the institutional framework within which we were operating. Suspicion that we might belong to the municipality, a real estate development group, a political party, or a politically oriented association was unfortunately deeply rooted.

We therefore took the time to clarify and explain every aspect of our work in order to establish a relationship of mutual trust, the sole guarantee for the success of fieldwork, without which all collected information risked being biased or deliberately altered by occupants as a means of self-protection. This trust-building process was gradual, fostered through repeated visits and our sustained presence within their territory. Initially, exchanges were limited to informal conversations; subsequently, we began recording, filming, and photographing. We employed various in-situ investigative tools, including mental maps⁴ and commented walks. We sought to make this phase a moment of sensitive writing that was both participatory and inclusive, involving men, women, and

children alike. After one year of close, on-the-ground engagement, this phase was followed by a period of critical distance and detachment, allowing us to reassess methodological choices, reinterpret findings, and objectively analyze the collected data.

In what follows, we present the guiding principles of the five phases of our immersive approach, with the aim of situating the tools employed, identifying the objectives of each phase, establishing the final analytical protocol, and delineating the boundaries of citizen heritage, ordinary maintenance, and architecture of use that characterize these novel forms of habitation.

These phases are structured as follows:

- Actively observing gestures and investments
- Adapting the approach to the studied context
- Narrating lived experience
- Involving and engaging occupants
- Analyzing and capitalizing on exchanges

ACTIVELY OBSERVING GESTURES AND INVESTMENTS

The field presents itself through dynamics, actor networks, interdependencies, and atmospheres. Observation asserts itself as a prerequisite for the success of this interpretive exercise, enabling access to interactions revealed through the “sensitive discovery” of the unforeseen, the unexpected, the fragile, and the affective. Observation is also a play of temporalities and paradoxes, of refusal and acceptance, distancing and proximity, of what is spoken and unspoken. Faced with the complexity of this dual posture, the observer is required to engage emotionally and sensorially in order to acknowledge alterity and experience this moment “as a shared experience of the sensible” (Ammar, 2017).

The degree of the researcher’s involvement within the field determines the nature of their relationship with its various components. Both observer and observed, the researcher’s presence must become a vector of enrichment and critical debate. Interactions between the oukalisieurs and ourselves throughout the investigative phases were likewise observed and analyzed. We began with ethnographic observation, defined as the “relationship between objects, human beings, situations, and the sensations they provoke in the researcher”, in order to move beyond superficial and momentary analysis and integrate the unexpected and unprecedented.

We committed ourselves to paying close attention to the words, narratives, movements, and gestures of the oukalisieurs, while simultaneously deploying appropriate actions, tools, and postures to facilitate exchange and ensure their active involvement. It was essential to remain proactive, approaching them, mobilizing them, and continuously raising awareness through ongoing adaptation of our tools and methods.

ADAPTING THE APPROACH TO THE STUDIED CONTEXT

Given the multiple possible interpretations arising from the heterogeneous range of actors involved in our research, it was imperative to adapt, contextualize, and simplify our methods. Translation, in this sense, does not merely refer to linguistic transfer, but rather to our capacity to grasp adapted expressions, assimilate vernacular language, and understand gestures and speech as articulated by the oukaliseurs and other participants.

Modes of expression were often basic and elemental. Drawing techniques were deliberately reduced to their essentials in order to avoid technical complexity or aesthetic over-elaboration that might obscure the central message and intended purpose. It was crucial to acculturate ourselves to the oukaliseurs' vision, vocabulary, gestures, and gaze in order to later recount them without distortion or misinterpretation.

This adaptive work also extended to the handling of personal data shared by occupants. In light of the trust established, it became essential to limit, modify, or partially suspend certain protocols. Some information, though highly relevant to our research, could not be disclosed or shared. Consequently, the oukaliseurs actively participated in defining what was publishable, in what form, for which audience, and for what purpose.

“A thought in action, caught [...] in the movement of life”.

NARRATING LIVED EXPERIENCE

Following observation comes the moment of narration, of reporting and writing the account of the investigation. This is not a mere descriptive narrative, report, or transcription of feelings, words, and gestures. Rather, it involves weaving connections, contextualizing each individual within their environment, and engaging with their lived experiences, perceptions, and representations. This phase corresponds to a direct, concise, and constructive form of writing grounded in direct observation.

The objective is to document what is “new” and “unprecedented” and to construct, both scientifically and methodologically, a narrative in the form of an “linguistic elaboration of experience”. Writing must thus go beyond what is simply “seen” or “observed” to achieve a nuanced and attentive translation that mobilizes the researcher’s “qualities of observation, sensitivity, intelligence, and scientific imagination”.

Positioned between immersion, subjectivity, objectivity, and complete detachment from the field, the researcher operates within an ethical and methodological framework. This difficulty is particularly acute when addressing atmospheres, emotions, and the realm of the sensible.

To address these challenges, we adopted an intersubjective posture, defined as the “transition [...] from self-sufficiency to infinite openness, from the enclosure of being to the horizon of becoming”. In other words, it interrogates both “cohesion and distinction, proximity and distance, shared space and personal sphere”. Accordingly, we position ourselves within an approach aimed at the objective construction of an affective narrative, grounded in the sharing and cross-referencing of judgments and viewpoints.

ANALYZING AND CAPITALIZING ON EXCHANGES

From the outset, we clarified to occupants that our research would not result in the immediate resolution of their problems nor in direct improvements to their living conditions. The trust agreement was clearly defined around the possibility of making their voices heard and of capitalizing on exchanges, debates, and investigations across multiple formats and media. Throughout the immersive process, participants were invited to collectively imagine possible forms of capitalization. For them, establishing a link with neighbors and civil society was essential.

Beyond written chronicles, later transcribed into podcasts inspired by field notebooks and used as tools for expression, sharing, confrontation, and comparison, we co-organized a roundtable involving neighbors, the mayor of Manouba, architecture students, and heritage preservation specialists. The aim was to incorporate new and complementary analytical perspectives that had not emerged during initial observations. Additional forms of capitalization are currently under review and are likely to shape the contours of our postdoctoral research.

INVOLVING AND ENGAGING OCCUPANTS

Citizen participation, collective writing, immersion, and the creation of a “shared commons” constitute the guiding principles of our research. Use value and residents’ voices are advanced not only as alternatives to canonical heritage preservation models, but also as key levers for successful in-situ and in-vivo research conducted with a population that is both vulnerable and sensitive.

The speed with which significant moments could be captured, combined with ease of use, made photography a privileged tool in our study. Photography unifies and brings together; Laplantine defines it as a “support for descriptive analysis of gestures, postures, and facial expressions”.

To preserve authenticity, occupants were directly involved in the process. A young adolescent was entrusted with producing videos, stories, and photographs freely, without interference. Provided solely with a smartphone, he documented what he deemed relevant. These moments of capture became opportunities for exchange and shared construction, greatly facilitating fieldwork.



Figure 3. Inclusive and active citizen participation. (Hamrouni, 2020)

The study aimed to compile narratives, testimonies, and anecdotes in order to reconstruct both original and contemporary atmospheres, cross-referencing vocal tones, gestures, and emotional inflections with co-produced surveys to reveal lived spatial practices through ambient qualities. The methodology combined commented walks, mental maps, and image-based reactivation, grounded in the hermeneutic hypothesis that an event becomes meaningful when it is perceptible and capable of speaking through us. Commented walks, understood as guided movement through space accompanied by verbal commentary, required adaptive protocols, with the researcher adopting a documentary role to ensure data quality. Mental mapping, as introduced by Tony Buzan (1974), and image reactivation supported memory, recall, and narrative construction. Participant selection was progressive and inclusive, involving voluntary residents, an ENAU student facilitating access to women, neighbors, and heritage experts, and the use of social media to gather testimonies and overcome pandemic constraints through remote interviews and digital immersion. The cross-referencing of these tools enabled the confrontation of discourse, representations, and individual and collective memory with in-situ observations, reinforcing the analytical robustness of the research.

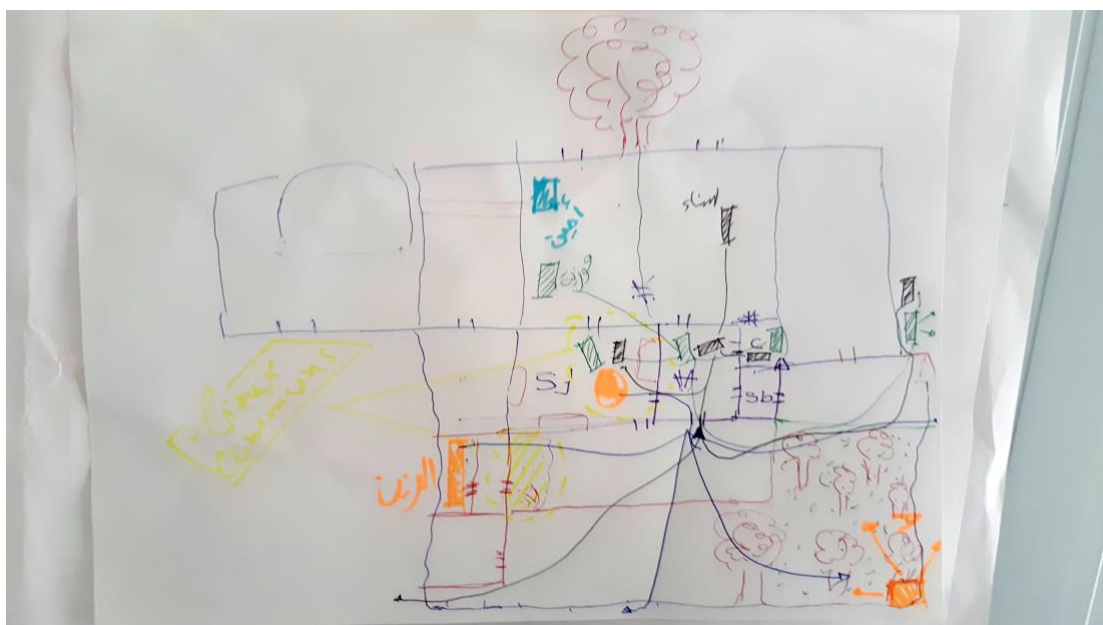


Figure 4. Example of plans and mind maps produced by oukalisours. (Hamrouni, 2020)

ALTER-PATRIMONIALIZATION AS A LIVING PROCESS

The core of this research is the concept of alter-patrimonialization, which integrates contemporary social dynamics into the conservation process. This approach demonstrates that usage can be a more effective vector of transmission than muséification, which often distances heritage from living practices. Occupants engage in a form of architectural listening, developing a fine sensitivity to thermal, luminous, and acoustic variations before making interventions. Transformations generally follow a logic of comforting rather than rupturing the original qualities of the building, such as creating openings to improve light or using greenery to regulate humidity. At Burj Toukebri, this is exemplified by the Ezzine family who moved from a functional occupation to a deep recognition of the building's collective heritage value.



Figure 5. Alter-patrimonialization as a heritage preservation policy. (Hamrouni, 2020)

Social Perception and Future Perspectives

The analysis of social representations suggests a gradual shift in how these spaces are perceived by the wider public. An investigation at the Burj café revealed that while fifty-one percent of respondents favored demolition, forty-seven percent defended conservation, indicating that visible efforts of maintenance and creative appropriation are influencing public opinion. Alter-patrimonialization demonstrates that heritage can be a living process that articulates material preservation with social innovation to generate collective value. Three factors are determined to be essential for successful oukalization as heritage preservation: stability of occupation, social recognition of the phenomenon, and minimal technical support. Ultimately, the study of oukalas as chronotopic units invites a deep rethinking of architectural and heritage frameworks. These spaces function as laboratories where new articulations between space and time are experimented with under conditions of vulnerability. Rather than seeing oukalization as an anomaly to be eradicated, public policies should recognize its creative potential and support the inhabitant dynamics that sustain it. This requires a redefinition of architects and urbanists as facilitators of emergent collective processes rather than mere prescribers of standardized models. The transmission of technical know-how developed in these contexts could significantly enrich professional practices and contribute to new paradigms of social housing and urban regeneration.

CONCLUSION

The immersive investigation at Bùrj Toukebri, combined with architectural and film-based analyses of a representative sample, made it possible to identify different forms of relationships between squatters and the occupied buildings, as expressed through modes of occupation and degrees of affective attachment. Three main scenarios were distinguished. Temporary occupation corresponds to a provisional presence marked by minimal investment, while occupants await more suitable housing. Imposed occupation reflects a permanence experienced as failure and distress, associated with rejection of the place and similarly low levels of investment. Durable occupation, by contrast, is characterized by a strong sense of belonging, recognition of the building's heritage, use, and utility value, and the deployment of adaptive actions that improve living conditions without degrading the structure, while fostering social inclusion and integration. Comparative analysis shows that oukalization practices often follow similar logics, mobilizing shared materials, skills, and DIY strategies, reflecting common social profiles marked by urgent housing needs and limited resources. The study also highlights that oukalas can function as flexible and dynamic living environments, encouraging mutual support, collective activities, neighbourhood interaction, and practices such as gardening and hosting, which strengthen social cohesion and self-esteem. Nevertheless, these internal dynamics do not necessarily alter external perceptions, as squatted buildings continue to be stigmatized and associated with danger and marginality.

NOTES

- ¹ “Oukalization” Refers to the process by which residents occupy, adapt, and personalize abandoned or underused buildings, often using diy methods, creating functional and social living spaces.
- ² The term refers to the way a space conveys mood, atmosphere, and social meaning, shaping how people experience and interact with it.
- ³ “Chronotopy” Is a concept from bakhtin adapted here to study how different temporalities heritage time, occupation time, daily life interacts within a single spatial setting.
- ⁴ Participatory mapping involves residents in producing maps or diagrams representing their use of space, which helps capture tacit knowledge and local spatial practices.

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