The Construction Site as Ecological Laboratory: Integrating Nature-Based Solutions into Architectural Practice

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The Construction Site as Ecological Laboratory: Integrating Nature-Based Solutions into Architectural Practice

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Abstract

This paper addresses the challenges and opportunities of integrating Nature-based Solutions (NbS) within the architectural design process, focusing on the regeneration of urban voids and periods of construction suspension. Moving beyond the conventional understanding of urban "downtime" as merely wasted time or empty space, the research reconsiders these intervals as critical design moments that can be strategically activated for ecological transformation. Drawing on both international and European case studies—ranging from peri-urban forests to post-industrial infrastructure and large metropolitan brownfields—the article analyses how architects can harness waiting periods and urban residual spaces as laboratories for ecological experimentation, soil regeneration, and the incremental construction of green infrastructure.

The methodological approach blends comparative analysis of emblematic projects with speculative design hypotheses, illustrating how vegetation and natural processes can be integrated into architectural workflows from the earliest stages of site preparation. The discussion foregrounds the architect's agency not only as a form-giver but as an orchestrator of dynamic, adaptive, and processual landscapes—capable of anticipating, accompanying, and enhancing the multiple temporalities of urban transformation. The proposed framework demonstrates how the architect's intervention, by aligning with the rhythms of ecological succession and integrating Nature-based Solutions, can generate measurable environmental benefits and open up new directions for sustainable urban development.

1. Introduction

The acceleration of urbanisation processes in the 21st century requires in-depth reflection on how cities and the environment relate to each other. In an international context increasingly oriented towards sustainability—as evidenced by the Sustainable Development Goals of the United Nations 2030 Agenda—there is a need to overcome the historical dichotomy between the built and natural environments, recognising sustainability not only as a programmatic objective but as a genuine generative criterion for contemporary design.

There is a growing awareness that the challenge of urban sustainability requires a radical rethinking of traditional infrastructure. Intervention strategies can be articulated on different spatial and temporal scales, derive from proactive planning or be triggered by socio-political factors, such as new urban regulations, market pressures or demands from civil society (IPCC, 2014; Van den Bosch & Sang, 2017). It is no longer enough to integrate green elements into established urban fabrics: we need to reconsider the very notion of "grey infrastructure"— as defined by Jack Ahern — as a system potentially capable of providing sustainable ecosystem services (Ahern, 2010). This requires planners and designers to develop strategies in which functions intertwine and overlap: from the verticalisation of solutions — such as green roofs, integrated urban drainage systems or wildlife corridors — to a more careful management of temporal dimensions, capable of enhancing the provision of ecosystem services in relation to the life cycles of the city. Such approaches, which are increasingly central to international thinking, underpin the latest theories and practices on green infrastructure, aimed at strengthening the resilience and adaptive capacity of urban contexts.

In this scenario, Nature-based Solutions (NbS) have emerged, born out of an awareness of humanity's profound dependence on ecosystems and the capacity of natural systems to respond to a variety of collective needs. NbS are now recognised by international institutions, scholars and organisations as a key approach to sustainable urban development (Cohen et al., 2016; Kandel & Frantzeskaki, 2024; Yu & Mu, 2023). According to the definition of the International Union for Conservation of Nature (IUCN), NbS include "actions aimed at protecting, sustainably managing and restoring natural or modified ecosystems that are capable of effectively and adaptively addressing social challenges while providing benefits for human well-being and biodiversity" (IUCN, 2016). In parallel, the European Commission defines NbS as "nature-inspired and nature-based solutions that are cost-effective, capable of delivering simultaneous environmental, social and economic benefits and enhancing resilience" (European Commission, 2017).

From this perspective, this paper aims to assess the potential of NbS in architectural construction and design processes, in particular by exploiting "downtime", i.e. those periods of suspension and waiting that punctuate urban transformation or construction phases. Far from being mere voids, these temporal interstices can be rethought as concrete opportunities to initiate processes of ecological and social regeneration.

The methodology proposed here is distinguished by the synergistic integration of renaturalisation practices and architectural design, suggesting that the relationship between nature and design is not a linear sequence of separate interventions, but a dialogical and co-evolutionary process. With this in mind, the proposed model is based on the integration of ecological processes and design practices, enhancing intervals often perceived as mere suspensions or moments of inactivity and reconfiguring them as opportunities to facilitate a gradual transition towards sustainability, laying the foundations for a new synergy between design and the environment.

Blocked construction sites, unfinished works and urban voids thus represent privileged spaces for experimenting with "close-range" synergy: they are the non-places of tomorrow, integrated yet separate, immobile yet changing—true space-time paradoxes in which to act both distant and close to the community. For political, bureaucratic or economic reasons, these urban residues emerge and disappear continuously, participating in the human flow of time but remaining, at the same time, outside of time.

This strategy requires careful reworking, adapting to different design processes and the urban specificities of various national contexts. However, thanks to its intrinsic flexibility, the proposed intervention model can be adopted as a methodological basis in very different situations. Here, we will mainly analyse European cases, with a particular focus on the Italian context. It should also be emphasised that the validity of this approach is not limited to scenarios where architectural planning is already defined; on the contrary, the methodology also proves effective in urban areas characterised by abandonment or planning uncertainty, where the activation of intentional ecological processes can bring environmental and social benefits, regardless of the future use of the space. In this perspective, reflection on temporality—both design and ecological—becomes a fundamental interpretative key to rethinking urban policies, orienting them towards greater inclusiveness and deeper adherence to the principles of sustainability.

2. Literature Review

Before delving into operational strategies, it is necessary to clarify how it is possible, in concrete terms, to reactivate ecological processes in urban areas and what the essential prerequisites are for effective regeneration. The most recent international publications emphasise the centrality of integrated and multisectoral strategies capable of acting on multiple spatial and temporal scales in a coordinated manner. These interventions, which may arise from forward-looking planning or in response to regulatory, social or economic pressures, often generate synergies but also require a delicate balance between environmental, social and economic benefits. The prevailing orientation in the literature therefore calls for the incorporation of ecological principles into urban design practices, promoting the multifunctionality of spaces and the resilience of urban systems through solutions that take advantage of natural processes themselves (Ahern, 2011).

This is the context for the issue of residual spaces, a topic that has been little explored in relation to construction sites but is widely discussed in the international literature on urban landscape. The so-called "residual spaces", "terrain vague", "interstitial spaces", "urban voids", "stalled spaces", or "tiers paysage" (to use Gilles Clément's terminology) are defined in different ways depending on the nuances one wishes to emphasise: from the neutrality of the interstice to the emphasis on emptiness or the expectation of transformation. In academia, "residual spaces" and "interstitial spaces" are the most common terms used to refer to urban spaces that escape the functional logic of the city but, precisely because of their indeterminacy, represent a strategic potential.

Particularly relevant in contemporary debate is the reflection on the theme of temporality as a design resource. Franz et al. (2008) and Oswalt, Overmeyer & Misselwitz (2013) invite us to read residual spaces not as simple voids without function, but as resources capable of accommodating processes of renaturalisation, social experimentation and new forms of urban habitability. The concept of terrain vague, introduced by Solà-Morales (1995), identifies precisely these spaces suspended between abandonment and potential as fertile ground for experimentation with Nature-Based Solutions: their morphological indefiniteness allows the activation of spontaneous regeneration processes, triggering new forms of social cohesion and responses to climate challenges.

Among the most influential voices, Gilles Clément has emphasised, through the concepts of "jardin en mouvement" and "tiers paysage", the ecological and cultural value of uncultivated and residual spaces. According to Clément, these should not be considered mere urban voids to be filled, but real dynamic reserves of biodiversity, matrices of regeneration capable of transforming themselves and welcoming collaborative processes (Clément, 1991).

Experiences such as tactical urbanism or so-called "urban acupuncture" (Lerner, 2014) have shown that even small-scale, temporary or reversible interventions can have systemic effects on urban environmental quality, acting as catalysts for more profound transformations. The concept of "productive waiting" (Oswalt et al., 2013) proposes attributing value not only to the final outcome of the transformation, but also to the intermediate stages and ongoing processes that unfold over time.

Urban ecology and research on spontaneous renaturalisation also teach us that cities can be seen as dynamic ecosystems, populated by a multitude of life forms and temporal relationships. Authors such as Kowarik (2011) Castelli et al. (2021) emphasise the importance of a process-based and adaptive approach, where uncertainty, resilience and adaptability are central elements of contemporary urban design.

Overall, the theoretical framework that emerges converges on the idea that urban sustainability requires the ability to think of design as an open process, to recognise the value of interstices and expectations, and to integrate ecological principles into city transformation strategies. The activation of nature-based solutions, the enhancement of multiple temporalities and the focus on residual spaces are thus fundamental tools for guiding urban policies towards greater inclusiveness, resilience and environmental quality.

3. Methodology and Procedures

The methodology adopted in this research is divided into two main phases, combining comparative analysis of exemplary case studies and verification of design hypotheses on real-life applications. In the first phase, a series of international and national projects were selected and analysed, including the regeneration of peri-urban forest areas in Switzerland, the Natur Park Südgelände in Berlin, Houtan Park in Shanghai, the Fonderies gardens in Nantes and the Alter Flugplatz Bonames in Frankfurt—considered emblematic for the variety of approaches to urban renaturalisation and the management of infrastructural voids. The analysis of these cases made it possible to identify operational principles, technical strategies and recurring critical issues, which were summarised in a theoretical framework useful for formulating working hypotheses.

In the second phase, the hypotheses developed were applied to three sample sites in the city of Milan (Via Lamarmora, Via Durando, Viale Molise), chosen for their different morphological and functional nature in the urban context. These sites were intended as real experimental laboratories in which to test the transferability of the strategies identified and evaluate their effectiveness in relation to local specificities. The survey was based on direct observations, analysis of environmental and urban data, and simulations of the different phases of ecological succession, with particular attention to soil regeneration processes, plant species selection and adaptive vegetation management during periods of project suspension. This dual approach has made it possible to develop an integrated methodology capable of both basing design hypotheses on evidence already established in the literature and international practice and testing them in a targeted manner in real, contemporary urban contexts, providing replicable operational guidelines for future regeneration interventions based on Nature-based Solutions.

4. Results and Discussion

4.1 Case studies: Regeneration strategies between nature and design

In order to understand how nature-based solutions can be integrated into urban projects in a concrete way, it is essential to start with the fundamental question of how ecological processes are activated: what conditions make them possible and which strategies are most effective? The recent history of landscape and urban design in Europe shows a growing focus on the regeneration of areas that have been deeply compromised by human intervention. Especially in the last two decades, many designers have taken up the challenge of restoring vitality to soils devastated by industrialisation, the construction of large infrastructure or progressive abandonment, activating processes capable of re-establishing a synergy between nature and human settlement.

The landscape of interventions is broad and varied: while on the one hand numerous projects have involved large areas and disused infrastructure, mainly located on the urban margins — residual spaces that, although belonging to the city, have been excluded from its social dynamics — on the other hand, there is no shortage of experiences involving denser fabrics, where the complexity of the transformations requires adaptive and long-term solutions, often incompatible with the accelerated pace of contemporary life.

Although not related to an urban process, studies on Swiss peri-urban forest areas, such as Allschwil, where Rusterholz and Baur (2014) showed how even minimal interventions—such as the temporary exclusion of humans — can promote soil regeneration and the reappearance of native plant species, provide a good starting point. The experiment, based on monitoring fenced-off areas for several years, showed that, with minimal disturbance, nature is able to spontaneously recover its ecosystem functions and original biodiversity, restoring vitality to land otherwise compromised by intensive recreational use. A key principle emerges from this experience: time, understood as a waiting period, can become the main regenerative agent, suggesting that design action may consist, at least in part, in the conscious suspension of direct intervention (Rusterholz & Baur, 2014; Gibson et al., 2000).

From the forest dimension, the discussion shifts to urban contexts marked by the presence of abandoned infrastructure, as evidenced by the Natur Park Südgelände project in Berlin (Grün Berlin, n.d.). In this case, the closure of the railway yard triggered spontaneous colonisation by vegetation, favoured by the long period of abandonment. Pressure from citizens, who opposed the conversion of the area to new infrastructural uses, made it possible to enhance a unique urban ecosystem, where industrial memory is intertwined with the formation of new natural habitats. Here, landscape design takes the form of listening to and accompanying spontaneous processes: elevated walkways allow visitors to cross the area without altering the delicate ecological balance, demonstrating that the direction of the project can be discreet, almost invisible.

On the other hand, projects such as Houtan Park in Shanghai (Turenscape, n.d.; ArchDaily, 2011) demonstrate that even in heavily polluted areas with a long industrial history, it is possible to activate innovative ecological processes by combining phytopurification systems and agricultural terraces inspired by local traditions. In this case, urban regeneration becomes an integrated process, capable of mediating between productive memory, environmental remediation needs and new ecosystem services. The seasonal rotation of plant species and the flexibility of the landscape design reflect a design vision oriented towards resilience and adaptation.

Similarly, in Nantes, the intervention on the gardens of the Fonderies (Doazan-Hirschberger, n.d.; Landezine, 2009) shows how specific technical strategies—such as raising the ground level by adding new soil — can overcome the critical issues of heavily polluted soils, promoting the growth of selected native and exotic vegetation. The conservation of historic structures and machinery, integrated into the landscape design, demonstrates the possibility of regeneration that also involves reinterpreting and enhancing the material heritage without compromising environmental objectives.

Finally, the case of the Alter Flugplatz Bonames in Frankfurt (GTL Landschaftsarchitektur, n.d.; Birdingplaces.eu, n.d.) offers a paradigmatic example of the recovery of abandoned infrastructure through a combination of technical interventions — such as the fragmentation and reuse of the concrete runway—and the activation of natural processes, such as the creation of wetlands and the reconstruction of a local ecological mosaic. Here, regeneration has required a long time and considerable resources, but it shows that even severely compromised situations can be addressed through a dynamic balance between design and natural spontaneity.

A comparative analysis of these cases clearly shows that time and the degree of anthropisation are decisive variables in defining regeneration strategies. In natural contexts, waiting and suspending anthropogenic pressures may be sufficient; in more compromised landscapes, however, the complexity of interventions increases, as does the need for close collaboration between nature and design. In any case, these examples confirm the importance of thinking of design as an open process, capable of enhancing both expectations and spontaneous transformations, according to a logic of "productive waiting" (Oswalt et al., 2013) that overcomes the traditional dichotomy between design action and natural processes.

Architecture and ecosystem processes: the construction site

Ecosystemic design in urban contexts is a highly complex exercise, as it inevitably clashes with the relentless dynamics of economic development and land use. The idea of suspending human activity seems utopian: every square metre of the city is claimed by economic processes, which tolerate renaturalisation only where it does not substantially affect daily life. In fact, the presence of "wild" nature in urban spaces is generally accepted only within well-defined limits, often relegated to a marginal and accessory dimension with respect to predominant uses.

However, observation of the concrete dynamics that characterise contemporary urban landscapes shows that it is not enough to rely solely on the regenerative power of nature. The starting conditions, often deeply compromised by decades of misuse, the continuous pressure exerted by urban transformations and the essential requirements of accessibility and usability make it necessary to move beyond a merely passive vision of renaturalisation. In this context, the remnants of spontaneous nature are inadequate. It is therefore necessary to enhance every space awaiting transformation — or currently undergoing conversion — through strategies that consciously activate processes of soil enrichment, environmental purification, increased biodiversity and improvement of general ecological conditions.

From this perspective, the construction site itself — whether it is an abandoned space, an interstitial area or a place undergoing transformation—must be rethought as a dynamic laboratory for regeneration. Only by productively integrating moments of suspension and stasis into a broader strategy of environmental restoration, in which design and natural processes operate in close synergy, will it be possible to avoid wasting time and resources and steer urban transitions towards more sustainable forms.

It is also clear that architectural and landscape design often faces a demand for immediacy and completeness that is difficult to reconcile with the slow and cyclical nature of natural processes. Calls for tenders and implementation procedures require solutions that are immediately accessible and fully usable, imposing strict and often compressed timelines. This results in the need, from the earliest stages of operation, to plan often costly and invasive interventions on the soil—such as replacement, enhancement or decontamination of substrates — to ensure rapid vegetative growth and immediate aesthetic results. However, as numerous case studies show, time is an essential variable for the formation of stable and resilient ecosystems: soil regeneration and the restoration of conditions favourable to biodiversity require patience and repetition, aspects that are difficult to compress within the time constraints imposed by the delivery of a finished work.

In urban landscapes, which are highly anthropised and subject to additional disruptive factors such as pollution, compaction, fragmentation and erosive agents such as wind, recovery times can be considerably longer, sometimes five or more times longer than in natural ecosystems. This consideration calls into question the traditional paradigm of the construction site as a linear and finite sequence: in reality, the urban landscape is characterised by multiple and layered temporalities, and every regeneration project must deal with moments of stasis, waiting and suspension that are an integral part of the design process.

It is precisely during periods of downtime—the intervals between the decommissioning of old functions and the start of new uses—that the most interesting opportunities for the initiation of spontaneous ecological processes emerge. In these temporal interstices, nature gradually tends to reclaim the space, giving rise to forms of biodiversity and aesthetic value that are often impossible to replicate through exclusively anthropogenic design. In some cases, simple abandonment can transform a disused area into an urban nature reserve, where native vegetation and fauna find favourable conditions to settle, thanks in part to the absence of human disturbance.

Such a strategy – so far confined to the realm of hypothetical research – would transform bureaucratic delays into periods of ecological capital accumulation, reduce the risk of landscape degradation and prepare sites for a smooth reintegration into the urban metabolism. On a socio-cultural level, carefully planned greening would help to mend the emotional relationship between residents and building "voids", promoting citizen science programmes and forms of neighbourhood stewardship. In this way, vegetation would go from being a simple ornament to a technology that bridges the slow times of nature and the fast – and unpredictable – times of the metropolitan economy, a theoretical model of more resilient and climate-friendly development that could potentially be exported to all cities that live with the unresolved tension between growth and sustainability.

4.2 Sample areas and lines of enhancement

The city of Milan, which has been engaged in a season of sustainable regeneration for over two decades, offers an almost didactic repertoire of urban interstices generated by unfinished economic cycles. The simultaneous existence of building voids and increasingly ambitious climate policies has led to the selection of three emblematic case studies—Via Lamarmora, Via Durando and Viale Molise—which, together, cover the entire morphological gradient of the metropolis (historic centre, post-industrial university belt, metropolitan production area) and allow for the validation of a regeneration model that can be replicated in heterogeneous urban contexts.

- Via Lamarmora (Crocetta district):
  The former convent and welfare complex, built in 1885, damaged by bombing and abandoned since the 1950s, represents the challenge of integrating a valuable neo-Romanesque building, "frozen" for over seventy years, into the 19th-century residential fabric. The architectural restoration work currently underway can be enhanced by a low-tech biological remediation programme: removal of secondary flooring, inoculation of mycorrhizal fungi and conversion of the large internal garden into a perennial meadow, so as to provide the neighbourhood with a climate-positive micro-park already during the construction phase.
- Via Durando (Bovisa):
  The former Ceretti & Tanfani factory, abandoned in 1989 and surrounded by a continuous wall, has been home to thirty years of spontaneous vegetation close to the railway tracks and the Politecnico campus. The site can be transformed into a "living façade laboratory" by opening pedestrian gateways, installing vertical green modules and environmental sensors, involving the university community in cycles of phytoremediation of soil

contaminated with heavy metals and turning the construction site itself into an educational facility.

- Viale Molise – Former Slaughterhouse (Porta Vittoria):
  The municipal slaughterhouse, which operated from 1912 and was decommissioned in 2005, covers an area of over 150,000 m² and offers the metropolitan scale necessary to experiment with ecological solutions for connecting the city centre and the suburbs. The current master plan, which involves selective demolition and material recovery, can be complemented by the creation of a transition forest: modelling of the reclaimed soil into permeable dunes, planting of fast-growing species (poplars, willows) and slow-growing species (oaks, elms) and the creation of micro-wetlands for rainwater management.

The three areas benefit from the same strategic plan based on three cross-cutting levers: (i) soil regeneration, through the removal of impermeable coverings, targeted grain size correction and microbiological inoculations; (ii) reduction of widespread impermeability, to improve water retention and mitigate the "heat island" effect; (iii) functional vegetation, with species suitable for phytoremediation of pollutants and the rapid establishment of shade and biodiversity. The formalisation of a "third landscape" statute would ensure institutional continuity, modest annual budgets and participatory governance based on open environmental indicators (temperature, soil quality, biodiversity), transforming the "dead time" of construction sites into growing ecological capital, ready to be reintegrated into the urban economic metabolism in an enhanced form.

The formalisation of a "third landscape" status for these areas—with small dedicated annual budgets, participatory governance and a set of open environmental indicators—would make it possible to transform the "dead time" of construction sites into accumulated ecological capital, ready to be reintegrated, enhanced, into the urban economic cycle.

(The following tables detail the physical, environmental and usage characteristics of the three sample areas.)

Table 1.1: Crocetta – Via Lamarmora. Compact Island in the Residential Heart of Milan

Area	Main Data
Urban context	High-density residential district; 880 km² built area, 380 km² streets; permeability mainly inside private courtyards (400 km²)
Soil and aquifer	Succession of silty sands and gravels, water table at 11 m depth; topsoil already poor and compacted
Winds	Prevailing WSW in the first quarter, SSW during the rest of the year; SE flows screened by tall buildings along Via Lamarmora
Urban heat island	Thermal peak recorded at 38°C in the center of the island
Pollutants	Accumulation of urban pollutants (PM 2.5/10, NO_2, benzene, etc.) due to traffic and long-term abandonment
Noise	Acoustic class III (60 dB day / 50 dB night); tram 16, Crocetta subway, and viale Caldara traffic

Source: Author’s elaboration based on field data and municipal records

Table 1.2: Bovisa – Via Durando. Linear Island along the Railway Tracks

Area	Main Data
Urban context	Residential-industrial mix with strong railway presence; 600 km² buildings, 200 km² roads, 160 km² wild green, 50 km² tracks, residual sand pits 8 km²
Soil and aquifer	Brown-red gravels and sands, water table at 14 m
Winds	SW flows channeled along Via Durando; minimal interference from railway traffic
Urban heat island	41°C in the built-up eastern area; drops to 34°C near spontaneous vegetation to the west
Pollutants	Residues from metalworking (iron, steel, VOCs, heavy metals) from historical Ceretti-Tanfani depot
Noise	Class III-IV; main source is train and tram 2
Solar exposure	Good insolation year-round; significant shadows only in winter along Via Andreoli

Source: Author’s elaboration based on field data and municipal records

Table 1.3: Porta Vittoria – Viale Molise (Former Slaughterhouse). Extended Island between Fruit Market and Lambro River

Area	Main Data
Urban context	1,083 km² of wholesale market, 480 km² built, 430 km² roads; large paved areas but also wastelands with potential ecological corridors towards the Lambro
Soil and aquifer	Alternating layers of silty sands and gravels; shallow water table at 7 m, topsoil contaminated by livestock waste
Winds	Dominant winds along Viale Molise, channeled between buildings; SW prevails in the last quarters
Urban heat island	Maximum temperatures 38–41°C, mitigated to 34°C in green areas along the railway and the Lambro
Pollutants	Complex mix of slaughterhouse emissions (NH_3, SO_2, PAHs, sludge, etc.), plus traffic and high impermeability
Noise	Class V (70 dB day / 60 dB night); main sources are railway and market operations
Shading	Shadows cast mainly by abandoned

	buildings, more extensive in winter in the southern sector

Source: Author’s elaboration based on field data and municipal records

4.3 Vegetation

Vegetation is conceived as a real design infrastructure, capable of anticipating and accompanying the construction phases.

This approach is based on an incremental and reversible logic: if the construction schedule resumes, the vegetation could be transformed into a neighbourhood park, an educational façade or a metropolitan climate infrastructure; conversely, if the impasse continues, the vegetation system would continue to evolve autonomously, continuing to provide increasing ecosystem services at minimal maintenance costs. In this perspective, vegetation takes on the role of an “environmental insurance” device, capable of converting periods of construction site inactivity into phases of ecological capital accumulation, reducing the risks of landscape degradation and facilitating the gradual reintegration of sites into the urban metabolism.

At the heart of these strategies lies the careful selection of plant species, a crucial element for the regeneration of residual soils. This selection requires a thorough analysis of the physical and chemical characteristics of the site, as well as microclimatic conditions such as rainfall, ventilation and solar radiation. It is therefore necessary to favour species that are not only capable of absorbing pollutants but also of adapting permanently to local environmental conditions, thus ensuring the sustainability and durability of the intervention. In the case of the Milanese areas, the choice has been oriented towards native Lombard and Milanese species, preferred to exotic ones in order to prevent the spread of invasive species, a phenomenon that is particularly widespread in urban environments. The identification of a comprehensive list of species has also made it possible to define criteria applicable to numerous design contexts, both nationally and internationally.

This experimentation could lead to a “vegetable construction site” capable of promoting soil regeneration through low-energy biological tools, producing measurable climate benefits, offering temporal flexibility to urban developments and fostering a shared culture of care, overcoming the passive and segregating logic of traditional construction sites. In this sense, vegetation acts as a bridging technology capable of reconciling the long timescales of ecological processes with the rapidity – and often uncertainty – of urban economic dynamics, outlining more equitable, adaptive and climate-friendly development trajectories. It should be noted, however, that the strategies outlined are, at present, prospective exercises and not yet scheduled interventions.

4.4 Hypothesised processes

In the Via Lamarmora complex, the proposed intervention begins with the selective demolition of the secondary paving, necessary to break up the impermeable crust that has formed over seventy years of disuse. The rubble is screened on site, reduced to coarse granules and reintroduced into the substrate to improve drainage capacity. At that point, a small amount of clay is added to balance the excess skeleton and allow the inoculation of mycorrhizal fungi, the first step in a low-energy biological regeneration process. In the first two years, hybrid poplars, willows and a carpet of phytopurifying grasses capable of sequestering light metals and reducing the background temperature of the courtyard take root. Starting in the third year, when the topsoil has reached a sufficient organic matter content, the initial planting is thinned out to make room for oaks and hornbeams, which will give permanent structure to the new garden. in the meantime, the building under restoration is integrated with loggia-greenhouses facing inwards, so that the planned residential use can immediately benefit from shade, climate mitigation and views of the maturing greenery.

The hypothetical construction site in Via Durando, in the Bovisa district, starts from soil historically contaminated with hydrocarbons and heavy metals: after core sampling and mapping of hot spots, the most contaminated soil is confined to piles covered with hemp mats where degrading bacteria proliferate; on the rest of the surface, already in the first winter, a mixture of legumes and brassicas is sown, which, over two seasons, lowers the zinc and nickel content to values compatible with regulations. The perimeter wall, which until now has been an opaque barrier, is partially dismantled and reinvented as a trellis for climbing plants – an experiment in "living facade" that acts as an acoustic filter towards the tracks. At the beginning of the fourth year, when the phytotechnologies have achieved initial chemical stabilisation, the Polytechnic students will begin participatory monitoring of biodiversity; the area will gradually open up with elevated walkways that will allow the evolution of the space to be observed without trampling on the network of roots in formation, perpetuating the educational vocation of the neighbourhood.

In the case of the former slaughterhouse in Viale Molise, the process is developing on a metropolitan scale and with a more markedly hydraulic logic. The demolitions envisaged in the master plan generate an initial landscape of rubble which, once crushed, is arranged to form permeable dunes arranged radially between the Lambro river, the railway and the fruit and vegetable market: these undulations, no more than three metres high, act as sponges that slow down runoff and feed temporary micro-wetlands. In the first three years, the scene is colonised by fast-growing willows, which cast shade on the phytopurification basins designed to treat rainwater; at the same time, herbaceous species typical of Lombardy's alluvial meadows are sown by broadcasting, so as to trigger a vegetation dynamic similar to that of river floodplains. When the dunes have settled and the tree cover begins to close (fifth to sixth year), young oaks and elms are planted in deep planting holes to form the definitive backbone of the "transition forest". Where historic buildings to be preserved regain their function, the mature greenery is grafted in as a public connective tissue: suspended slatted walkways, shaded rest areas, experimental vegetable gardens tended by neighbourhood cooperatives, in a continuum that links the new productive centre with the ecological network that runs up the river.

Common to all three cases is the entirely forward-looking idea that vegetation can transform the expectations, delays and uncertainties of construction into a period of accumulation of ecosystem services. In the absence of a binding work schedule, the root systems break up compaction, improve water retention and sequester pollutants; the canopy regulates the neighbourhood's heat and sound balance; biodiversity colonises previously non-existent niches. If and when construction programmes resume, they will find a green infrastructure already in place that is capable of adapting to their needs. If not, they will continue to evolve autonomously, guaranteeing, at minimal cost, an ecological capital that the city can redeem at any time.

Plant species take on a well-defined technical function: by taking root before the start of final construction work, they activate soil self-purification cycles, contribute to heat island mitigation, promote the deposition of organic biomass and generate micro-habitats that increase the overall resilience of the area. These processes are based on a controlled ecological succession: the removal of impermeable surfaces and the improvement of the soil's grain structure, together with the inoculation of mycorrhizae, create a substrate suitable for hosting, in an initial pioneer phase, pollutant-tolerant species such as poplars, willows, locust trees and phytodepurative herbaceous plants, capable of decontaminating and restructuring the topsoil within two to three years. Once a minimum threshold of ecological functionality has been reached, the area is further enriched with oaks, elms, hornbeams and a honey-producing undergrowth, thus creating a "transition forest" that provides shade, ecological connectivity and increased urban biodiversity.

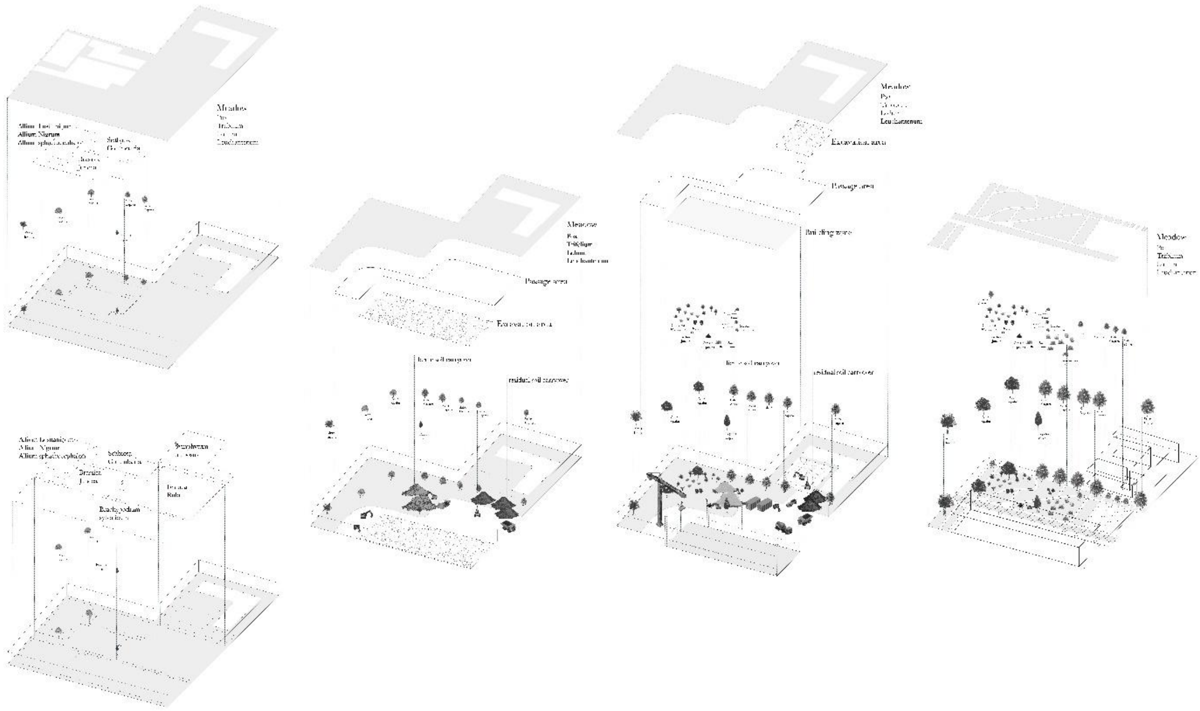

Figure 1.1: Bovisa process

This table summarises the main operational phases envisaged for each of the three areas in Milan.

Tabel 1.4: Regeneration phase diagrams

Phase	Via Lamarmora (Crocetta)	Via Durando (Bovisa)	Ex Macello (Viale Molise)
Soil preparation	Demolition of secondary paving; addition of clay fraction; mycorrhizal inoculation	Core sampling; confinement of contaminated hot spots; biopile with degrading bacteria	Selective demolition; crushing of rubble into permeable dunes; hydraulic modelling
Pioneer phase (0–3 years)	Planting of Populus × canadensis, Salix alba and Festuca + Trifolium carpet for phytoremediation and shading	Sowing of Brassica juncea + Helianthus annuus; Robinia pseudoacacia for decompaction	Establishment of Salix purpurea, Populus nigra; wet basins with Typha/Iris
Consolidation / Transition forest (3–7 years)	Diradamento pionieri; inserimento di Quercus robur, Carpinus betulus; sottobosco di Cornus/Sambucus	Sostituzione graduale con Acer campestre e Fraxinus angustifolia; rampicanti su muri (Humulus, Clematis)	Piantumazione di Ulmus minor, Quercus cerris; prati di Arrhenatherum + Carex

Phase	Via Lamarmora (Crocetta)	Via Durando (Bovisa)	Ex Macello (Viale Molise)
Adaptive management / Final integration	Climate-positive park serving the neighbourhood; greenhouse-loggias integrated into the building	Construction site-laboratory with elevated walkways and student monitoring	Transition forest with public walkways; Lambro-centre ecological connection

Source: Author's elaboration

5. Conclusion and Suggestion

The analysis conducted lays the foundations for a radical rethinking of the role that urban downtime—i.e., the intervals of suspension between building cycles and functions of use—can play in the ecological and social regeneration processes of contemporary cities. The case studies and theoretical references discussed highlight how proactive management of these temporal interstices, based on the introduction of vegetation processes and nature-based strategies, can generate tangible environmental benefits, reducing soil vulnerability, mitigating heat islands, increasing biodiversity and facilitating the future reintegration of spaces into the urban metabolism.

However, it remains clear that what is outlined here is a conceptual model and not an empirically established practice: the feasibility and effectiveness of the proposed strategies depend on multiple factors, including the availability of resources, the collaboration of institutional actors, regulatory flexibility and the involvement of local communities. The strength of the suggested approach lies in its ability to integrate the slow timescales and incremental processes inherent in nature with the adaptation and speed required by urban dynamics, offering a possible trajectory for sustainability-oriented policies and projects.

The perspective presented here therefore invites us to consider temporality not as an obstacle but as a design resource, prompting a renewed dialogue between architectural design, ecological practices and urban governance. Further experimentation and monitoring will be necessary to validate, contextualise and refine the operating principles outlined, transforming this conceptual hypothesis into a truly effective tool for the cities of the future.

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