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MONOGRAPHIC ISSUE:
WASTE ARCHITECTURE / WASTE MANAGEMENT
IN LANDSCAPE AND URBAN AREAS

Guest Editors:
Anna Artuso
Elena Cossu

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Detritus - Multidisciplinary Journal for Waste Resources and Residues - is aimed at extending the "waste" concept by opening up the field to other waste-related disciplines (e.g. earth science, applied microbiology, environmental science, architecture, art, law, etc.) welcoming strategic, review and opinion papers. **Detritus is indexed in Emerging Sources Citation Index (ESCI) Web of Science, Scopus, Elsevier, DOAJ Directory of Open Access Journals and Google Scholar**. Detritus is an official journal of IWWG (International Waste Working Group), a non-profit organisation established in 2002 to serve as a forum for the scientific and professional community and to respond to a need for the international promotion and dissemination of new developments in the waste management industry.

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Editorial

WHY ARE WASTE MANAGEMENT FACILITIES SO UNATTRACTIVE?

Waste Architecture is a branch of the design field relating to the Architecture and Land Planning of waste management and disposal facilities based on projects ranging from a vast (landfills, incinerators, treatment plants) to a municipal and peri-municipal scale (waste collection systems, recovery and recycling plants, etc …).

This branch therefore deals with works and products featuring a marked environmental, territorial, economic and social impact, a topic towards which Society is known to be highly sensitive. The issue therefore dictates a need for targeted political and planning strategies aimed at increasing awareness of the importance of these structures in ensuring quality of the environment and the territory, which may also produce major repercussions on our health. Health intended, according to the WHO definition, as "a state of complete physical, mental and social well-being" achieved through the actual and perceived quality of the space within which one lives.

Waste management is a topic that actively impinges on society, although frequently associated with clichés and misleading persuasions that result in the infrastructures present throughout the network being viewed as areas of neglect, environmental and territorial eyesores to be placed on the margins of shared community spaces.

The demographic increase and scarce availability of space have both resulted in landfills, incinerators, treatment plants and integrated waste disposal systems becoming an integral part of our daily routine. Whilst in the past similar issues were viewed as technical aspects of Engineering, the current need to include these works in a detailed land planning has highlighted a requirement in the fields of landscape and urban design to rely on a multidisciplinary team that extends to the area of Architecture.

In the specific context of wastes, with very few rare exceptions, architects are however inexplicably excluded from the conception, planning and development of these key infrastructures.

On the whole, the majority of nations worldwide fail to envisage an integration between the waste management system and the territory throughout which the system operates. This criticality is largely due to lack of recognition of the role of primary urban infrastructure, i.e. an essential service in the life of a Community. The waste system, in the same way as other infrastructures comprising hubs and networks, is linked to a need for works and interventions for which (with very few exceptions) no planning aimed at ensuring integration with the landscape (natural and urban) is envisaged, nor architectural research to promote manufacturing quality of the goods.

In common practice, architectural techniques for the collection and treatment of wastes are designed as highly efficient industrial products. Technical and functional requirements that frequently dictate the form of these works thus evolve into overt limitations that hamper the potential configurations, with functional needs rarely being supported by architectural and manufacturing studies.

Indeed, many of the works undertaken are conceived based exclusively on technical aspects, with negative architectural and social implications. The majority of plants adopted by the "waste system" have tended to create feelings of threat, diffidence and hostility, thus frequently being considered an unnecessary "evil" to be eliminated or hidden from view (think of landfill constructed in the past, with the black fumes rising from the heaps of waste and of the incinerator chimneys).

Viewed to date by politics as a "problem" rather than a resource, by communities as a threat, by environmentalists as an endless source of pollution, by sanitary engineers as functioning machines and by architects as works in which design is limited merely to the packaging, the infrastructure hubs throughout the waste collection network have struggled to achieve any form of "dignity" as public works, although being of fundamental importance for modern-day society.

Accordingly, the inescapable role covered by the waste management network should be acknowledged in the same way as other public services (transport, water supply, lighting, etc.), and all associated works undertaken with the same attention to details of planning and design devoted to any other works of community concern in terms of planning, siting, study of the context, choice of shapes and material, legibility of spaces, levels of planning and design , economic analysis . And, in the same way as planning for all major works (ranging from bridges to skyscrapers, from museums to airports …), the technical requirements will need to adapt to the architectural needs rather than the contrary.

Numerous works undertaken throughout the world, from the Ariel Sharon Park on the Hiryia landfill in Israel, to the Val d'en Joan in Barcelona and the Amarger Bakke incinerator in Copenhagen, have demonstrated how this type of architecture constitutes a highly interesting sector that highlights, throughout the various stages of the project, a series of potentials: the recognisability of the structures may be exploited to characterise a landscape or a city; a

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high-quality architectural project will contribute towards enhancing legibility with a view to raising environmental awareness and may provide an opportunity to create new functionalities; degraded areas may be restored to a new vocation.

Based on these considerations, and with a view to "ennobling" this sector, in 2015, Arcoplan Associates devised the Waste Architecture Platform, a showcase for initiatives that has brought together environmental experts, architects, designers, urban and land planners to encourage networking on an international level on the topics of mutual interest in seminars, design workshops, publications, etc. Since then, Arcoplan has been consistently involved in the organisation of oral sessions at the prestigious Sardinia – International Waste Management and Landfill Symposium, a reference event over the last 30 years for the scientific community that rotates around waste, thus rendering Waste Architecture one of the main topics of the Symposium.

This monographic issue represents one of the outputs of the Waste Architecture Platform, providing a selection of papers presented during the third edition of the International Workshop on Waste Architecture / Landscape and urban areas, held in October 2019, listing in the final columns the results of the design workshop focused on the redevelopment of landfills scheduled on the second day of the event. The Workshop was organised by Arcoplan Associates with the scientific support of ReLOAD Lab / ICEA - Department of Civil Environmental and Architectural Engineering, University of Padova (IT).

The issue moreover includes a series of external contributions from designers working in the specific field on both an academic and professional level.

It is to be hoped that the planning and design of key infrastructures in the waste sector such as those described in the papers present in this monographic issue, with their ability to conjugate environmental requirements with care for the territory, high quality architecture and wellbeing of the community, will gradually start to be provided for as a matter of routine.

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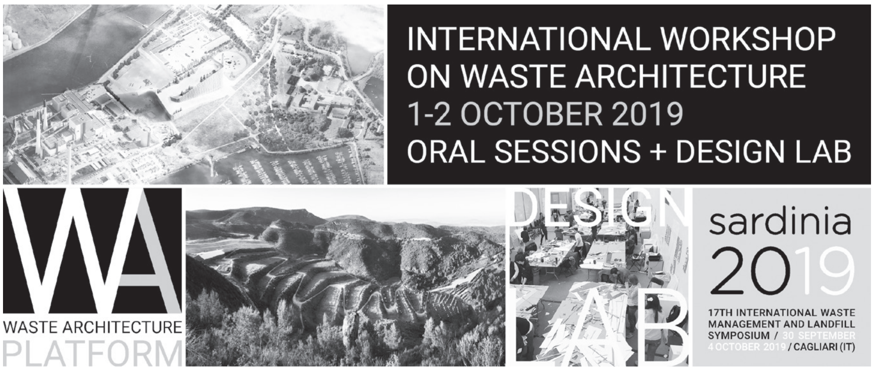

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COMPUTATIONAL ARRANGEMENT OF DEMOLITION DEBRIS

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ABSTRACT

The average builder in the USA provides a warrantee for 10 years, and the US Department for Energy calculates that US office buildings have an average lifespan of 73 years. No building is permanent, and all will face demolition at some point. When a building comes to the end of its safe and useful lifespan, there is no method for re-using the material in new buildings, instead, all constructions today require virgin material. This is a problem for sustainability because US cities, like most other global cities, require cyclical replacement of ageing buildings, and therefore perpetual resource extraction. This paper provides techniques for computationally arranging materials after the demolition and unmaking of architecture. Rather than downcycling concrete into low-value aggregate or melting float glass into opaque bottles methods are shown for this material to be indexed, re-machined and algorithmically arranged into new assemblies. These assemblies are conceived of as holding patterns; an indexed library of materials that are put into useful architectural arrangements, but ready to be disassembled towards some future use. These holding patterns are used as infill to the city rather than landfill beyond. Rather than building for sixty-year life spans, the project offers an imagination of eternal re-constructions that can learn from the carcass of past buildings. Based on rough estimates 2016 could be the first year where there exists more than one trillion tons of concrete on earth. More than the total weight of living trees on the planet (Crowther et al. 2015; USGS, 2018). This paper begins to develop new aptitudes for re-fitting misfit material rather than consuming evermore.

1. INTRODUCTION

Each year, roughly 16 million tons of demolition waste is discarded from the New York City Tristate region (EPA, 2018). The origin of this material is predominantly buildings, however, the replacement of roads and bridges, and urban landscape can contribute to the total weight of material that is thrown away (Figure 1). In New York the development pressures drive the continual replacement of buildings, for instance the Empire State Building exists on a plot of land that had seen a collection of brick houses, followed by 36 years of the Waldorf-Astoria Hotel before the Empire State Building was erected in 1930 (Moe, 2017). Despite the sublime character of New York's architecture, the buildings are far from eternal. For instance, the 22 story tall Hanover National Bank Building was demolished in 1931 after just 28 years. Today in 2018 there are debates on JP Morgan's plans to demolish the Union Carbide building, which would be the first building over 200 m to be demolished, standing at 52 stories after 68 years (Shaw, 2018).

Whatever the cause of a buildings replacement, this paper points out that the urban fabric has not been built to last permanently. Even the everlasting iconic Eiffel Tower has seen each piece of its steel structure replaced at least twice during its 130-year life span (Moe, 2017). Buildings and urban infrastructure will inevitably reach the end of a safe life-cycle, and require replacement.

But one can just recycle this material, correct? The first step to reusing this material is to understand the shape of the demolition debris - what happens to the fabric of architecture when it is unmade.

The majority of demolition material is concrete, with 8.2 million tons being produced each year. Two-thirds of this material is typically taken to landfill outside New York State. The other third is "recycled". In reality the material is ground up into a fine powder to be mixed with new cement, sand and water to make new concrete. Of course, this recycling process only eliminates some aggregates, and not cement, which is the most unsustainable part of concrete manufacturing, requiring coke to be burnt 2700 degrees Fahrenheit. This concrete is not a high enough grade for building; rather it is only suitable for road surfaces. In other words, when you demolish a concrete building there exists no way of using that material to "recycle" it

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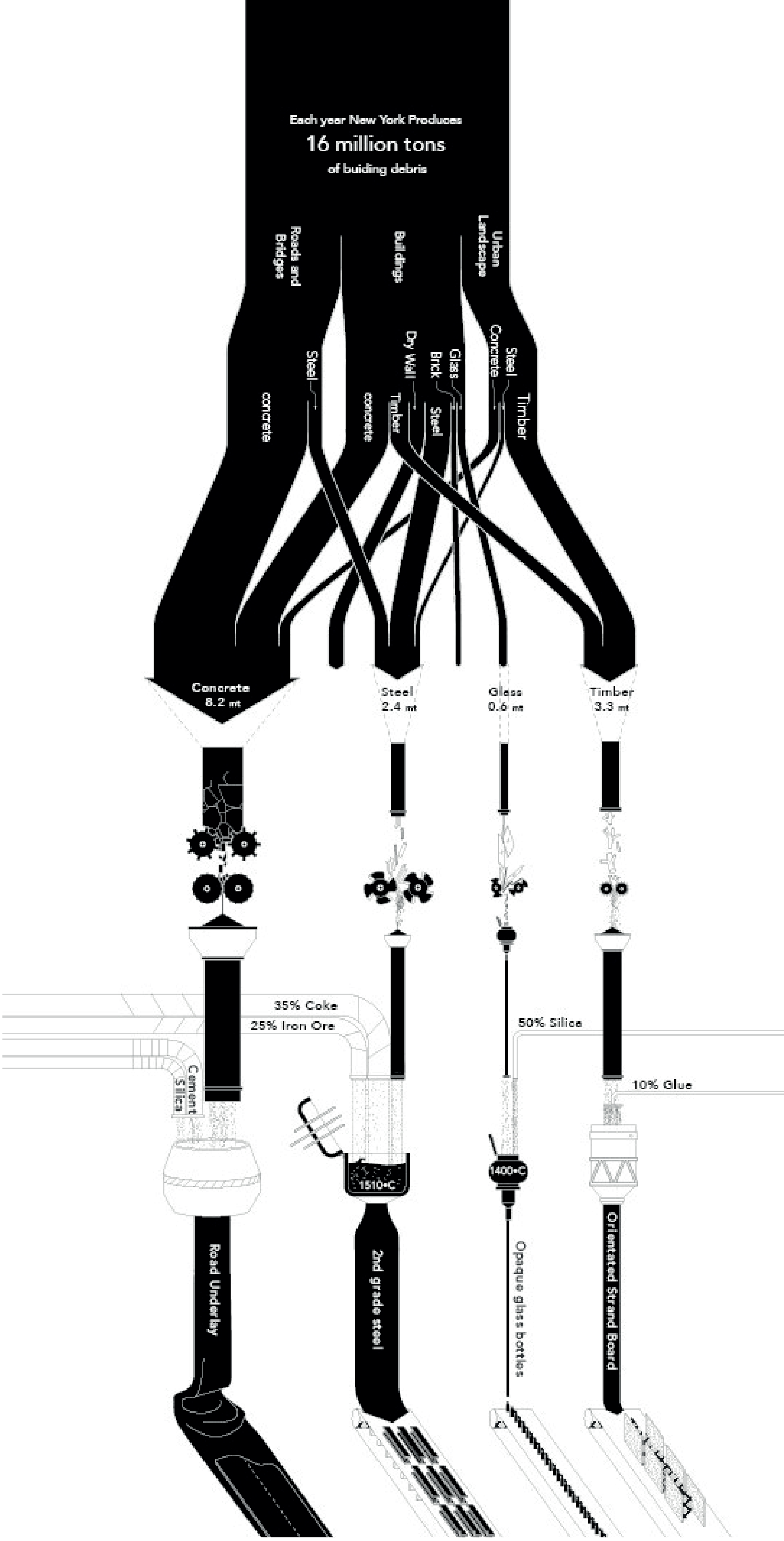

FIGURE 1: Best practice concrete recycling process illustrated based on research by Irmak Turan (2016) "From sink to stock: the potential for recycling materials from the existing built environment".

into a new building. Instead the concrete is downcycled and the replacement building must be constructed with new material.

Demolition of glass from the built environment follows a similar trajectory. The glass is shredded and then remelted with additional silica. However this new material is only useful for making bottles as it is not clear enough for the crystal glass that New Yorkers are accustomed to. When steel is recycled it is typically mixed 50% fresh coke and 25% virgin iron ore because the 100% recycled steel has structural impurities that make it useless for building construction.

The culture of construction that exists within New York City today may claim to be sustainable and recyclable, but this is a fallacy. Instead, the demolition of buildings leads to a down-cycling of material, and fresh extraction of new material to replace that which was removed (Figure 2).

There have been many calls for municipal recycling schemes that encourage the population to preserve precious material. For instance, Rania Ghosn and Jazairy el Hadi study the "Geographies of Trash"[5] with their focus on municipal waste. Yet the volumes of trash produced by the construction industry far outweigh the industrial and municipal waste streams. Are there alternative ways that architects might do more to address their unsustainable industry? Can architects begin to make use of the epic amounts of byproduct material that are already being produced in the city as it exists today?

2. MAPPING NEW YORK'S CEMETERY OF DEMOLISHED BUILDINGS

According to the New York City (NYC) building permit data, there have been 14,885 demolitions in the city since 1989. This information can be mapped out through the city to give a sense of the hot-spots of these most recent demolitions (Figure 3). Many demolitions are focused in areas of redevelopment, yet also around Carney Island and Jamaica Bay, following Superstorm Sandy.

Figure 4 shows the locations of trash moving out of New York. Construction debris is taken to transit facilities by building contractors or demolition teams. This material is sorted at the transit facility before being taken to landfill locations across the east coast.

New York regulations state that companies cannot take demolition material to landfill. The reason for these stringent regulations is political. Historic landfills have taken garbage, septage, medical waste, and industrial waste into C&D landfills, and thus created numerous environmental problems to communities and landscapes living around landfill sites. The state imposes high fines for any landfill that accepts construction debris, $2,500 for each violation, with an additional penalty of up to $1,000 for each day during which such violations continue.

The result of these regulations is a large network of landfill sites in nearby states which accept construction demolition debris. Often as much as 500 miles away. The majority of this material is taken by truck transportation.

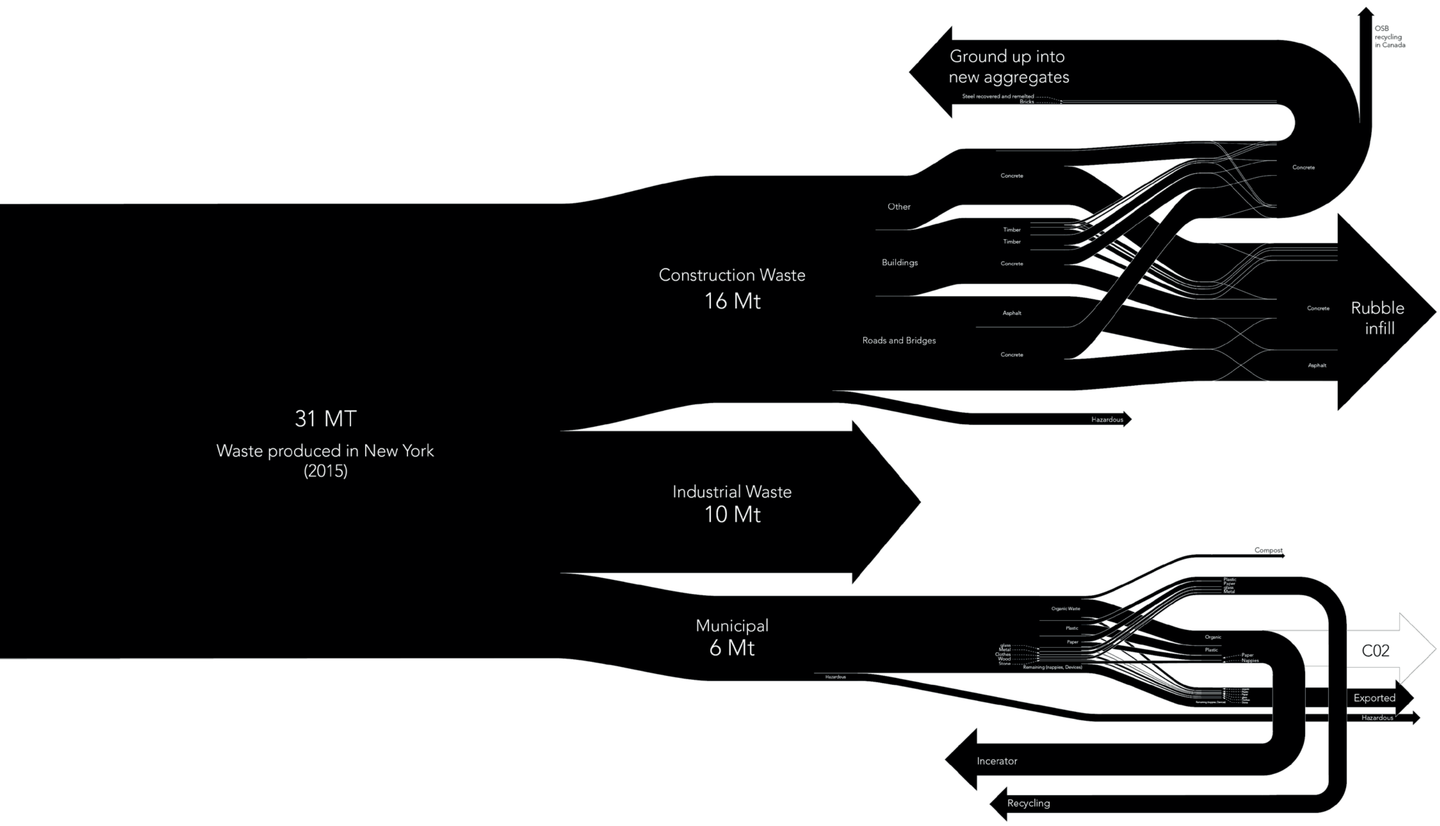

FIGURE 2: Diagram based on Data from a survey of construction and demolition waste by the EPA. Environmental Protection Agency, Office of Resource Conservation and Recovery (2018) "Construction and Demolition Debris Generation in the United States".

FIGURE 3: Based on New York City building permit data since 1989 there have been 14,885 demolitions.

Each mile of a typical truck taking 15 tons of material costs $1.09: $0.375 for the driver's salary, $0.17 for fuel, $0.545 for other insurance, truck costs, taxes etc. Demolition and construction waste creates a large market for this transportation, with 22,000 tons of material taken to landfill per day from New York.

The cost of disposing of construction debris is therefore a balance between state-level regulations and the distance involved. Demolition companies like Waste Management maintain ownership over dozens of landfill sites across the east coast such that they can respond to changes in landfill from different locations. The net result of the economic cost of taking a tonne of material to a NYC trash transit facility to be taken out of state is $75. With this $75 charge the cost of just dealing with the demolished material from a typical house, weighing 80 tons, would be $6,000. This is a significant factor in recycling, as heavier materials will be more beneficial to keep in the context that they were produced.

2.1 Economic and technical development of the demolition waste industry

Until 1925 demolition teams were willing to pay for a building to demolish because of the value that could be yielded through salvage; however, by 1929 both the value of labour per hour increased, and the cost of building material reduced making it more profitable dump scrap material. The last scavengers in New York were roving wood merchants, filling up a cart for $10 and selling it as firewood to tenements in the early 1930s. The movement away from masonry towards steel and glass meant that many of the buildings being removed were no longer useful to the construction industry. Just as modernity encouraged a fleeting aesthetic that was dislocated from historic materials, recycling brick masonry became a practice lost to the annals of history.

Since the patent of the Bulldozer in 1932, buildings have been transformed from building to debris without regard for the potential value of the material. There was public outcry in 1955 when demolition companies smashed up granite bathrooms in the Hotel Majestic West 72nd Street; the contractor argued: "To recut the rosewood, mahogany and black walnut used in the interiors of the old glow room and the rose room… would have cost more than to use new materials".

Blowing up a building creates dust that is illegal in accord with clean air regulations, and so it's use in cities is limited to isolated council estates or stadiums in the middle of large parking lots.

Recent inventions of the hydraulic excavator jaw and concrete slab saw are designed to help expedite the process of removing material in economies where construction labour is expensive. Unlike the wrecking ball, the jaw and slab saw are also particularly specialized for cutting large amounts of steel reinforcement that exist within the concrete, with replaceable blades that can be kept sharp. These are the tools that define the state of the art in contemporary demolition, and as such the paper takes the output of these machines as the ingredients for the holding patterns.

Today, the waste management and recycling industry is a multi-million dollar practice. Most revenue comes from lorries that are weighed before and after dumping their load at transit stations scattered throughout New York City. They typically pay $75 per tonne.

The economics favour large conglomerates that can merge landfills with trash collection and large-scale distribution networks of trains and trucks that can help minimize the costs. States that are keen to bring in business might sacrifice environmental standards to encourage high-value contracts with large multistage conglomerate businesses.

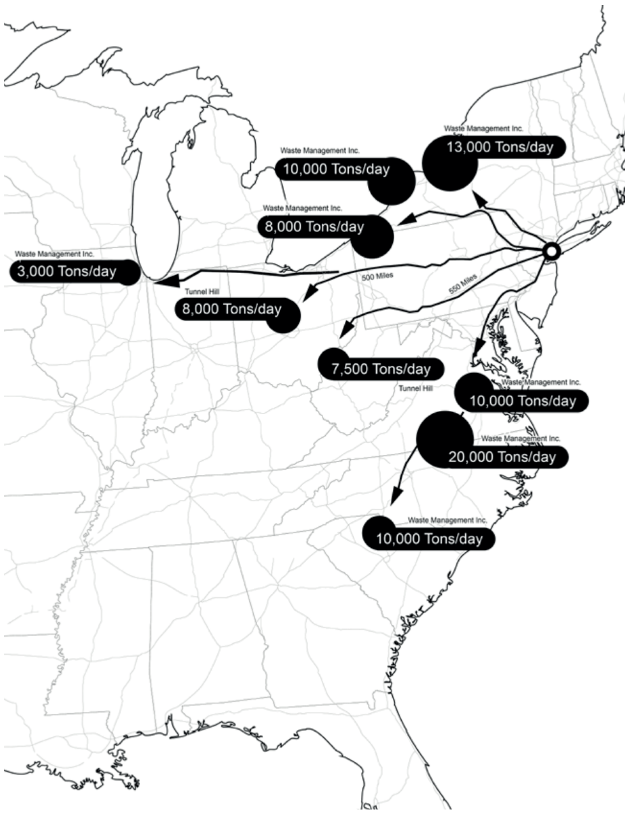

FIGURE 4: Out of state landfills for accepting construction and demolition debris from New York. The map also shows the volume of material they are permitted to accept according to the company website.

2.2 New York's rubble concrete mountain

Visualising the volume of scrap materials can help to contemplate what design responses might be necessary. Each year New York Tri-State Region disposes of 8.2 million tonnes of concrete. Using the basic density of concrete ate 2,400 kg/m^3, this would equate to about 3.4 million cubic meters per year. If one were to pile this concrete up into one huge concrete mountain, it would begin to settle at an angle of repose, at about 20 degrees. Using this information one can begin to imagine the volume of the concrete mountain that New York tristate C&D waste would amount to (Figures 5-6).

2.3 New York's scrap glass ceiling

Similarly, it is helpful to visualise the amount of glass that gets discarded each year such that one could begin to speculate on what architectural possibilities might exist for this volume of material. In the case of glass, over six hundred thousand tons of material are disposed of within the Tristate region each year. Of course, all of this glass is different size and different grades. But if one where to find a way to arrange them all together in one surface, the glass trash since 1955 would measure 6,320m square (Figures 7-8).

2.4 The future of demolition material in New York City

Whether one is shocked or awed by the volume of scrap concrete, glass and steel produced historically in New York, these quantities pale in comparison to quantities of scrap material that are due to be generated in the future. Each

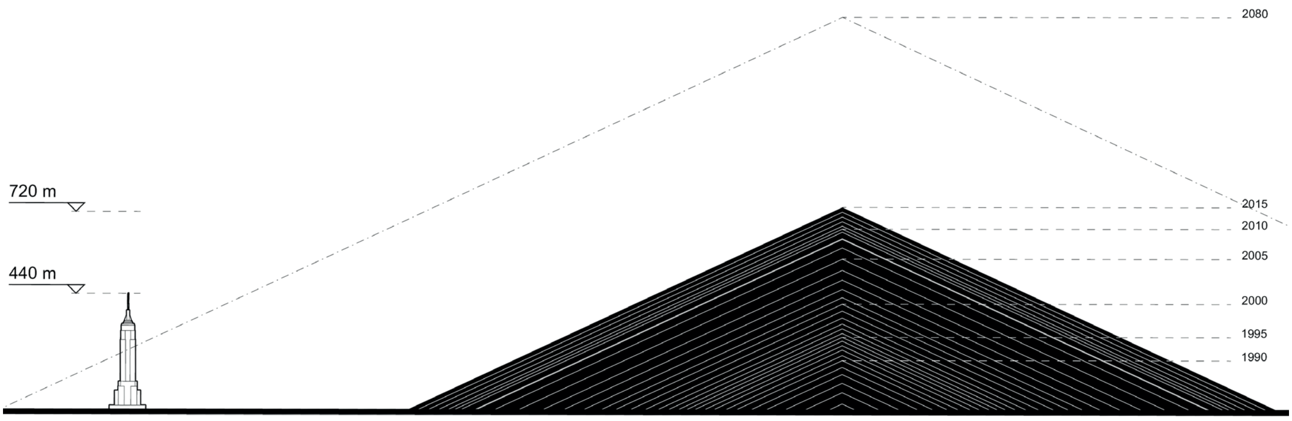

FIGURE 5: Diagram based on data from a survey of construction and demolition waste by the EPA - Environmental Protection Agency, Office of resource conservation and recovery (2018), "Construction and demolition debris generation in the United States".

FIGURE 6: Visualisation to indicate the mountainous volumes of concrete that have been demolished within the New York Tristate Region since 1989.

year, the United States Geological Survey publishes data on the global production of cement. If one adds up the cement produced each year in a cumulative graph this dataset can show the total volume of cement produced in human history - roughly 200 million tons. Of course, cement is just one-fifth of the concrete mixture, so the total volume of concrete would be equivalent to one trillion tons in human history.

The European Union suggest that 20% of all concrete structures ever made have already been demolished (Huu-

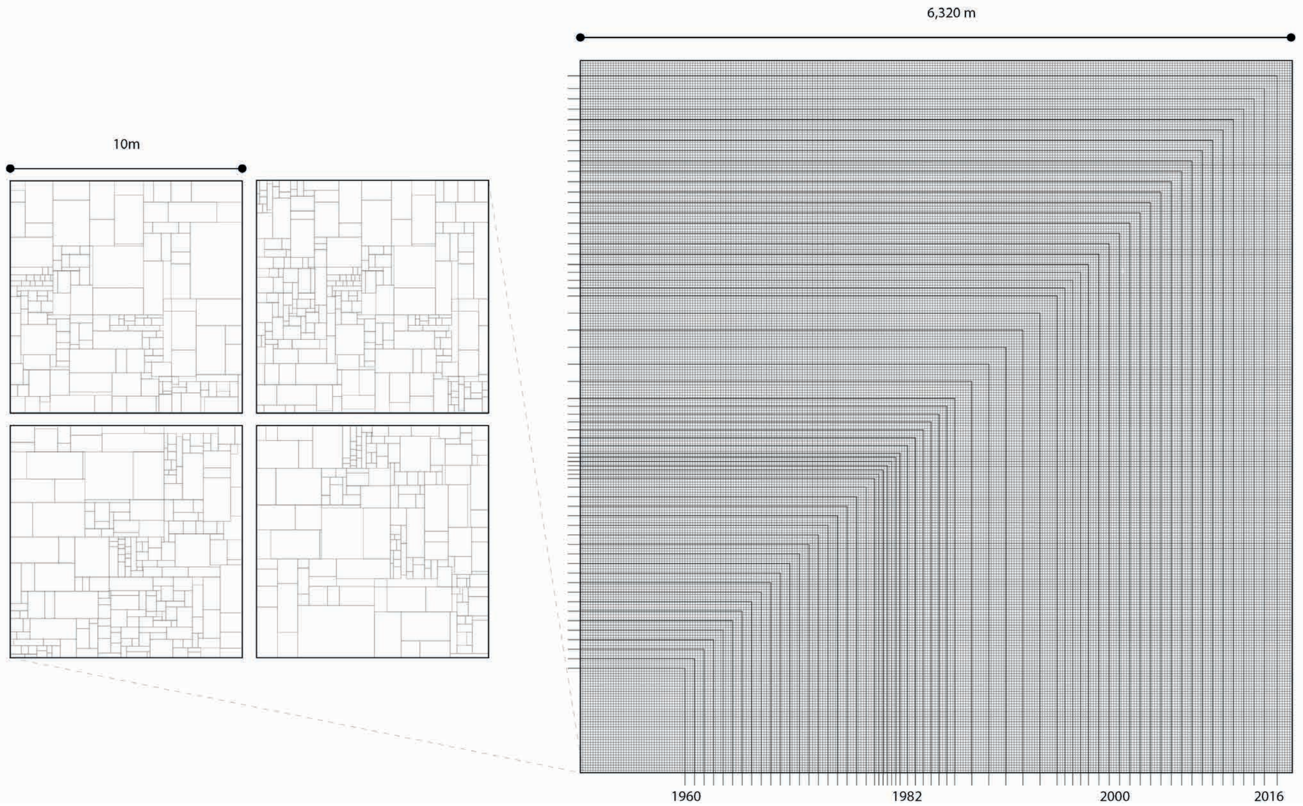

FIGURE 7: If New York arranged all of the glass demolished since 1955, the city could make a glass ceiling approximately 6320m square.

hka & Lahdensivu, 2016). When the proportion of demolished buildings is overlaid with the accumulation of concrete globally, one can begin to see that there is a lag time between the casting of concrete buildings and the demolition of the building. Concrete structures have a lifespan of around 60 years, and the peak of concrete production has been between 1960-2015. As such, there is likely to be a large and steady increase in the amount of concrete rubble produced globally over the next decades (Figure 9).

3. A BRIEF HISTORY OF COMPUTATIONAL METHODS FOR SOLVING IRREGULAR JIGSAW PUZZLES

In response to the abundance of demolition material presented in the preceding sections, this paper proposes computational methods for recycling irregular demolition material into new salvaged constructions. If demolition debris can be input into three-dimensional design software (through scanning) the resulting library of trash can be used as a catalogue for designing new constructions. This is not the first piece of research to propose the use of computer algorithms for solving irregular jigsaw puzzles and it is necessary to situate this research within a broader historical context.

The megalithic sternotomy of Inca masons is remarkable for the range of idiosyncratic approaches to arranging irregular material that, while not computational, demonstrate precise algorithmic thinking. As documented by Brandon Clifford in the Cannibal's cookbook, this culture of stone cutting and arranging "rubble" stones can also be found across the planet, for instance, the Edo castle in Tokyo, or the Osirieon Temple in Egypt (Clifford, 2017).

Computational methods for finding ways to fit shapes in space might trace back to the hunt for the "perfect squared square" at Trinity College, Cambridge during the run-up to the Second World War. The squared square is a square that is made up of other squares, and the subsquare of the "perfect squared square" are each different. The students that worked on this problem transformed the square tiling into an equivalent electrical circuit — they called it "Smith diagram" — by considering the squares as resistors that connected to their neighbours at their top and bottom edges and then applied Kirchhoff's circuit laws and circuit decomposition techniques to that circuit. This was the beginning of graph theory, and the students went on to apply the thinking at Bletchley Park during the war (Brooks et al., 1940).

According to graph theory, a "graph" is a structure comprised of a set of related objects, such as related pairs of vertices forming edges, which can be arcs or lines (Cormen et al., 2001). This paper uses the Hungarian method – an algorithm that finds maximum-weight matchings in bipartite graphs, or in more simple terms, a set of vertices that can be partitioned into two distinct sets where no vertices share a common edge (Ahuja et al., 1993). The Hungarian method was published in 1955 by mathematicians Denes Konig and Jeno Egervary. It is also called the assignment problem, which is commonly used in operations optimization, transportation and even naval research. This paper ap-

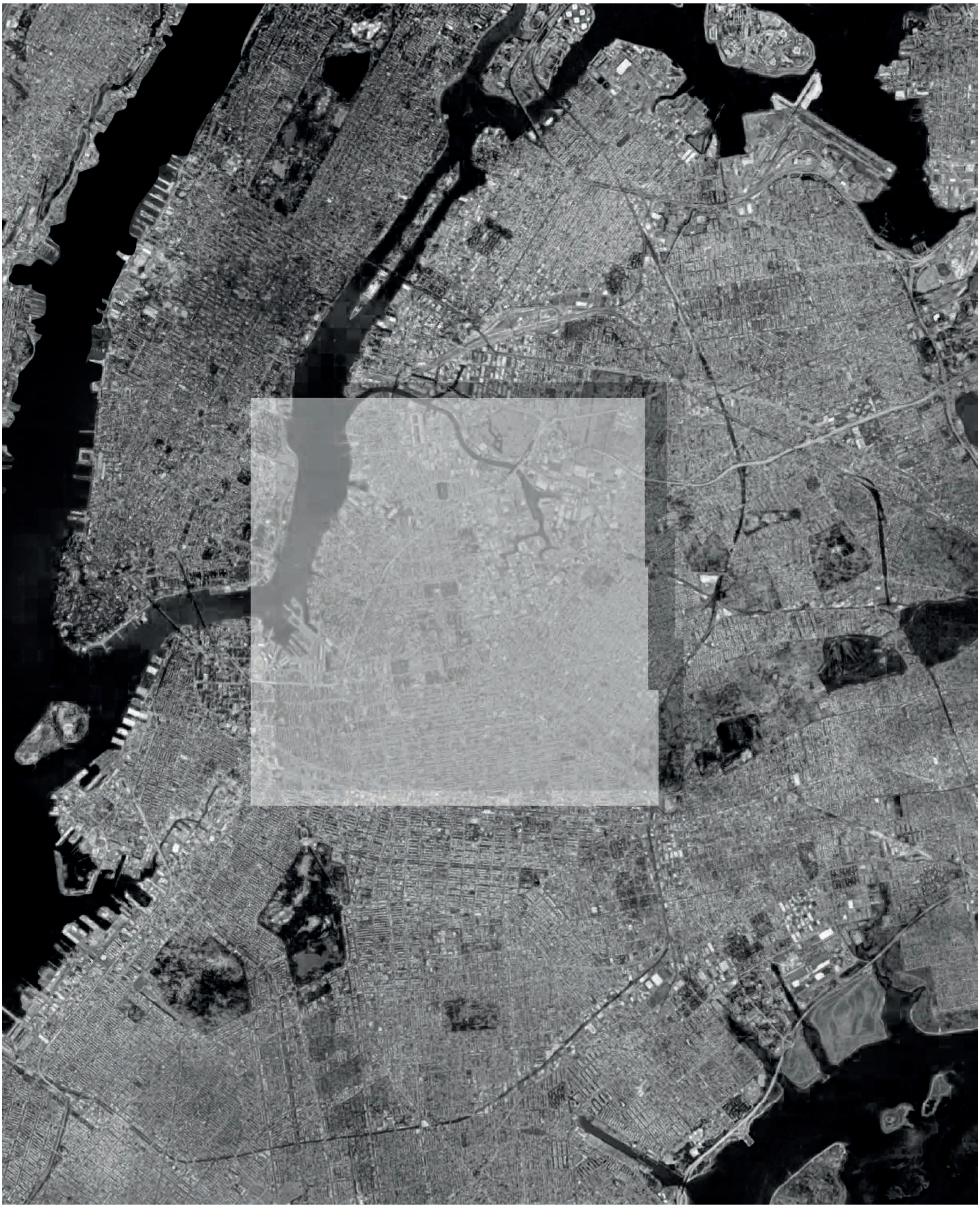

FIGURE 8: Visualisation to indicate the 6320 m scarp glass ceiling for scale.

plies the logic of bipartite graphs to match distinct sets of irregular materials in architectural assemblies.

Computational Evolutionary algorithms for the arrangement of objects may have been first credited to Adrian Thompson at the University of Sussex, who created an algorithm that could incrementally adjust the layout of elements on a silicon chip. These evolutionary optimization algorithms are utilized in the paper in conjunction with the Hungarian algorithm. The Hungarian algorithm provides a score of best match, of the library of material into the target structure. The evolutionary algorithms then adjust the configuration of the target geometry to optimize the match.

Within contemporary digital design discourse, the idea of scanning objects, and then arranging them in computational space might originate with Greg Lynn's recycled toy furniture, where rubber ducks were scanned and Boolean-union joined together into aggregate tables that were then fabricated (Lynn, 2008). Jonathan Enns' thesis "The New Non-Standard" investigated the scanning timber elements for use in irregular constructions. Later researchers at Hooke Park combined this research from Enns with genetic optimization algorithms to re-adjust the arrangement of branches into the best fit (Enns, 2010; Mollica & Self, 2016). Most recently, the Harvard GSD Assistant Professor Andrew Witt and his firm, Certain Measures, have shown algorithms that utilize publicly available artificial intelligence algorithms, to organize scrap material and re-arrange it into facade systems (Witt et al, 2017). The research of Certain Measures, organizes scrap into search engines using artificial intelligence libraries, and then selects the best fit at each step along the process, adapting the target shape in to accommodate the library of material as best as possible.

The use of Neural Networks and Machine Learning to sort through trash is also being implemented by Zen Robotics, a company in Germany that uses image recognition algorithms to sort trash into different recycle streams. The future work suggested by this paper would involve the use of machine learning to address two key challenges. Firstly in providing a low-cost method for identifying and grading the structural quality of waste material. Secondly as further research for the creation of algorithms that can solve the zig-saw puzzle problem posed by irregular material to meet the challenges posed by the character of the concrete, glass and timber that emerges through the demolition stream, and in ever more precise ways.

4. COMPUTATIONAL ARRANGEMENT OF CONCRETE DEBRIS

Based on the principals of structural bending, 70% of the structure exists in the floor-plate. Within a concrete building this means that most material not in the walls, but rather in the flat cast slab with steel reinforcement mesh. Floor plates are most commonly cut apart using a slab saw; 100 hp diesel engines spinning diamond-tipped saws with pressured water to help remove dust. Extracting concrete from both floor-plates and Plattenblau buildings would therefore yield a collection of irregular concrete that is roughly rectangular, but perhaps with some chipped corners (Figure 10).

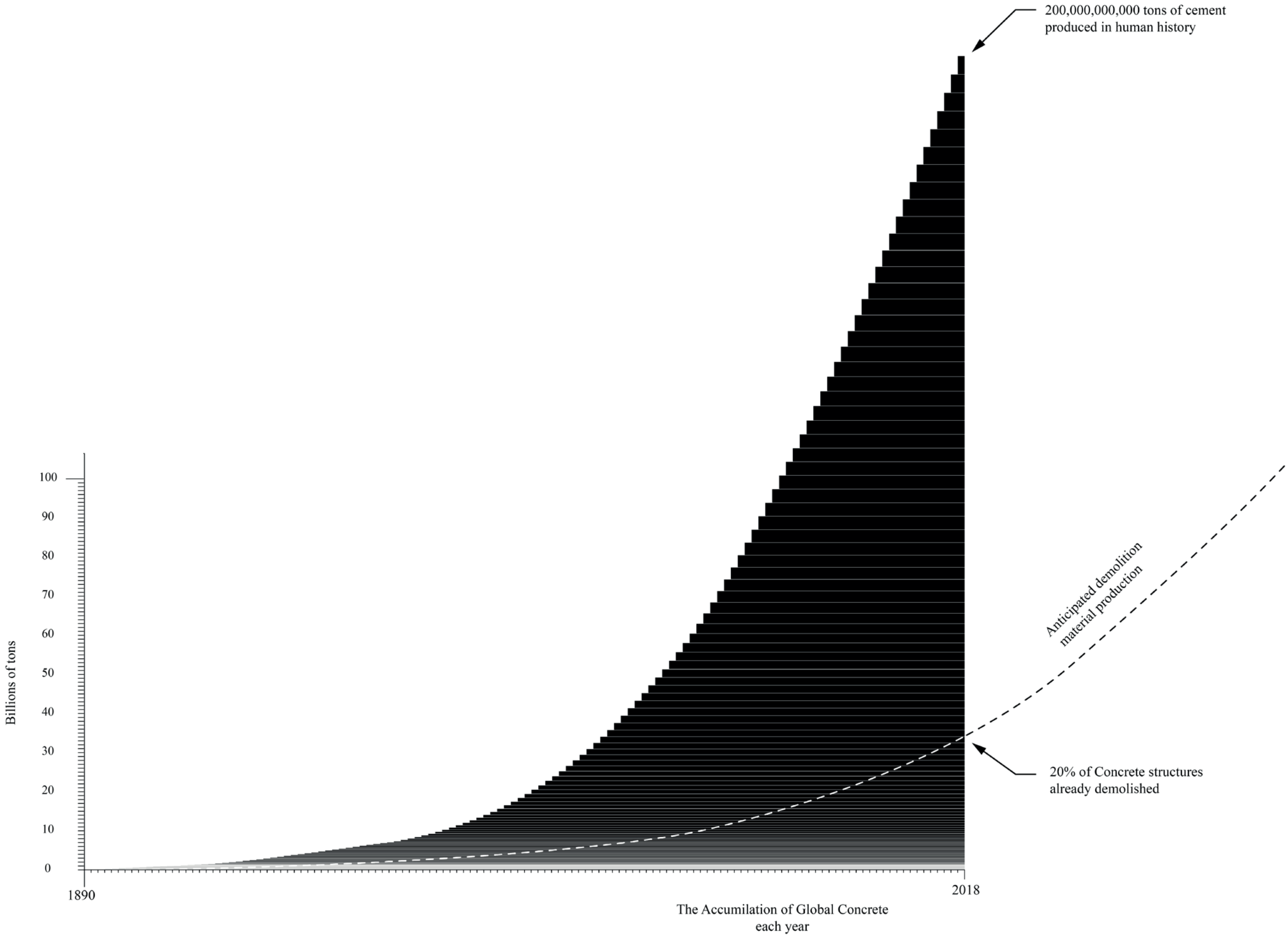

FIGURE 9: The accumulation of global concrete each year, based on data from the USGS (2018) "Minerals commodity summaries: cement statistical compendium".

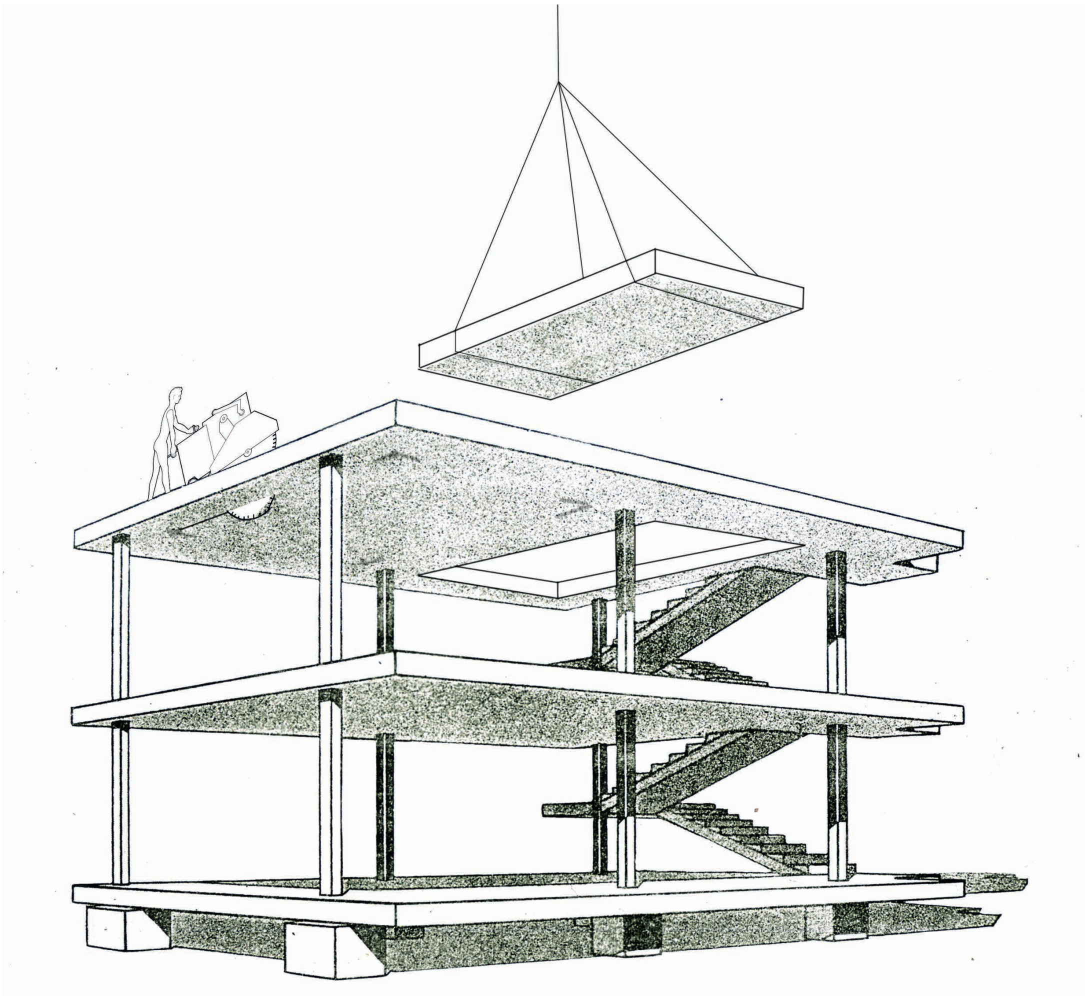

FIGURE 10: Le Corbusier created the Domino House in 1915. The Design for the house reveals the distribution of concrete within the design. Most of the material being positioned within the floorplate The diagram speculates on the possibility of using a slab saw to extract rectangular volumes from the floor slabs.

Once the rectangular material has been extracted from the structure, it would need to be scanned. The first step is to arrange it into rough groupings. It is convenient when the slabs are grouped into collections that have the same vertical height. This can be achieved when large precast slabs from buildings like the plattenblau are all cast to be the same size, or when smaller blocks of irregular concrete are stacked on top of each other to form piles that are of the same height. This process is completed using best-fit algorithms, which automatically position objects into the best arrangement to fill a quota. One can adjust the size of the gap between the two lines until you achieve the best groupings of the material, and the algorithm loops around different options until the optimal groupings are determined (Figure 11).

Having assembled the rubble into the best fitting groups, the concrete elements will next be arranged into a working configuration. The bottom layer is begun dividing the shape into a series of pieces and then using the hungarian matching algorithm to find the shapes that will fit into those positions best. Multiple iterations are made until the algorithm arrives at a distribution that makes an optimal utilisation of the material. Subsequent layers are resolved in similar manners, but with a constraint that all elements are supported on the bottom two corners for stability, spanning across the openings below. Finally, any missing gaps are filled in using the leftover library of pieces. If spaces cannot be filled custom made infill pieces can be fabricated (Figure 12).

Two particular problems for this building are the fragility stacked concrete slabs and the poor insulating properties of concrete. One solution could be the use of a diaphragm wall section where two walls of concrete slabs provide extra structural depth and a cavity for insulation. Insulation might sit in-between the two walls, with thermally broken steel connections spanning between the concrete slabs. Such a design would offer greater stability for the wall, but also insulation for the interior.

Once the basic workflow is understood, a workflow is scripted into a parametric model. This model can be adjusted by the parameters of: Base size, Floor to Ceiling Heights at each level, Window Position (Figure 13).

With this model the entire library can be matched onto a variety of shapes, allowing for a holistic optimization. Leftover material is positioned in front of the model and the amount of extra infill material required to finish the shape shown at the foot of the model. These two measures allow for multi-objective optimization, where the amount of infill and amount of leftover material are both minimized. The optimization algorithm can keep adjusting the basic geometry until it finds solutions that both use a lot of material and require small amounts of infill (Figures 14-15).

The algorithm described in this section was then tested in a model format. A collection of irregular concrete elements were modelled. Each piece was scanned, indexed and input into the evolutionary algorithm within the 3D modelling software Rhino, and using the parametric scripting plug-in Grasshopper. Multiple iterations were made until the software produced an optimal utilisation of the rubble material. A few patched were infilled with a brass element that was cut to fit the gap. The resulting model provides a vision of a building that can be fabricated from irregular material, without the requirement for new material to be extracted from the natural environment (Figure 16).

Such holding patterns might find their home on riverbanks in the old industrial areas of the city. The weight of concrete makes it a good candidate for transportation by water. The holding patterns could be erected on the banks of old industrial canals, ready to provide new spaces for inhabitation within the ruins of the city past.

5. CONCLUSIONS - SEEING THE CITY AS A HOLDING PATTERN FOR MATERIAL

There have been persistent calls in history to think of the city as a mine at this specific moment. Both Jane Jacobs and Cedric Price recognized in the post-war housing boom that these structures would not last indefinitely. In 1962

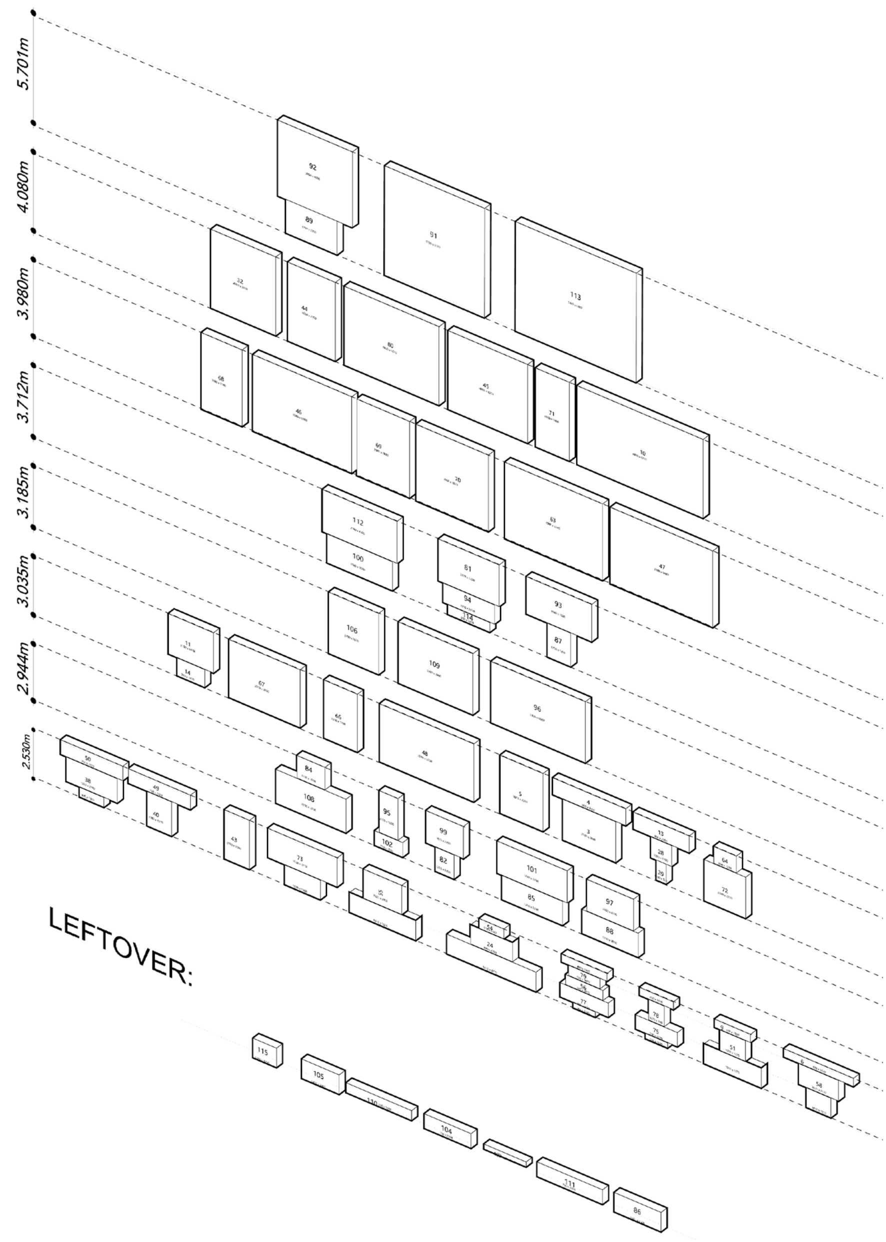

FIGURE 11: Initial organisation of rectangular floor slab elements into the best possible groupings.

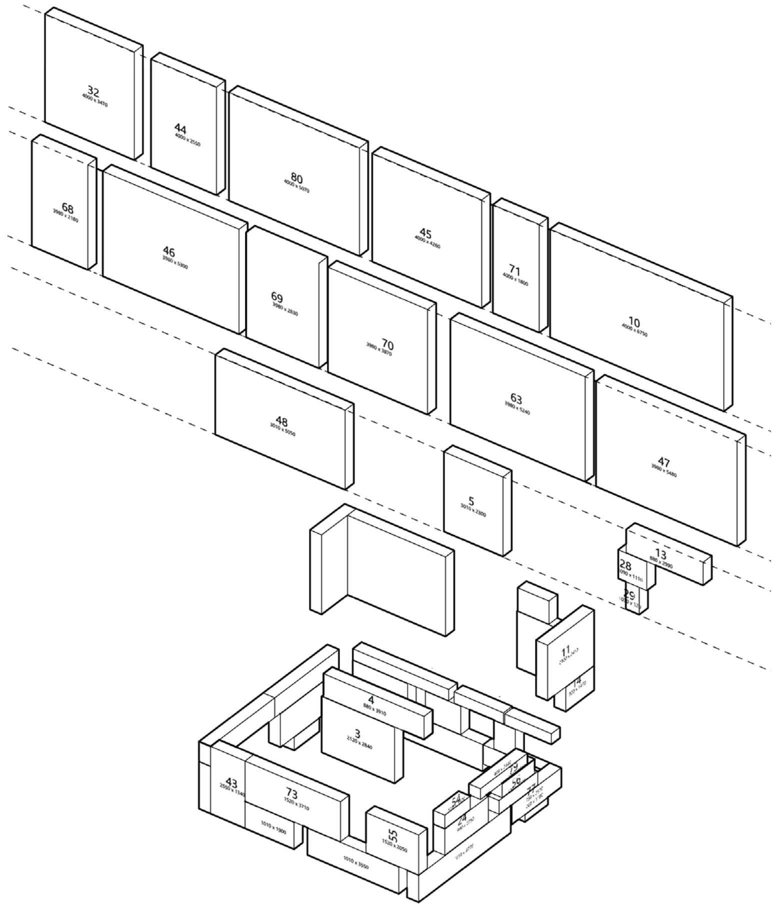

FIGURE 12: Procedural sequence for positioning irregular concrete blocks into a facade system.

Jane Jacobs suggested, "cities are the mines of the future" (Jacobs, 1961) criticizing the productions of postwar urbanism in a precursor to Rem Koolhaas' reading the city as "Junkspace" (Koolhaas, 2002). As these post-WWII buildings come to the end of their life cycles, the last decade has seen renewed interest in the problem of recycling for different ecological concerns. In 2014 Jorge Otero-Pailos who 'retrofits' buildings by barely touching the surface dust argued, "the earth simply doesn't have the energy resources to allow us to continue to demolish and rebuild everything. The logical step is to reduce our reliance on ground-up construction and instead focus on adapting the building stock we have". With a similar logic to John Soane's famous painting of the Bank of England in 1830, Reiner de Graaf in 2017 lamented the fact that no buildings can escape eventual demolition; "we build in the express knowledge that ultimately all buildings disappear", and argued that "The rubble becomes the source material for other buildings, elsewhere, for a different purpose". Researchers in at TU Delft have attempted to "prospect the urban mine of Amsterdam" with maps showing the precise volumes of different materials that exist within the built fabric of the city.

Yet this notion of the city as a resource for reconstruction is not just a niche idea in architectural histories, The debris of architecture is the frequent victim of science-fiction dystopia. Mad Max and Blade Runner speculate on the scavengers and pirates that might exist within future trashscopes of abandoned cities. Wall-e positions the robot as a way of dealing with the junk space, arranging the waste

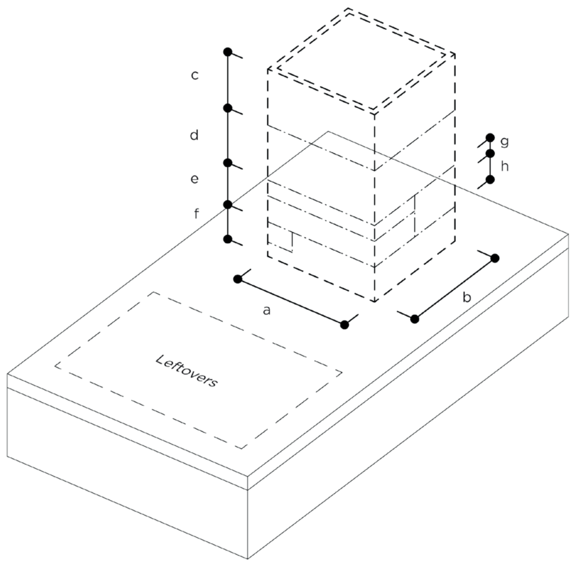

FIGURE 13: Parametric model for adjusting parameters of the proposed building. The different variables, a through to h can be adjusted and will yield different results from the procedural arrangement algorithm outlined above.

of humankind into meticulous mountains. Special effects have almost anesthetised the mind to the aesthetics of how a building will come apart. There is a subtle culture that has both fetishized and devalued the destruction of the city as a daily aspect of urban life.

Yet the idea of rebuilding from the rubble of a previous city presents relationships that are more complex than the dystopian waste-scapes that we find in movies or architectural texts. It is not to remove material and replace with the "new", rather it is a city that is re-mediating itself. Which is to say that it is both a restructuring and a continuity of the past. There are perhaps two versions of this architectural phenomenon. One would be the logic of Spoila – where something has been defeated, and the new architecture is

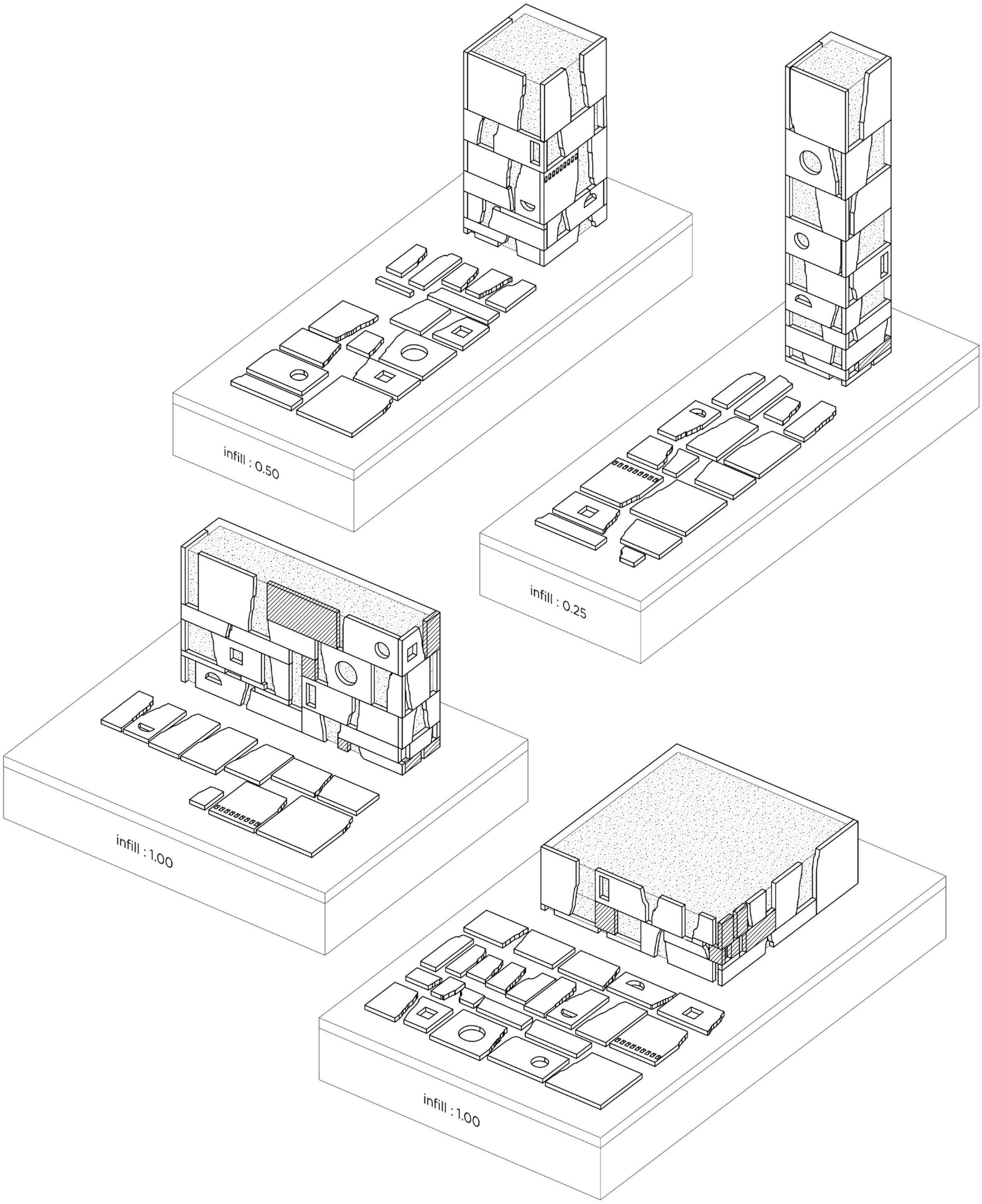

FIGURE 14: Variety of options generated by adjusting the parameters of the parametric model, and the resulting procedural concrete placement with corresponding utilization of the debris.

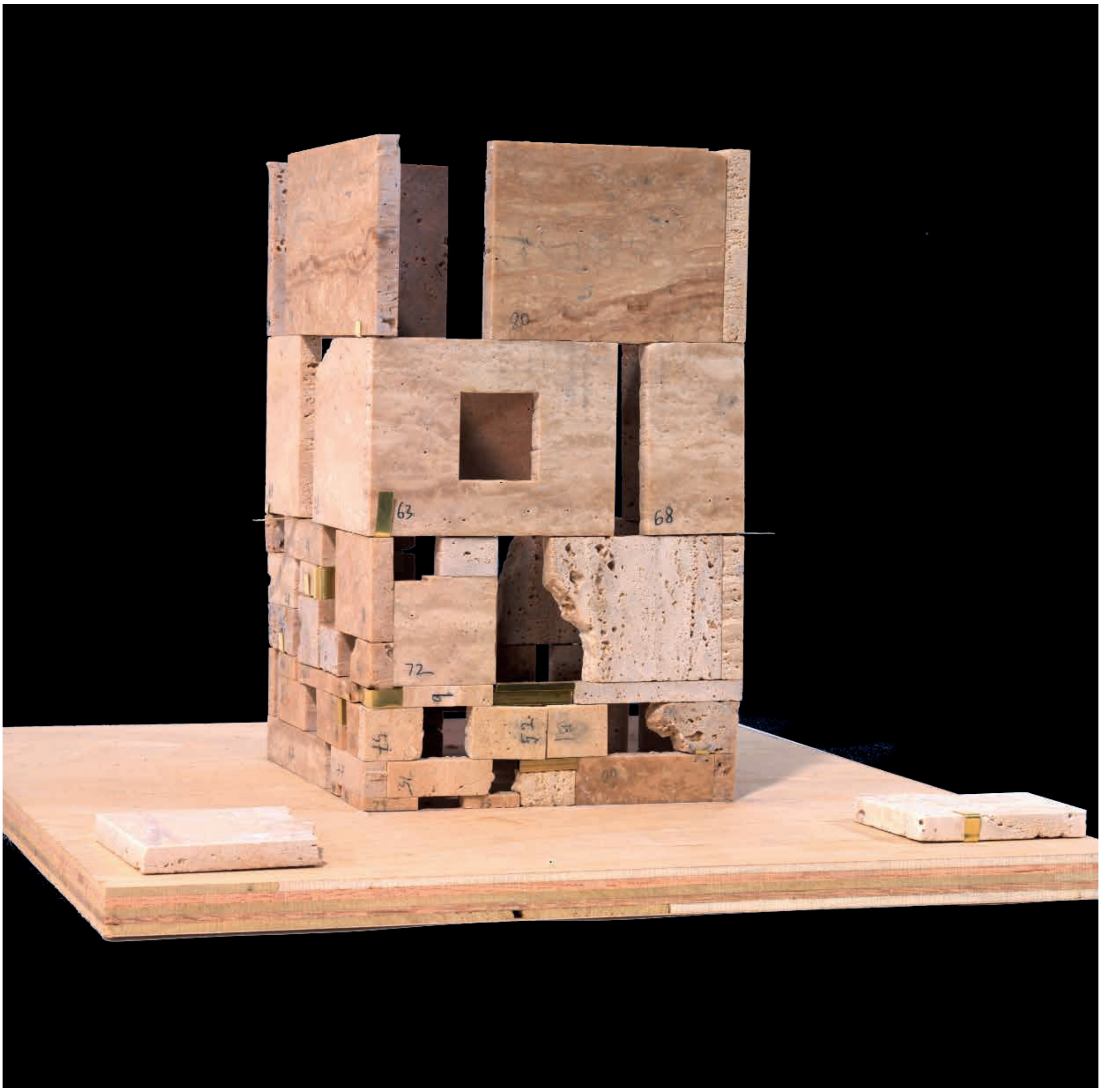

FIGURE 15: Model created by arranging a collection of irregular rectangular elements.

triumphant. The other derived from Kintsugi – the regret something was destroyed and the idea that putting it back together can yield a new sensibility. This paper is more interested in the latter.

The designs presented in this paper rely upon the indexing of material. Objects are scanned and catalogued. These catalogues are then searchable during the process of computational arrangement. The imagination is therefore that the material of the city, when a building comes to be demolished, is all indexed, allowing for designers sitting at their computer to "drop" these indexed items into new computer models for future designs. Fragments of the city therefore re-appear across time as they are used in different configurations at different moments.

Once an object is scanned, indexed and catalogued it becomes different from what it was before. If scrap material is measured and identifiable there is a new anxiety to not loose it or break it. Once its index is lost, some of its history and meaning disappear. The simple act of indexing the material of the city therefore becomes a call for preservation in its own right, and poses new possibilities for cities that might be able to last beyond the limited lifecycles that we currently build to.

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FIGURE 16: Demolition material may be placed into “holding patterns”. Rather than grinding the concrete up and sending the material to landfill, perhaps architects and urbanists can find temporary uses for this material. Holding patterns would allow future generations to accumulate resource libraries for new constructions.

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CISA

LANDFILL URBANISM: OPPORTUNISTIC ECOLOGIES, WASTED LANDSCAPES

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ABSTRACT

"As a child, my father would take my brother and I to the local junkyard. We'd watch, amazed, as the compressor squashed our waste into a dumpster, then scavenge through piles of scrap metal and climb gigantic wheeled Caterpillar earthmovers." For better or worse, this archetypal junkyard has given way to strictly controlled spaces of waste disposal. When this paper was originally published in 2010, demand for material had been continuously increasing. This, coupled with a culture of disposability, had coincided with heightened policy measures restricting landfill development. And today, we still have a crisis of waste management. Meanwhile, as landfilling has grown from a localized phenomenon into a regional set of distribution networks, neo-industrialization is emerging throughout the Great Lakes megaregion, suggesting new opportunities for re-territorialization of wasted landscapes. This project posits that extraction of existing landfill sites for material and energy is inevitable. Landfill Urbanism suggests that the act of landfill mining, a contentious and stinky proposition, has the capacity to foster a localized, robust industrial ecology, while also recasting the public's relationship with our waste through tactical deployment of architecture and urban space-making. Directed Robotic Trash Extractors (DRT-E) exhume and cultivate material, as the project's conveyor-belt infrastructure allows individuals, cooperatives and corporations to safely sort and collect based on their needs: a novel approach to accessing our 21st century resource. By allowing complete engagement with the public, Landfill Urbanism fosters productive interdependent relationships between consumers, as well as offering to its users a series of spectacular didactic, practical, and recreational experiences.
Where the public of today consumes, the public of Landfill Urbanism harvests.

1. INTRODUCTION

Hills rise in the dross of the American post-industrial landscape. Surrounded by nondescript warehouses, oceans of asphalt and retention ponds, expansive PTFE bowls are filled, covered, capped and monitored. Typically situated at the perimeter of the urban landscape, landfills have, in recent years become consumed by the confines of civilization. Yet the increased demand for material coupled with decreased natural availability, as well as heightened policy measures barring landfill site development and airspace, have collectively fostered a growing crisis of waste management. Blane Brownell exclaims in his essay Material Ecologies in Architecture, "Citing a recent USGS study, American Environmentalist Lester Brown informs us that we will exhaust known stores of several metals, including lead, copper, iron ore, and aluminum, vital to construction and other industries, within the next two or three generations." The extraction of existing landfill sites for material, energy and airspace is thus inevitable (Figure 1).

Landfill Urbanism proposes logistics, operations and architectures requisite of landfill extraction as a catalyst to implement a multifarious agenda aimed at fostering localized industrial, commercial and recreational ecologies across its industrial zone (as well as novel operations within the confines of the site). Positioned in the reality of our current economic and political environment, the project envisions a deterministic future encompassing technological advancement pitted against increased environmental degradation, and an urgency for alternatives (or augmentations) to existing societal practices. No more merely the mummified mass, the landscape of the landfill fulfills its destiny as an agent continuously manipulated by the wills of civilization, throbbing to the pulse of the urban metabolism, while also working as a catalyst to foster a thickened, yet localized industrial ecology (Figure 2).

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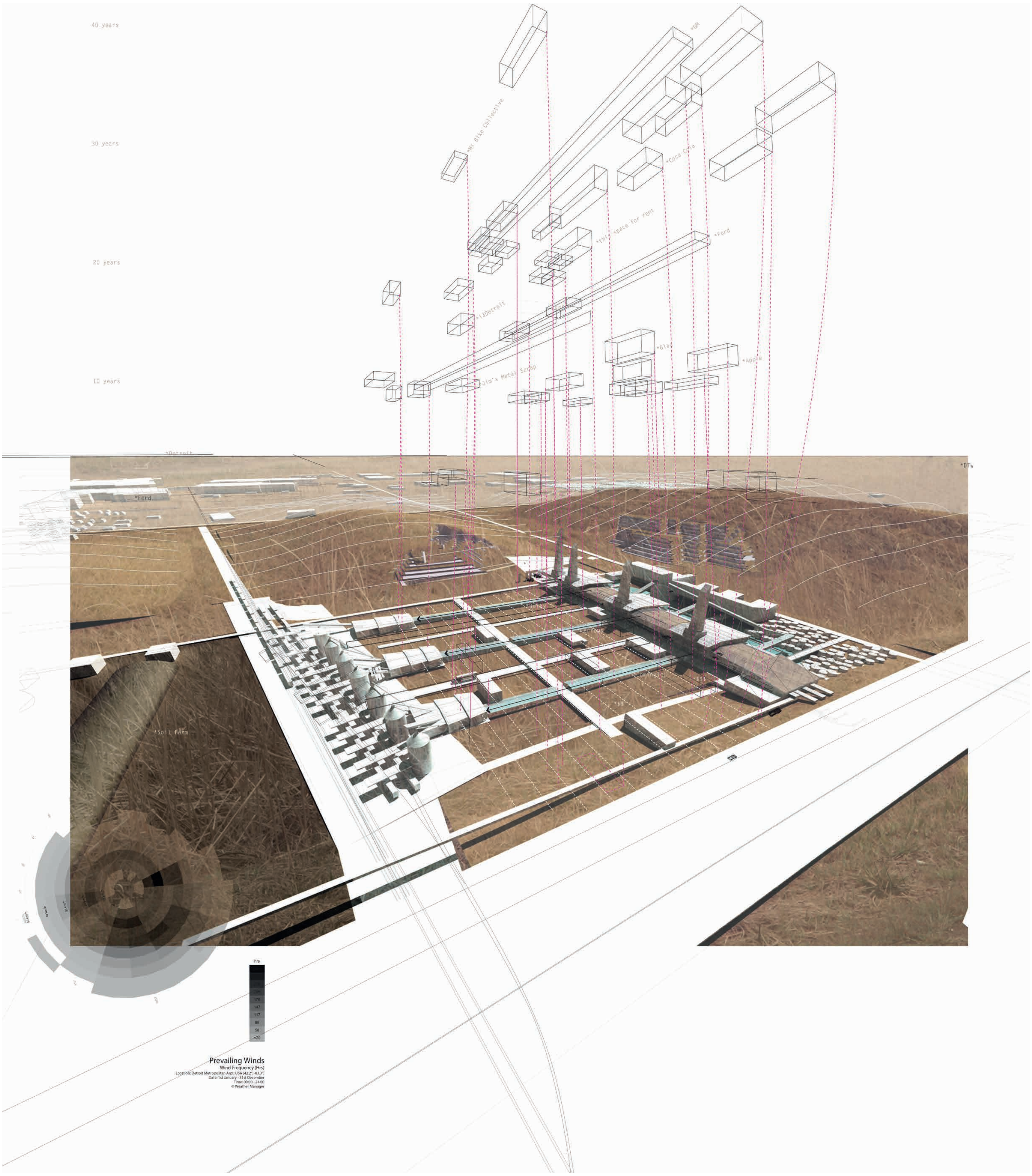

FIGURE 1: The infrastructure of emergent sorting.

FIGURE 2: The mound.

This paper summarizes a Master Thesis published in 2010, at the University of Michigan Taubman College of Architecture. Nevertheless, the proposed project may continue to be of interest to professionals and academics working in the field of Waste Architecture.

2. LANDSCAPES OF OBSOLESCENCE

Alan Berger connotes wasted land as Drosscape, illustrating in his text a categorical set of distinct dross territories visible throughout North America. Of these territories, the Landscapes of Obsolescence (LOO's) render visible the open loop in material and energy flows. The Landfill, out of the public consciousness, is neglected. Due to the lack of strong governmental oversight, Landfill operations have historically been a breeding ground for corruption, excess, and sluggish-to-backward environmental stewardship, its owners focused on waste quantity as income. Recent shifts, due to a more enlightened public, and stringent policy decisions following 1990's 'Subtitle D' Federal mandates, have served to increase awareness of the waste management process. Or at least increase the marketing campaigns by the largest waste management corporations expounding their environmental stewardship.

Regardless, the generation of waste is clear. We Americans produce on average some 2 Kg (4.39 lbs) of waste per day. However, for much of human history, waste collection and disposal were a purely local process dealing primarily with organic matter, generally relying on natural processes to ultimately renew waste into usable material. The proliferation of inorganic materials into the 20-21st century waste stream has exacerbated traditional waste handling procedures of in-ground disposal or incineration. While costs incurred extracting virgin resources continue to mount, recycling programs have yet to make a significant impact on waste reduction.

3. GLOBAL LOGISTICS NETWORKS. FORM FOLLOWS ENERGY

The landfill is, by all accounts, the end node of global flows of capital, save for the burgeoning market for landfill gas extraction, and the transfer of capital into the pockets of corporate waste management and government entities (which does not account for the potential worth of material dumped). It is where investment goes to die. In this role as end node, the landfill gives physical form to the inefficiencies in our systems of civilization: it grows, mocking us and our inability to keep such material (and therefore energy or capital) flowing. But why let that be? The material is not gone; as the first law of thermodynamics states, energy within a system is neither created nor destroyed. The landfill is not the end of the system, even though it seems that way given today's practices. What if the landfill is merely a bottleneck inhibiting flow? Landfill extraction removes the bottleneck, injecting currently secluded material back into circulation (Figure 3).

The nascent potential of landfill extraction may, when endeavored upon, tap right back into the markets and flows by which it came. The mechanisms in our society that allow Walmart, McDonalds, or Amazon to deliver products have conditioned us to assume their methods of material transfer are the only solution. Landfill mining, when linked into global supply lines, could, and by many accounts should, bypass the local scale. However, as Pierre Belanger notes in his essay Landscape as Infrastructure, a shift is occurring "from conventionally large, centralized industries of mass production to a decentralized pattern of production."

Global networks require a coarse level of granularity to maintain efficiency, such as seen in standard recycling

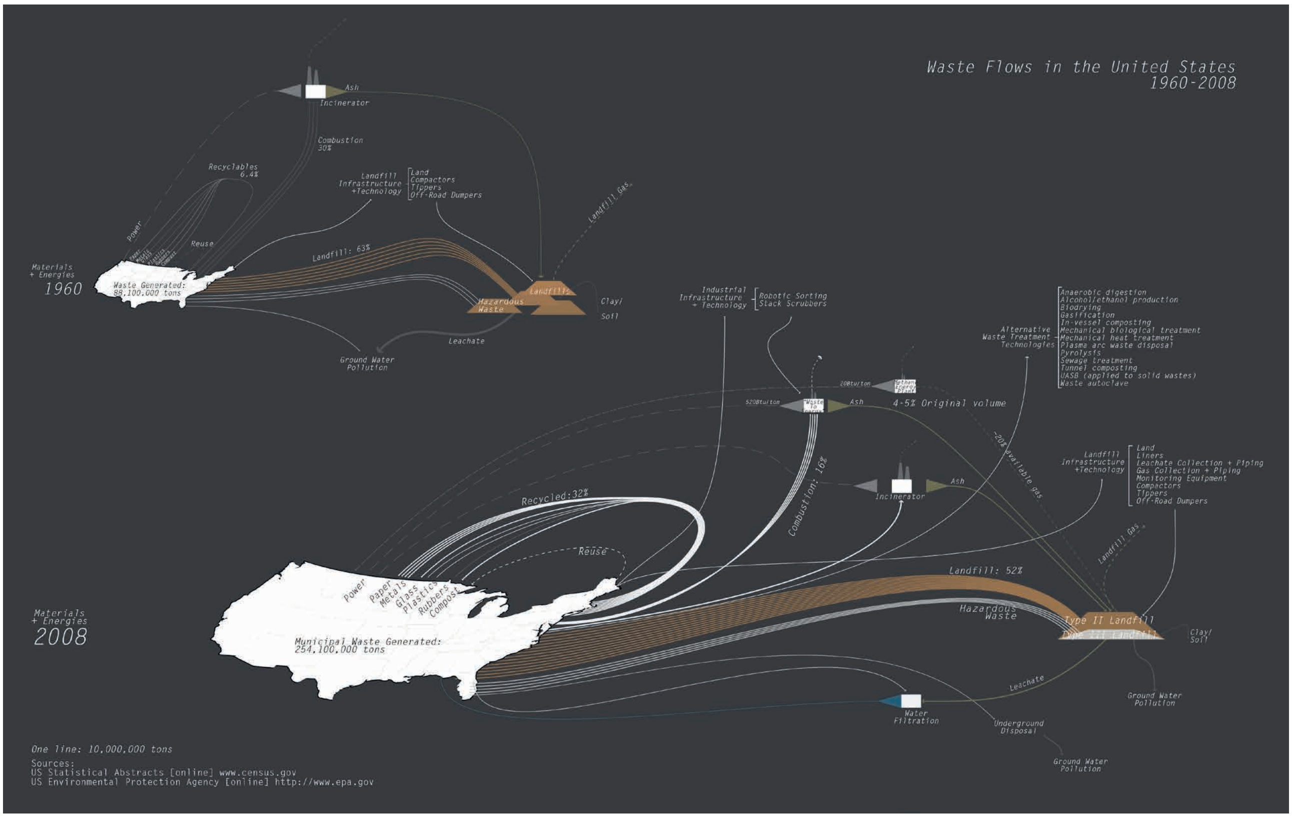

FIGURE 3: Material flows.

facilities that sort material by major commodities. This method of sorting does not account for any non-standard or finer grained elements in the system, and therefore sees anything unprofitable as waste. Landfill Urbanism offers an alternative: do both. Engage global networks while also offering direct public access unmediated by such networks, allowing for fine-grained economies to fill the gap. Foster emergent localized networks to provide that last percentage of efficiency unavailable to global flows. In plain terms: send out the bulk plastics and metals, but only after they've been sifted through by individuals who may find more immediate use for the oddities exhumed from the fill. Although not guaranteed, this may facilitate interdependent industrial networks at multiple scales similar to existing landfill networks, projecting completely unforeseen growth patterns (Figure 4).

As Peter Hasdall, in his essay Pneuma: An Indeterminate Architecture, or Toward a Soft and Weedy Architecture, explains that "A possible framework for reconceptualizing the design of ecologies as a raw, open-ended, open-sourced and non-prescriptive research-based practice is outlined ... as Pneuma. As a point of departure, this practice comprehends architecture as a mediating entity (a medium) that regulates flows and balances in an ecological field." Therefore, although grounded in the requisite industrial operations, Landfill Urbanism's architecture becomes an active agent, heightening operations beyond industrial infrastructure to project new and emergent relationships between material and energy flows, local climate, infrastructure and humans.

4. EXPLORING THE SORTED PROJECT

As of 2010, the State of Michigan was the third largest importer of waste in the United States, and in 2009, twenty percent of the material landfilled in the state originated in the Toronto region of Ontario, Canada. To address this alarming statistic, the newly formed Federal Agency for Waste Reclamation, or FAWR, seeds funds to the State of Michigan to develop a pilot program. Michigan's Department of Natural Resources and Environment, the agency responsible for landfill development, management and oversight, partners with the Department of Energy, Labor and Economic Growth to form the Southeast Michigan Landfill Development Initiative (SEMLDI). Charged with developing programs to productively utilize the state's growing resources found within landfills, the Woodland Meadows Landfill constellation has been chosen for this historic pilot project (Figure 5).

Twenty miles from Detroit near the Industrial community of Wayne, Waste Management Inc. owns and operates the 80+ha (200+acre) active Woodland Meadows landfill adjacent to two capped landfills. This campus of waste resides adjacent to an additional 80+ha (200+acre) landfill operated by Republic Waste Services across Interstate 275. These two active fills represent almost a third of the airspace available in the southeast Michigan Region (Figure 6).

The Sorted Project is the primary sorting facility on site. Just as sorting adds value to material, so to can architecture become that 'value added' to a large territorial project. Stan Allen, in his essay Infrastructural Urbanism

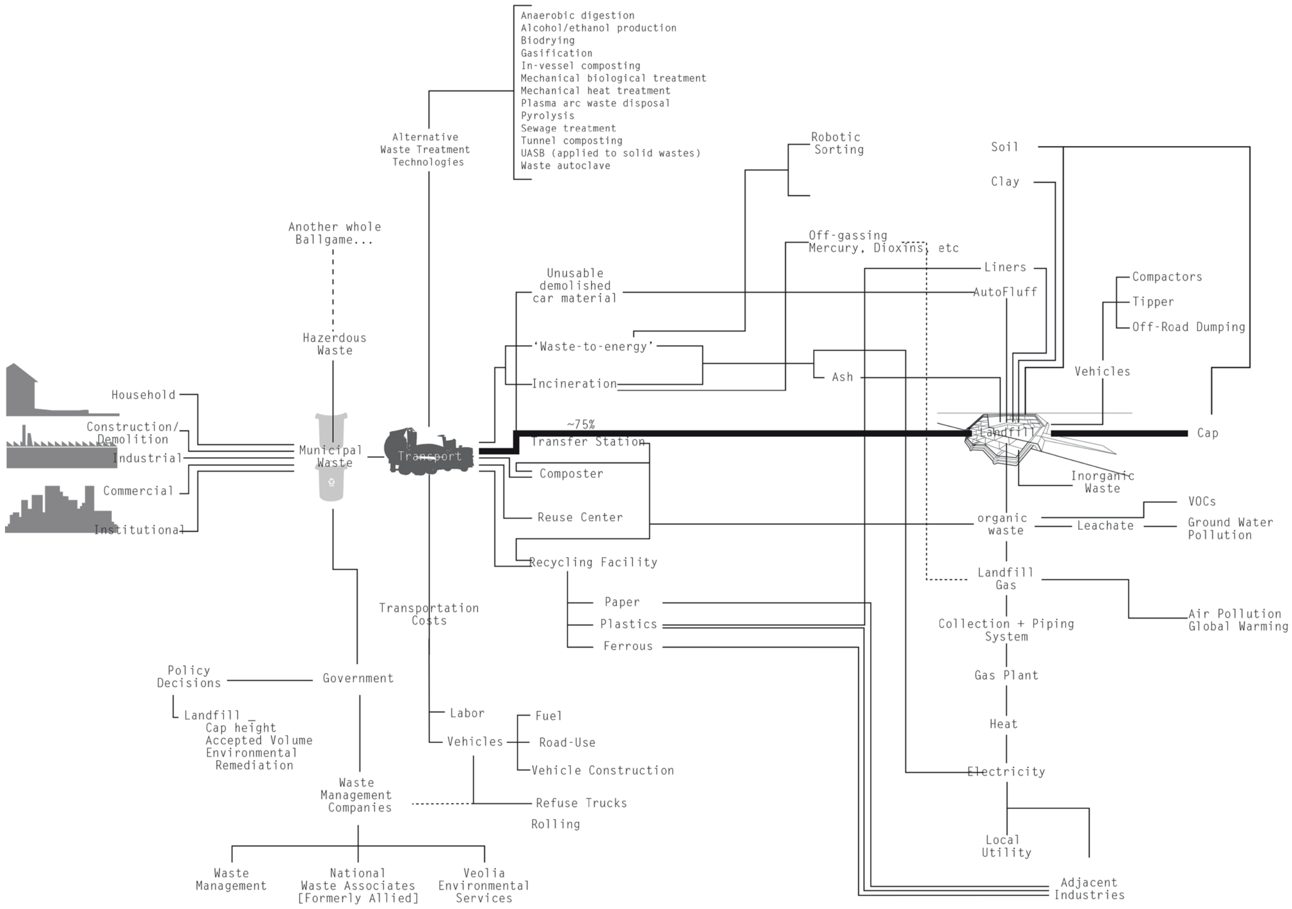

FIGURE 4: Taxonomies.

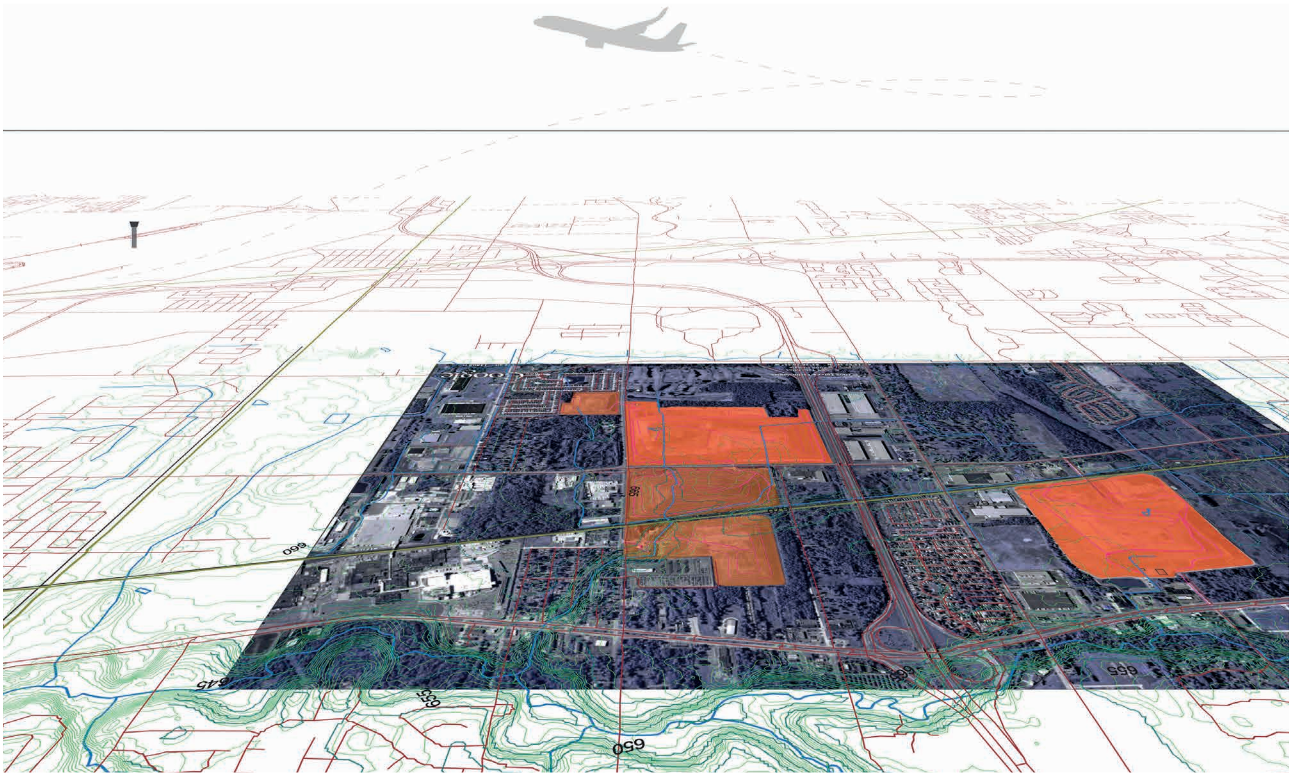

FIGURE 5: Site perspective.

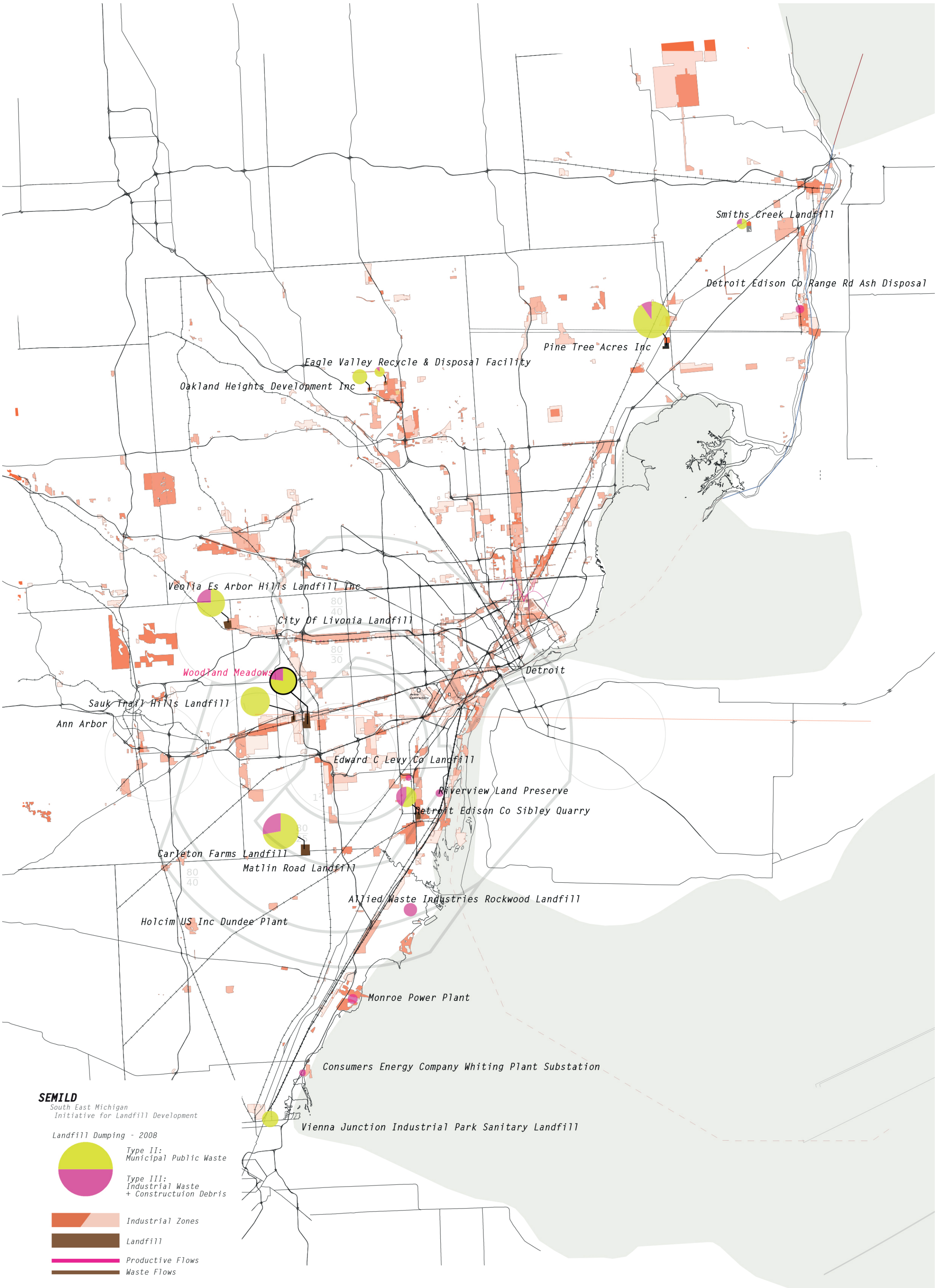

FIGURE 6: Detroit regional landfills, 2008.

notes that “Architecture is uniquely capable of structuring the city in ways not available to practices such as literature, film, politics, installation art, or advertising. Yet because of its capacity to actualize social and cultural concepts it can also contribute something that strictly technical disciplines such as engineering cannot.” Where typical industrial facilities hide themselves from the public, here the architecture seeks to say: “Come explore me!”.

Site for the work exists in multiple arenas across the landscape. First, situated on the landfill, extraction machines creep across the mounds, exhuming entombed material, ATVs skirting around DRTEs. After initial extraction, material is trucked to adjacent facilities, sorted into basic material categories where applicable: Metals, plastics, paper products, organic material. Waste material, typically categorized and sorted by these elemental substances, takes on new agency, as the taxonomy of material becomes a critical player in the spatialization of operations with possibility for emergent conditions of alternative sorting. The architecture of the sorting facility naturally evolves a series of networks, housing space specifically targeted as an incubator for entrepreneurial interaction that may capitalize on these non-traditional taxonomies. The obsessive compulsive will cull every measuring device exhumed, while the ‘Glad’ company contracts to capture all spent plastic bag material; the Geek Squad collects all E-waste, or an artist will rent space as a testing ground for multi-media work. In this alternative sorting, rusty rebar, Styrofoam cups and electric scissors are all implicated.

Any matter unable to be reused is either partitioned as hazardous waste or sent to the power plant for incineration. Water is processed through a series of bioremediation drops before returning to the retention pond for use as coolant and cleaning water for both the sorting and power generation facilities. The power plant will intensify power generation capabilities of the landfill by incorporating landfill gas processing, waste-to-energy processing, and various other technologies, including leachate geo-thermal, wind and other available renewables. Fly ash created as waste from the incinerator is sent to a concrete manufacturer nearby for use as aggregate (Figures 7).

Seen through the lens of the long view snapshot, the Woodland Meadows site is tracked from inception through multiple states of dumping, excavation and use. Politics and economics govern project feasibility; as sorting production fluctuates, facilities grow and shrink to accommodate demand. As the mounds evolve, so too does the architecture. Build-up of sorted material occurring on site renders legible the status of material use and waste in the region. As extraction architecture remolds the landscape,

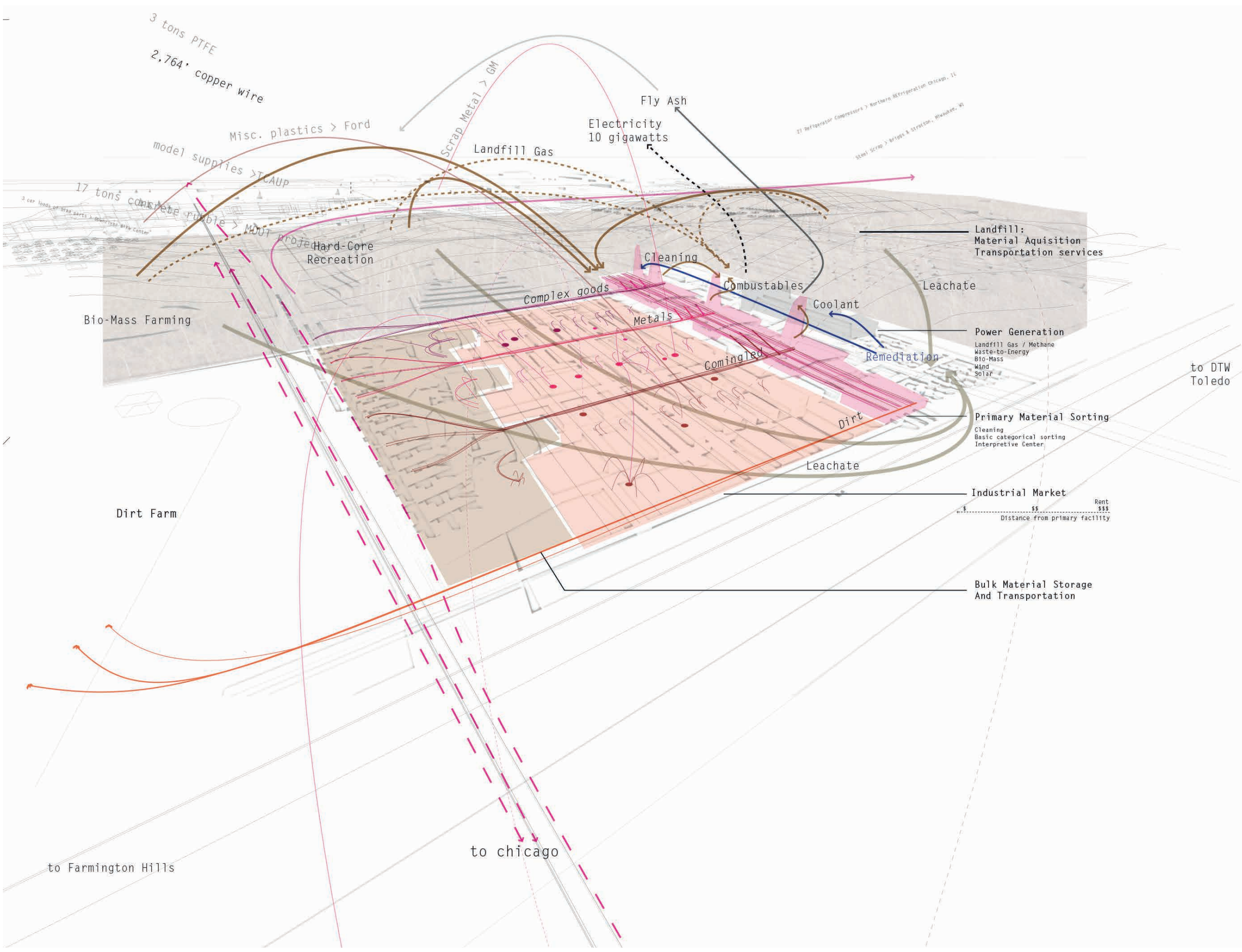

FIGURE 7: Site flows.

off-road sport takes advantage of this continuously repackaged condition, gloriously conquering the territory.

4.1 On the fill

Directed Robotic Trash Extractors, or DRTEs, and other mining equipment extract material, as recreational activities such as ATVs or mountain bike riding, snowmobile or even DRTE rides take advantage of the constantly remolded landscape (Figures 8, 9).

4.2 The power station

Directly adjacent to the mound, this facility harnesses energy from multiple sources: landfill gas, methane, waste material and biomass incineration, distributing the energy across the project, as well as supplying local businesses such as the Ford assembly plant down the road (Figure 10).

4.3 The Remediation pond

Handling runoff and leachate from the surrounding landfills, the remediation pond serves to clean and recycle water from both the sorting facility, and power station for reuse as cleaning and coolant in both facilities. A living machine filters out heavy metals and other toxins.

4.4 The Headhouse

Three Head-houses serve as transition points from primary sorting to the line conveyor belts, carrying material

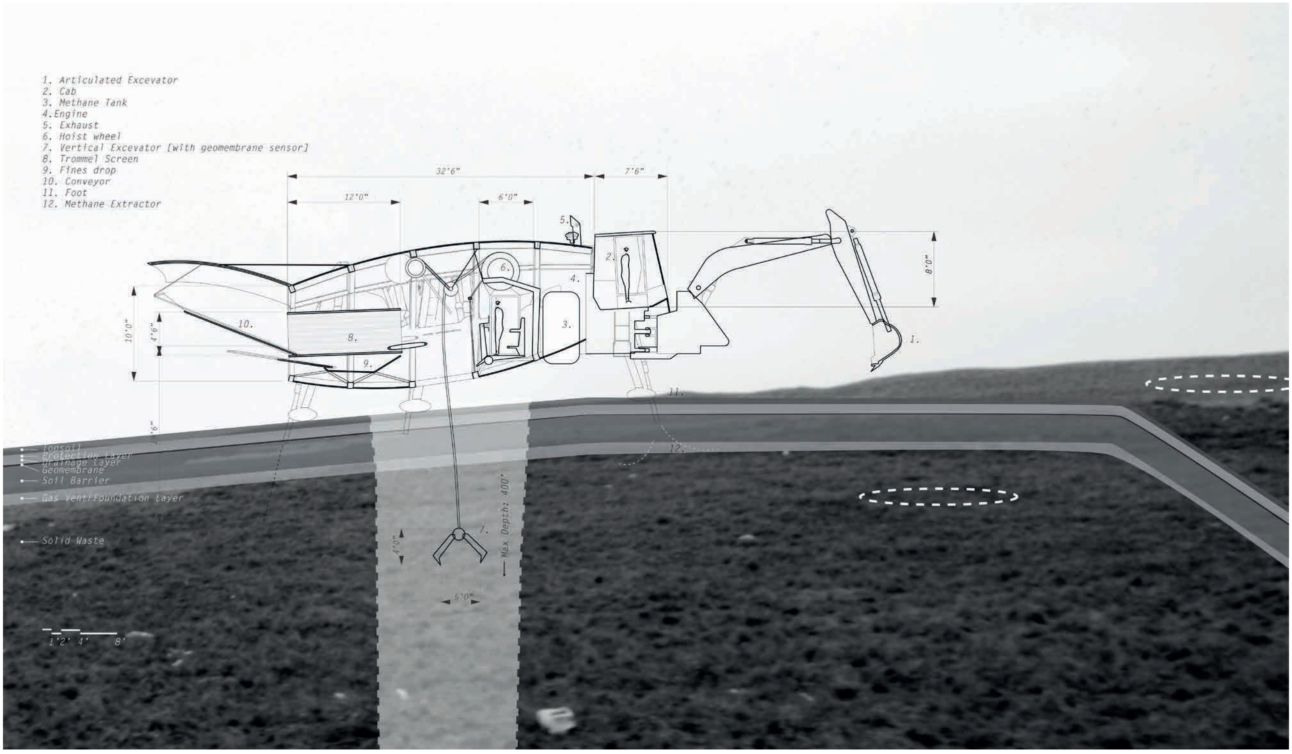

FIGURE 8: DRTE (Directed Robotic Trash Extractor).

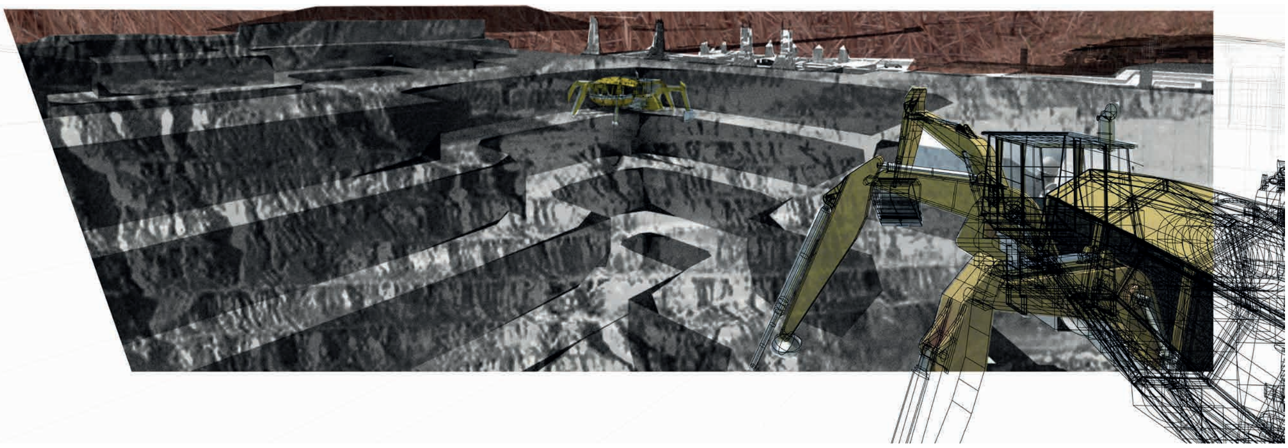

FIGURE 9: DRTE on the mound.

into the backlot. The Head-houses also serve as central locations for public interaction through an interpretive center featuring dynamic viewing experiences of the facility. Here, a convection chimney functions to suck smelly air from the recently exhumed material, generating electricity from a turbine when conditions allow, and moreover serves as a dramatic backdrop to the moment of revelation witnessed below (Figures 11, 12).

Workers stationed in the pit watch for materials specific to their operations, radioing back to their colleagues stationed along the line. The public is welcome at any time to view or participate in the experience. The structure predicts its own obsolescence, and therefore is designed for disassembly.

4.5 The line

Along the 250 m (800 ft) long conveyor-belt lines, lots are rented at rates based on proximity. Closer to the head-house, the higher the rent. Although nothing would prevent a single company from removal of all material on the belt, a significant cross section of material exists on each conveyor belt to warrant multiple interests served. Cree pulls aluminum and zinc for recycling into their LED heat-sinks, while the Glad company contracts workers and robotic armatures to capture spent plastic bag material; computer repair specialists collect E-waste, or an artist collective rents space as a testing ground for multi-media work. While typical sorting facilities of today will only sort what is economically productive to their networks, the line allows

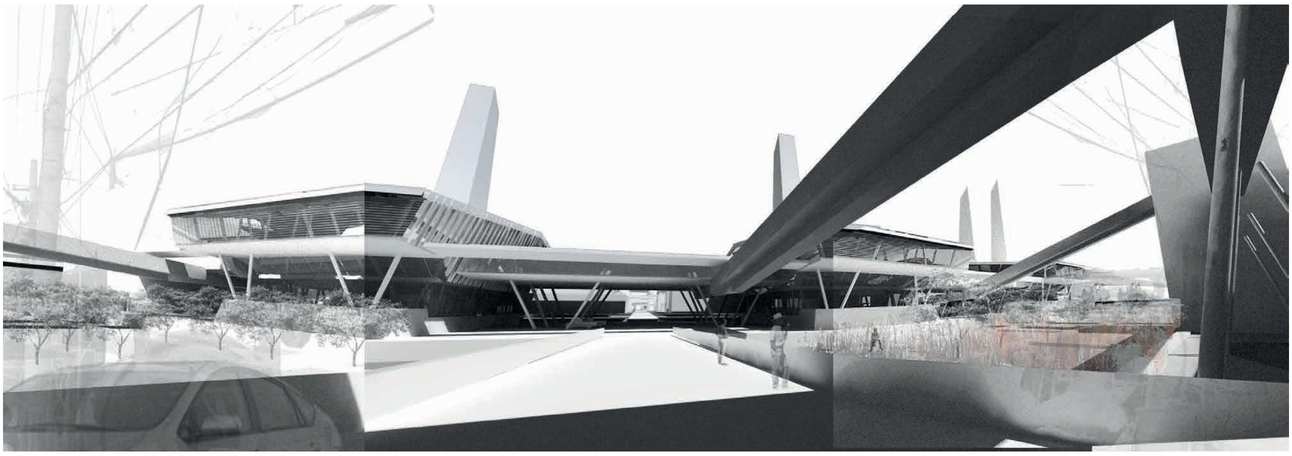

FIGURE 10: Power-remediation.

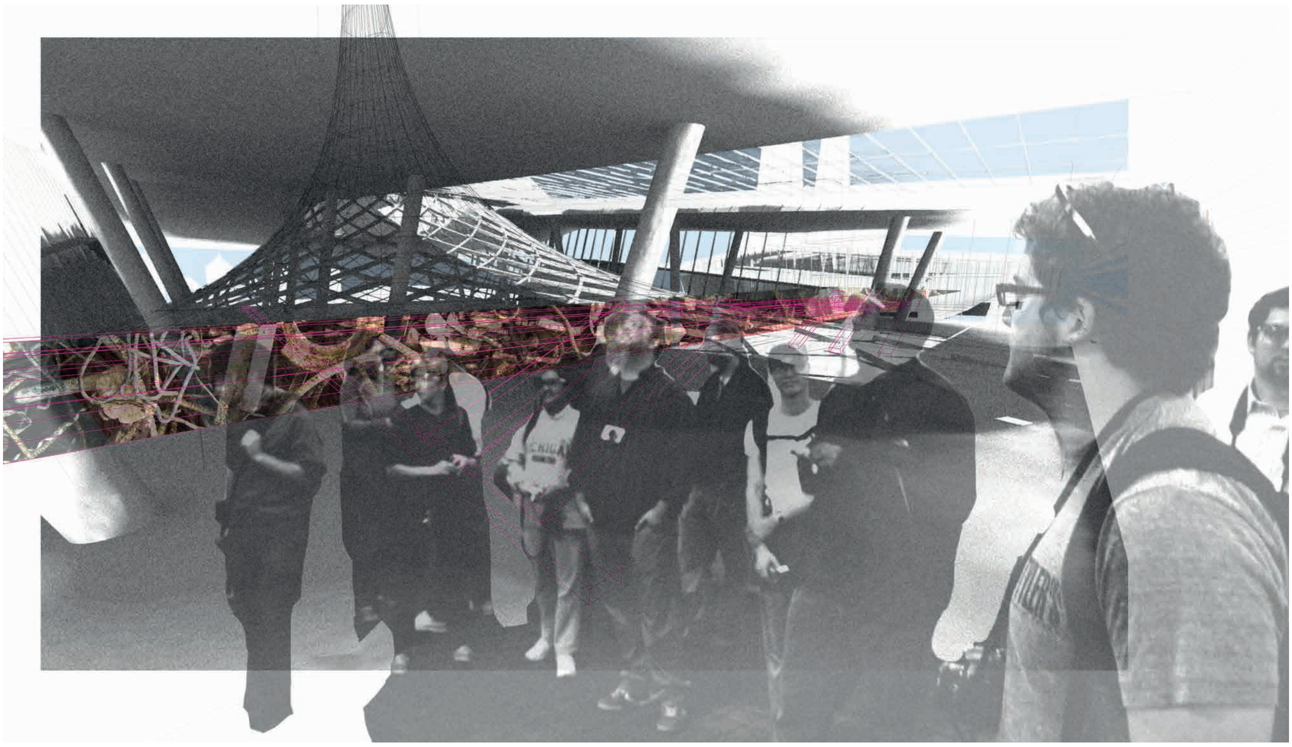

FIGURE 11: The headhouse.

any material to be productive again: rusty rebar, Styrofoam cups, or electric scissors (Figure 13).

4.6 The Backlot (Industrial market)

The backlot's zoning accommodates any configuration of structure within each 550 m^2 (6000 ft^2) lot - tenants may build any structure they wish within general guidelines to facilitate their own agenda, subdividing or accumulating additional lots as needed. As tenants move in, cross-pollination occurs. Independent harvesters may begin working together, creating new material networks and economies unavailable to traditional recycling practices (Figure 14).

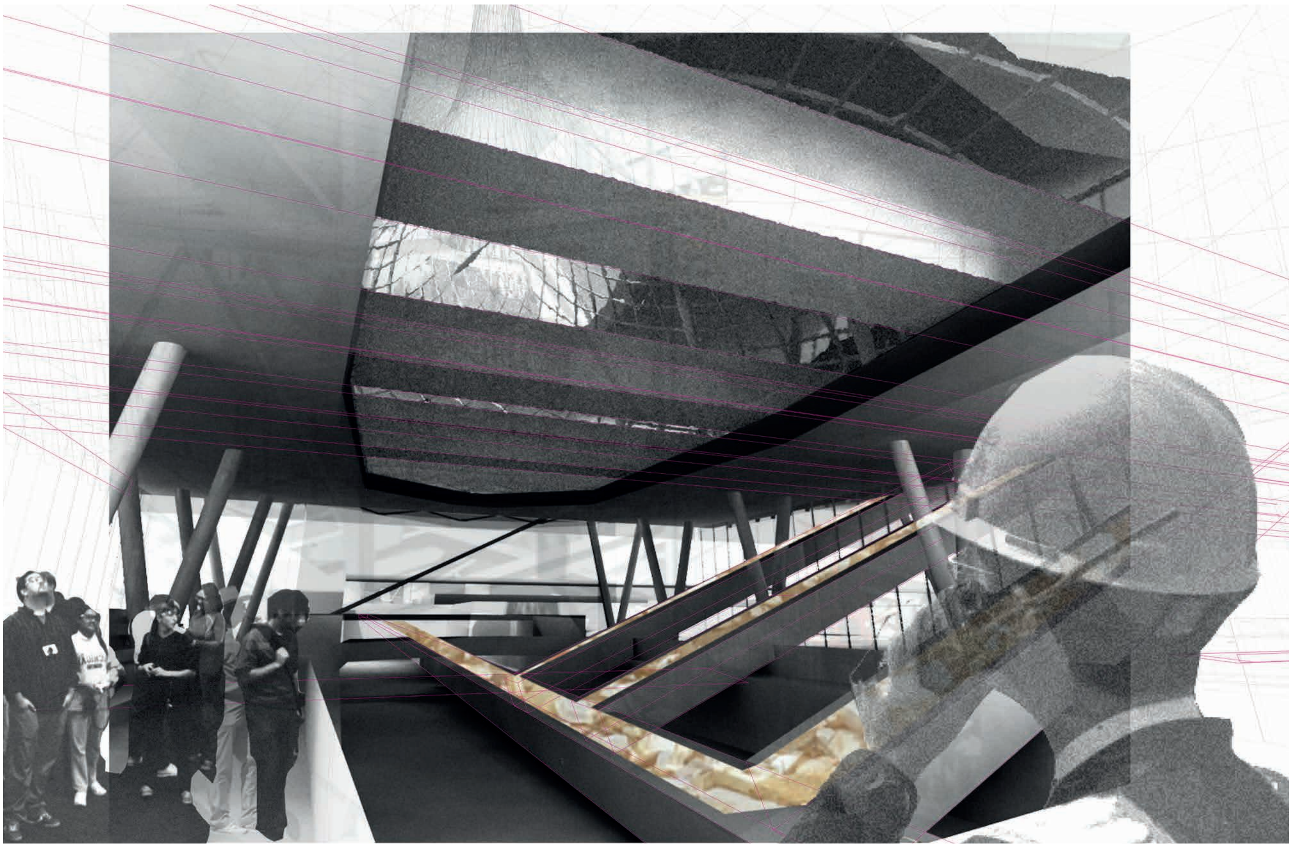

FIGURE 12: The pit.

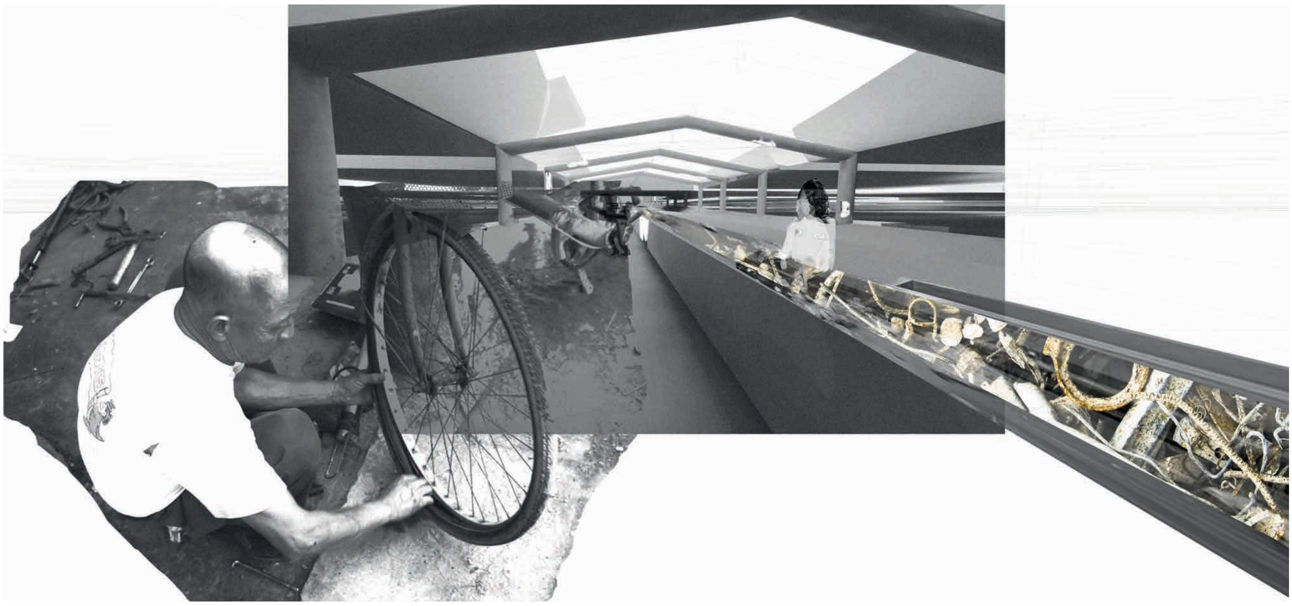

FIGURE 13: The line.

4.7 Export

Unclaimed material is either injected into the global supply lines to buyers via train or truck, or if the economy does not exist for particular materials, those materials may be re-deposited in the landfill for future extraction (Figure 15).

4.8 Dirt Farm

As a significant portion of the landfill consists of soil (generally used as daily cover), any reclaimed dirt may be remediated and sold to customers (Figure 16).

5. CONVEYOR-BELT INFRASTRUCTURE

The junkyard lacks apparent form - an underlying logic exists, but it does not present itself formally to the visitor, making accessibility of materials difficult. Conversely, the traditional recycling facility is logistics based but one-dimensional, seeking specific materials for specific destinations. The Sorted Project proposes that a third, hybrid solution may be the mechanism needed at this newly opened node in material flows.

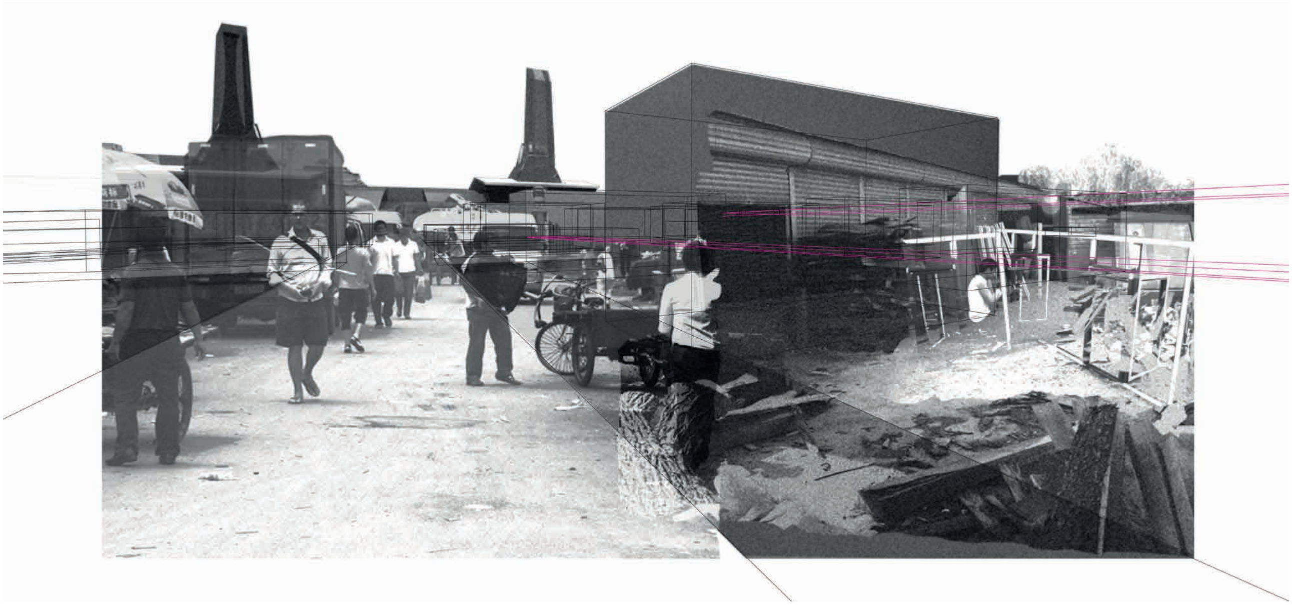

FIGURE 14: Backlot.

FIGURE 15: Export.

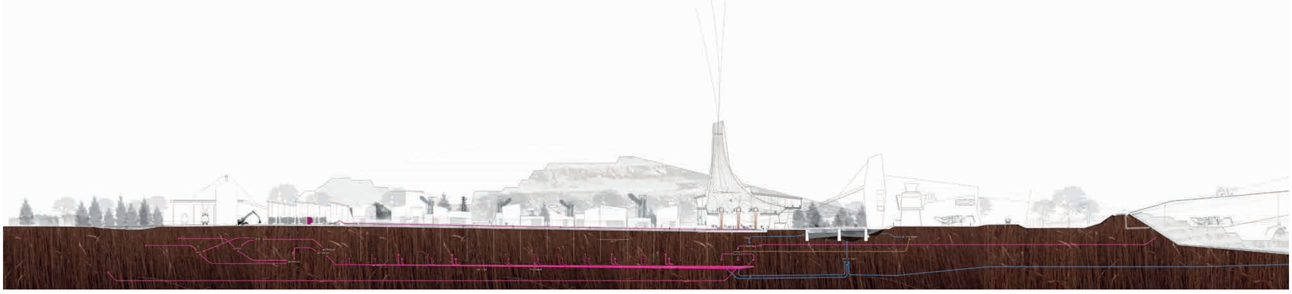

FIGURE 16: Site section.

An emergent market-based urbanism of reuse suggests that on-the-ground access to the flow is critical in fostering novel material industries. Adjacency could allow for disparate tenants to expand their networks in wholly unique and emergent ways, a phenomenon untenable in the Drosscape. As previously unproductive material finds meaning and purpose, a new economy emerges (Figure 17).

Beyond the scale of the site, the project suggests that re-territorialization of the regional urban ecology is imminent as new industrial, commercial, and agricultural spheres grow in the landfill's shadow, taking advantage of new opportunities. This intensification could adversely affect local residents of the area, as low-density residential development is not a productive adjacency. Rezoning (or un-zoning) of landfill adjacencies will be inevitable to facilitate this industrial ecology.

Projecting beyond the site of the landfill, Landfill Urbanism suggests potentials for pre-cycling. Instead of merely digging up the past, the urban and emergent sorting techniques presented could provide the needed filter to redirect material flows before the landfill. Sites and potentials for future work could include denser urban contexts, commercial/light industrial districts, transfer stations, and transportation hubs (Figure 18).

Although technological advancement will no doubt minimize the impacts of increased environmental degradation, alternatives (or augmentations) to existing social practices are critical to maintaining our way of life. Landfill Urbanism operates within today's reality that global capital drives contemporary urbanization, and is not seen as a long-term solution, nor does it seek to fix past wrongs. In a perfect world, we as a species would realize that completing the cycle is not a matter of choice, but a critical element of sustaining our very existence. In the meantime, and under the constraints of our current socio-economic reality, the project seeks to take advantage of every possible material and economic opportunity, and therefore is unforgiving in its operations. Yet it projects hope that through a reconditioning of our relationship to waste, the project's very existence will cease to be relevant at some sought-after moment in the future (Figure 19).

The problem of waste is deep - it's systemic. Landfill Urbanism realizes human nature for what it is; Blane Brownell notes that "Homo Sapiens is the only species that creates what may be truly considered waste." But the cat is out of the bag so to speak, regarding the convenience of that light-weight throw-away cat-caring plastic bag. We must, as a species realize that completing the cycle is not a matter of choice, a granola-crunching utopian manifestation, but a critical element of sustaining our very existence and civilization. Landfill Urbanism is not the long-term solution, nor does it seek to fix past wrongs. It is wholly opportunistic in operating in our current reality, and therefore it is parasitic in its deployment and unforgiving in its operations. Yet it projects hope that its very existence will cease to be relevant at some sought-after moment in the future. On the landscape of the landfill, entrepreneurs, corporations, artists and consumers are pitted against each other in the epic battle for control of energetic flow, where closing the cycle on material and energy flow is the key to power.

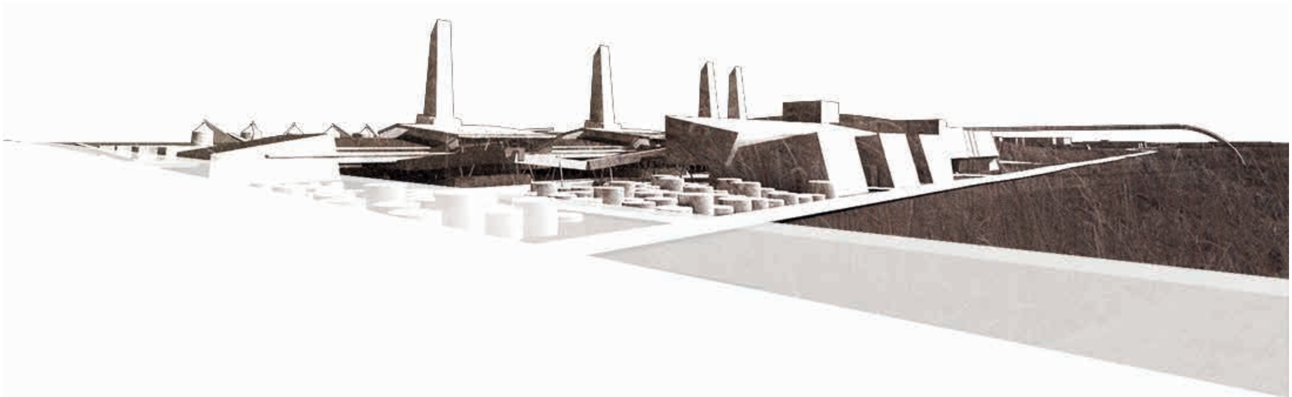

FIGURE 17: Freeway - I275North.

FIGURE 18: Phasing (continues in the next page).

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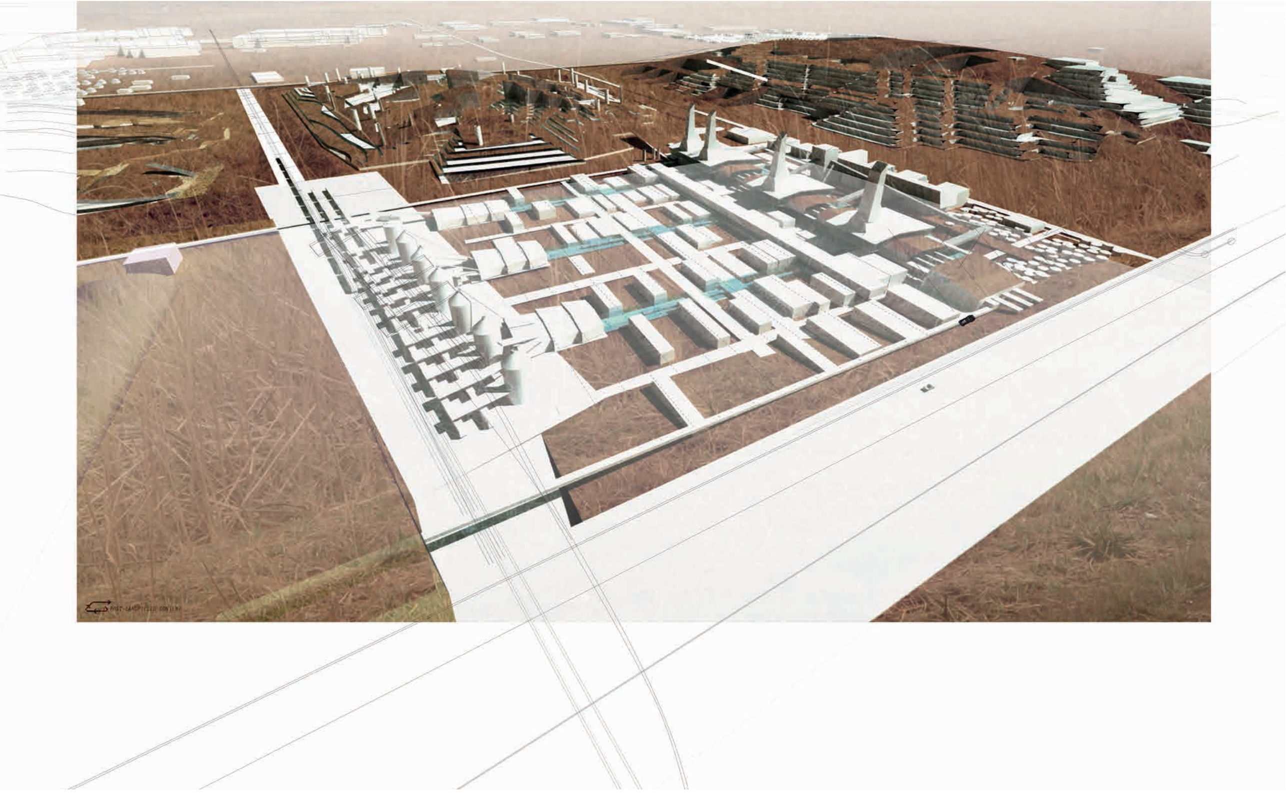

FIGURE 19: General view of the proposed project.

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SHORT SUPPLY CHAIN OF WASTE FLOWS: DESIGNING LOCAL NETWORKS FOR LANDSCAPE REGENERATION

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ABSTRACT
Creating a circular economy poses multiple challenges yet has social opportunity. It represents a key approach to implement the management of more sustainable waste flows to achieve win-win solutions consistent with the EU environment goals, and with the social-economic expectations. As part of the comprehensive outcomes of the EU funded research project REPAIR, the paper presents the results for new technological soils, designed with the aim of implementing the number of products coming from the recycling of both C&D waste and organic waste. The paper discusses the technical issues of this solution in the framework of the specific characteristic of its supply chain. The research aim is focused on the design approach, working on the new products and process at once. Further, the project highlights the importance of dedicated local networks for sharing knowledge in between different stakeholders and experts, and for promoting innovation at local scales.

1. INTRODUCTION

The paper presents several of the outcomes of the EU Horizon 2020 program - REPAiR (REsource Management in Peri-urban Areas). The project aligns with several initiatives of the European Commission oriented toward establishing circular economy processes by limiting resource consumption and waste disposal (EC, 2010; EC Horizon 2020, 2019; EEA European Environment Agency, 2015). The general aim of the project is reducing waste flows through a better use of secondary raw materials, especially focusing on Construction and Demolition Waste (CDW) and Organic Waste (OW). These categories are both included in the priority list identified by the EU Action Plan for Circular Economy (COM (2015) 614 final) due to their value-chains potentials and their environmental footprint. Further, C&D waste is the largest flow in the EU based on volume (EU Commission, 2018), while organic waste (namely bio-waste), is estimated at 180 kg/ pro capita/ per year (EU Parliament, 2015).

According to these insights, the specific aim of the research is to figure out new forms of circularity, addressing recycle and reuse of both C&D waste and bio-waste through the design of innovative processes, specially focusing on the opportunities of implementing collaborative design practices. The paper presents the results of the DiARC research team, stressing the concern of short supply-chain and local networks as key strategies for promoting recycle and reuse at local scales. Despite the fact that the recycling operations for C&D waste and bio-waste are not complex (due to they both work on well established technologies), the management of their supply-chain is quite hard because it includes the collaborations of manifold subjects; the compliance of strict regulatory standards, and it provides low economic returns. Additionally, the major challenge in reducing waste flows is the systemic approach to the design process, embedding economic issues, social habits and technological responses into planning (EU, 2013).

This research also assumes that the transition toward more sustainable waste management is not only a technical matter but it depends on creative visions by which breaking the circuit "take-make-dispose", and promoting design solutions for implementing circularity locally, stressing the concept of a 0KM supply-chain. Research background concerns two main fileds of interests: 1) planning approach, by which it is possible to integrate the goals of waste reduction into the comprehensive territorial strategy, especially focuses on the regeneration of peri-urban areas; and 2) the design of artificial soils, as Eco-Innovative Solutions (EIS) aimed at both producing ecosystem services and new public spaces (Rigillo et al., 2018). These solutions will potentially lead to the modification of existing waste flows, reducing the impacts coming from transport (mainly economic), and implementing the recycling of raw materials into new flows and processes. Moreover, the artificial soils are designed for being part of new green-infrastructures in the peri-urban area, producing original landmarks for these areas often under-used, abandoned and/ or polluted.

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As part of the research assumption, the paper posits short supply chain as prime condition to re-think waste management as site specific and eco-innovative process, facilitating circular economies locally, and offering benefits for local inhabitants and stakeholders. Short supply chain can reduce current costs and the impacts related to waste transport; it improves the awareness of local communities about the potential value of wastes, and strengthens the importance of user's habits in separating household waste (Berruti, Palestino 2017). The research devises a set of "overlapping networks" (Figure 1) as collaborative strategy for developing co-design experience, merging different competences and expertise into dedicated Living Labs. The networks focus on the goal of shortening waste supply chain locally through the proposal of a new recycled product (techno-soil) made by the combining of construction debris and compost. Further the different Labs validated the latter in operational and regulatory terms, and spent their expertise for designing the new peri-urban landscapes (namely green infrastructure and new public spaces). Techno-soils have been here interpreted as innovative resources thanks to the implementation of more inclusive design approach, decoupling economic growth from resource consumption and environmental depletion (UNEP, 2011).

2. STEPS IN METHODS

2.1 Case study area

REPAiR focuses on peri-urban areas, intended as territories characterised by a mix of dispersed urbanised and rural areas, interlinked with infrastructures, agriculture and natural patches (Formato, Amenta & Attademo, 2017). The Italian case study is the Metropolitan Area of Naples. It includes 92 municipalities on a total area of 1.171 km, inhabited by 3.117 million people. In this area, between 1994 and 2009, the Regional Waste Emergency, and the newest phenomenon of the so-called "Land of Fires" increased the environmental risk from soil pollution (Berruti & Palestino, 2019). These crises depend on both the government inabilities and on the poor governance of waste management (REPAiR, 2017). Acting as a driver for further improper land uses and for out-of-control activities, the waste emergencies contributed to turning open spaces and agricultural plots into abandoned and neglected landscapes (Berruti & Palestino, 2017). In this context, circularity represents a key challenge for designing a waste supply-chain capable of improving job creation and fostering social acceptance locally.

Whithin the Metropolitan Area of Naples, the research defined a Sample Area (Figure 2). Such identification has

FIGURE 1: Overlapping networks (UNINA graphics).

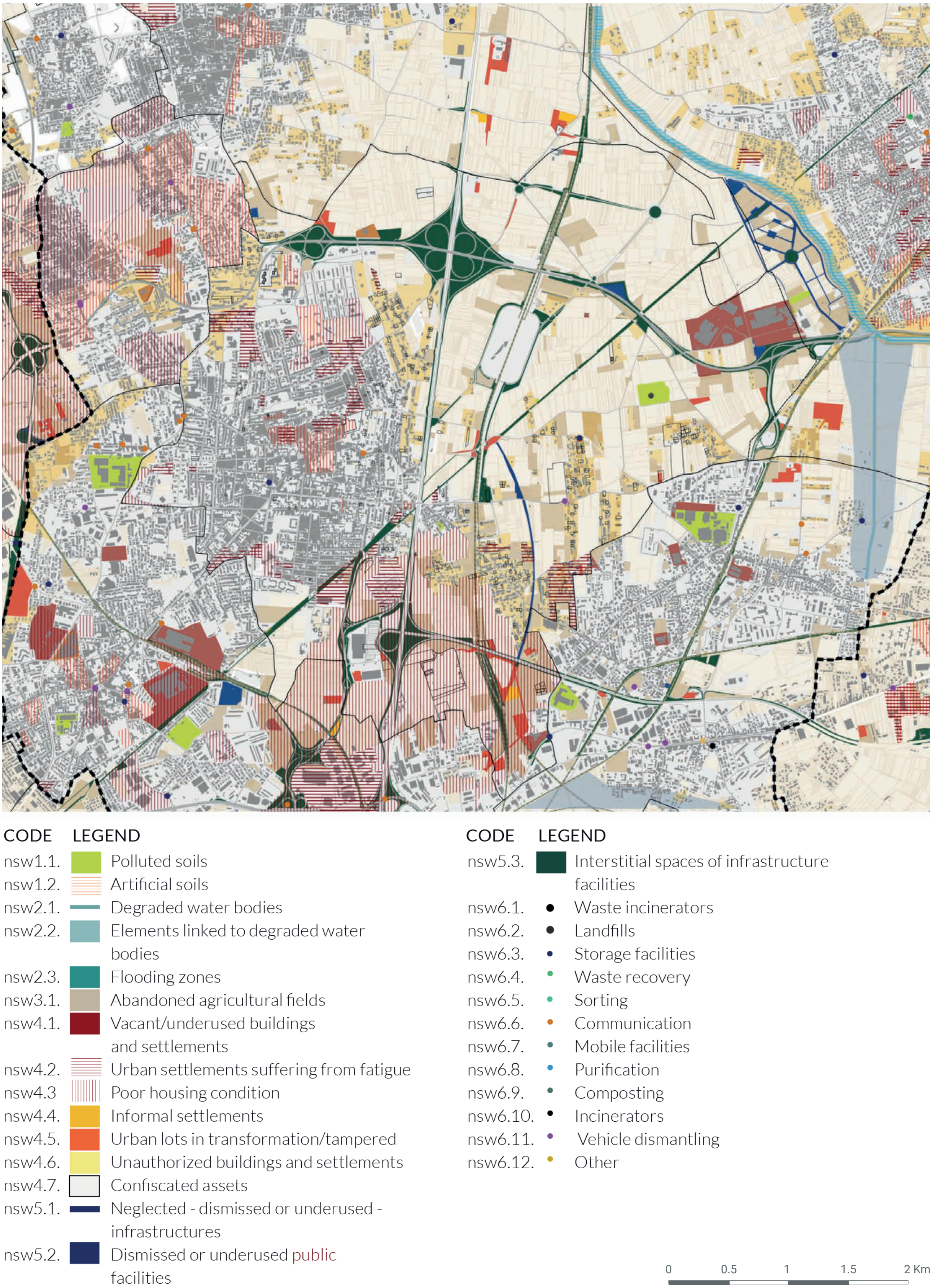


FIGURE 2: Case study area (UNINA graphics).

been made based on the activities of the PULLs, and it aims at defining a smaller area featured by the same physical, socio-ecological and administrative characteristics that describe the entire Metropolitan Area of Naples.

2.2 Definitions adopted

2.2.1 Eco-innovation

The starting point of the study has been the EU definition of eco-innovation as both technological and non-technological innovation «that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimising the use of resources […] It encourages a shift among manufacturing firms from "end-of-pipe" solutions to "closed-loop" approaches […] by changing products and production methods – bringing a competitive advantage across many businesses and sectors» (EC, 2014). Such definition stresses the need for achieving a comprehensive approach to innovation, putting in evidence the request of win-win solutions able at improving environmental efficiency as well as social and economic investments. In order to do this, the research defines Eco-Innovative Solution as «elementary responses to case-specific problems, in a contextual approach towards innovation, where the real innovation is the process to achieve the result» (REPAiR, 2018).

2.2.2 Circular Economy

The study refers to the definition of a circular economy as «an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, […] and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models» (Ellen MacArthur Foundation, 2013, p.7). Such definition looks at a quantitative reduction of waste flows according to territorial and socio-economical interfaces. Hence, it refers to the business model as a not-neutral tool for oriented regenerative and/or restorative processes, thus shifting the concept of circularity from the single field of the environmental care to that of industrial and social innovation.

In the framework of the REPAIR research, the principles of circular economy are mainly referred to design waste supply chain featured by being adapted to the local productive context and to the social practices. Further, this research posits short waste supply chain as a key goal, both in order to identify technical and social constraints locally, and overcome the typical CE model, focused on resource-reduction approach (Ellen MacArthur Foundation, 2015). The research works on the circular reuse of wasted materials (CDW and OW) through a systemic planning approach, designing the waste supply chain as a technical and economic opportunity for the regeneration of peri-urban landscapes, especially those abandoned or polluted (Formato, Attademo, & Amenta, 2017).

2.3 Designing innovative strategies

2.3.1 Waste flows analysis

The research approach starts from the analysis of waste flows (C&D waste and organic waste) within the case study area by the aim of detailing their life cycle assessment (LCA), and of spatializing their flows at local and national scale. Data collecting was made thanks to the data source of Regione Campania, and according to the constraints of the Geodesign Decision Support Environment (GDSE) model, that is part of the REPAIR innovative approach to planning. GDSE is a web-based open-source tool that adapts the geodesign framework for the purpose of spatial diagnosis and elaborates scenarios about the application of systemic eco-innovative strategies to territories (Arciniegas et al., 2019). Thanks to the GDSE tool, we visualize the different typologies of C&D waste flows and the organic flows within Italy, specializing the relationship between the waste production sites and their destination inside and outside Campania Region (Figure 3).

Waste flows analysis shows most of both C&D and organic waste flows directed out of the Region. Such resultants are consistent with the fact that few treatment plants work in the study area, but above all, it reflects the social difficulty to accept the construction of new ones. With regard to the technical constraints, the main barrier in recycling organic waste is the lack of efficiency in the household refuse selection - mainly dependent on the final user's skills. The lack of user's ability in waste selection produces low quality material, not consistent with the requirements for returning recycled organic substances (namely compost) in the biological cicle. Similarly, the deficiency of guidelines and protocols for facilitating building demolition, places construction debris into the "special waste" list, due to the pollutants potentially embedded in (Codice dell'Ambiente, d.lgs n.152/ 2006); further, the cost of a waste audit, together with the difficulties to re-introduce debris into the construction supply-chain as secondary raw material, reduce the opportunities for recycling and reusing C&D waste. In addition, the special condition of the case study area, affected by both poor social context and informal/ illegal activities, makes the control of the debris disposal very hard, so that the unauthorized dumping is recognized as a public emergency in the area.

2.3.2 Innovative design process: collaborative networks for devising waste supply chain

With the aim of integrating waste reduction goals into peri-urban planning, the research provides a collaborative design process for making waste supply-chain part of the future territorial development. The research develops a proper method for involving stakeholders into the project, designing collaborative networks for enhancing co-design within a panel of experts and beneficiaries, both acting in the context of the case study area. In order to do this, a number of Peri-Urban Living Labs (named PULLs) (REPAiR 2018) were planned since the beginning of the project in 2016. They are aimed at facilitating knowledge transfer through different subjects and different goals, according to the Lab participants specific. The results of the different Labs were discussed within all the subjects involved, adopting the process of the "overlapping networks". The latter was designed as dedicated Labs, where both expert and not-expert subjects can merge their different competences. The purpose of these networks is to collaborate

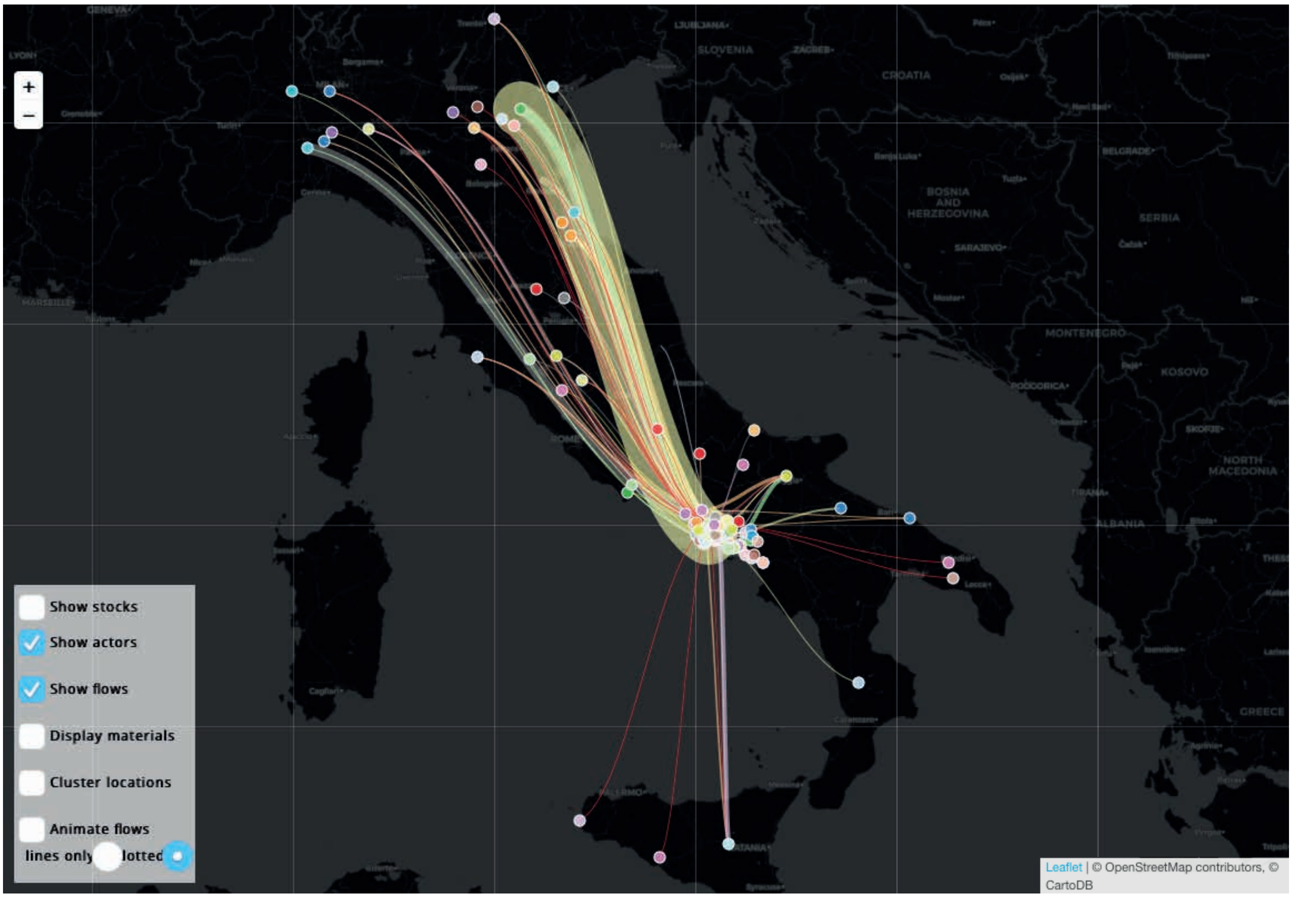


FIGURE 3: Existing organic waste flows in the case study area (UNINA graphics).

in devising proposals for shortening the C&D waste and organic waste supply chains, enhancing the many points of view, and the specific knowledge about the site-specific potentials and constraints. Such method merges together the goals of co-designing and validating new products (techno-soils). A further focus was given to the proposal of using techno-soils for planning new green infrastructure and public spaces in the peri-urban area. Techno-soils have been here interpreted as innovative resources to be reused thanks to the implementation of more sustainable, inclusive and circular waste metabolisms, decoupling economic growth from resource consumption and environmental depletion (UNEP, 2011).

The strategy adopted aims at streamlining the main criticalities affected the waste flows management and discussing effective solutions for reducing waste[1]. The research identifies the following steps:

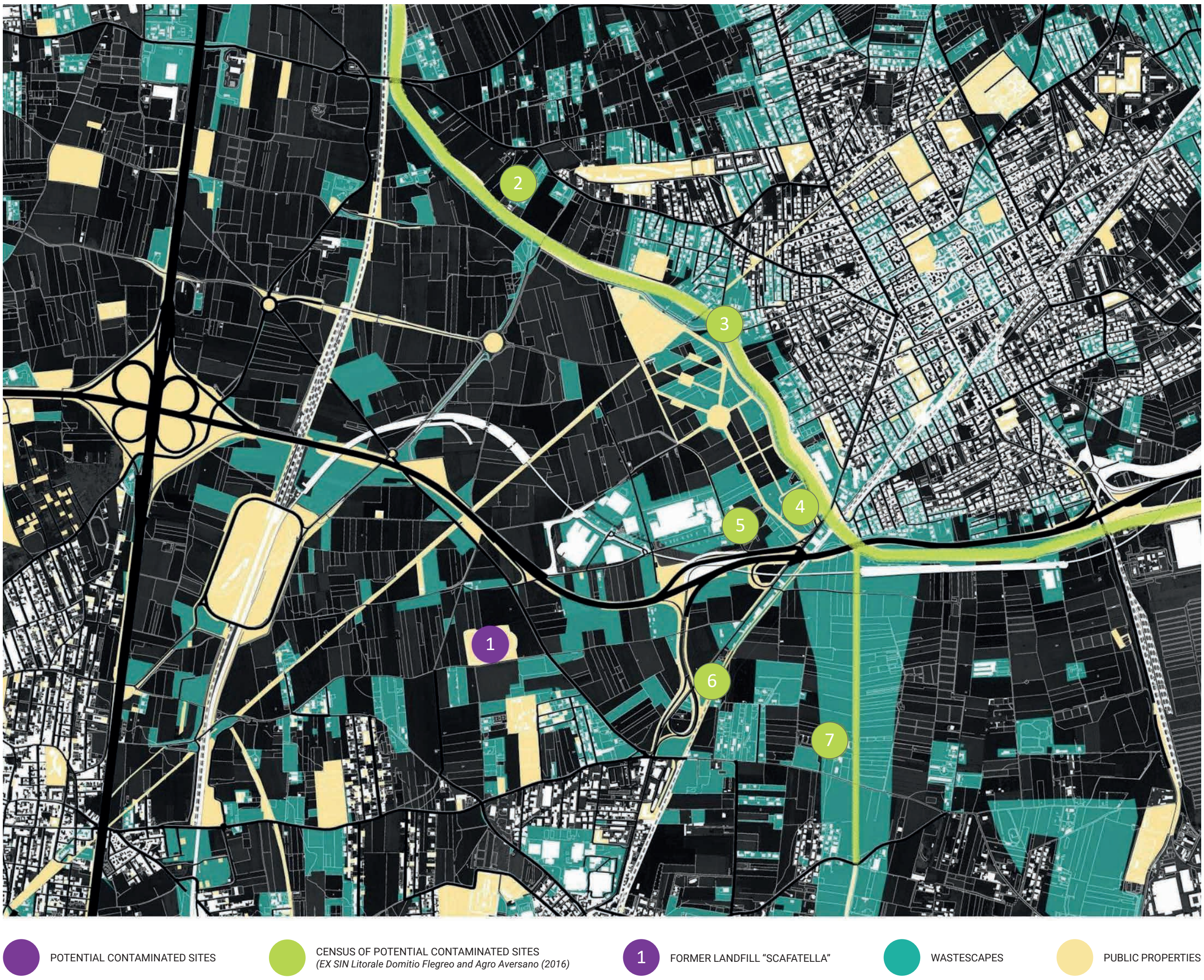
a. Recognizing wastescapes in the case study area;
b. Providing potentials scenarios for improving 0KM supply-chain for C&D waste and Organic Waste;
c. Producing a comprehensive master plan for both improving peri-urban environment and waste management.

Participants co-created several GIS-based maps of the case study area, in which the layers of spatial information were overlapped to those related of the wastescape perceptions, and discussed (Figure 4). Such methodology implements the comprehensive understanding of peri-urban area, and improves the site description with both the overlay of thematic maps (based on the official data-sources) and further layers, coming from bottom-up information. Description is here considered as the main conceptual tool for catching the inner characteristics of the place. Therefore, information coming from the Repair Labs supports the mapping process in recognizing abandoned and neglected areas in the Sample Area, and producing a new understanding about planning opportunities (Figure 5).

According to the advances produced, the co-design process provided three eco-innovative solutions aimed at creating a tentative frame of action for implementing waste management (Rigillo et al., 2018). Starting by the waste flows analysis (C&D Waste and Organic waste) the research groups developed the spatial proposal for waste supply-chain into the sample areas, promoting different potential scenarios (Russo et al., 2019). Each proposal takes advantages from the skilled views of the Peri-Urban Living Labs (PULL) participants, and from the opportunity of depicting criticalities at a local scale.

Therefore, the research introduces a Master Plan for waste reduction (Figure 5), running on the following points:

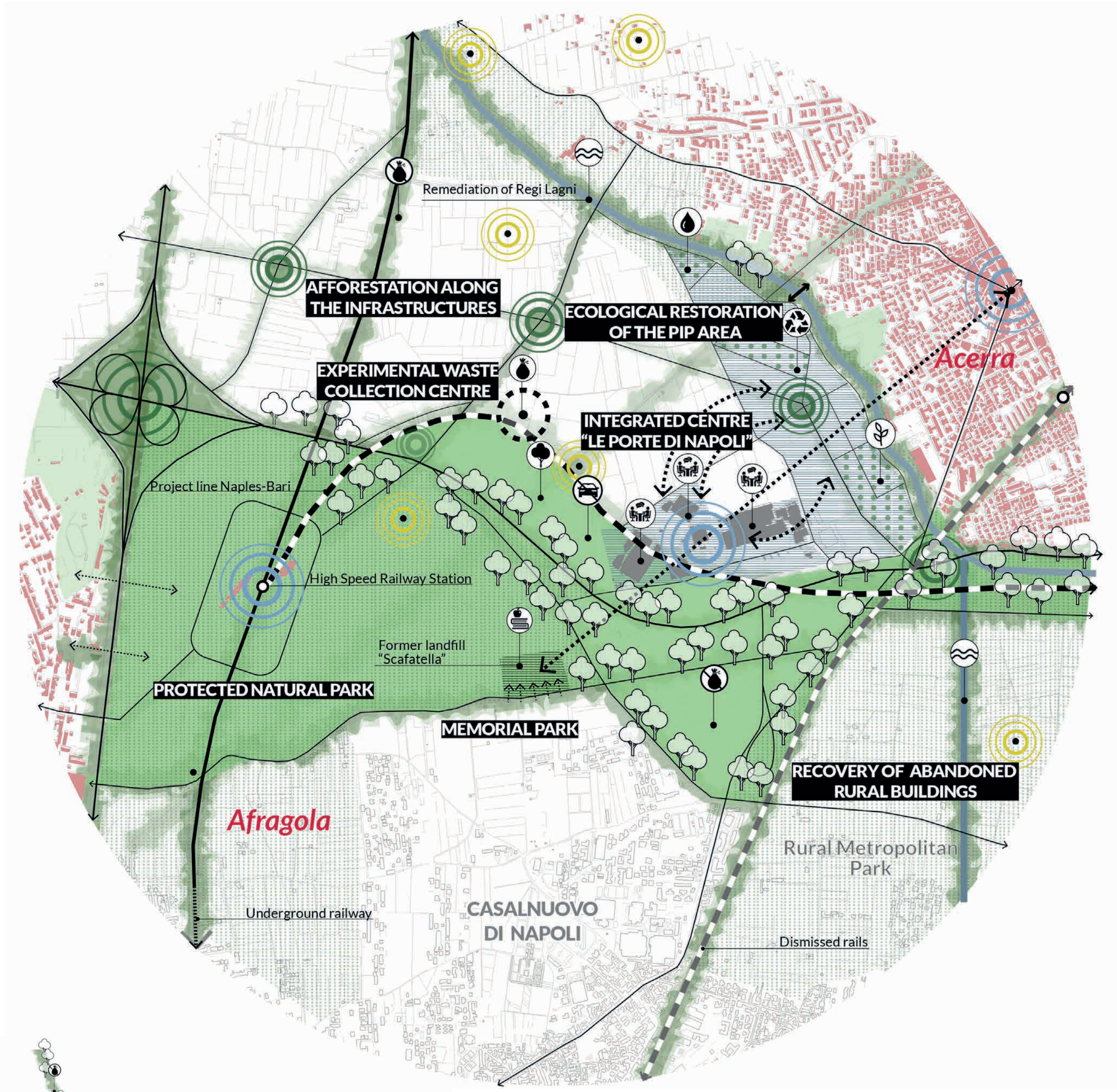
1. Free C&D waste disposal sites, aimed at intercepting those construction and demolition waste that could not otherwise be transferred to the recycling sites (i.e. de-



	Name	Code	Address	Municipality	Province	Property	Tipology of site	Contaminated matrix	Pollutants	Process 2016	Activity	Area	coord. X	coord. Y
2	Pellini Srl	3001A504	Via Tappia, 35	Acerra	NA	Private	Waste treatment plant				Waste treatment plant	0	444986	4533208
	Zito recupero Plastica Sas	3001A520	Via Volturno, 61	Acerra	NA	Private	Waste treatment plant			Approved Characterisation Plan	Waste treatment plant	4754	445042	4533174
	Ecotrasporti	3001A549	Via Volturno, 61	Acerra	NA	Private	Productive activity				Productive activity	0	445051	4533180
3	Regi Lagni	1506A001	Regi lagni	Regional site	-----	Pubblic	Surface water	Soil/Surface and groundwater	Dioxin and Furans, Metals, PCB, IPA, Hydrocarbons, Pesticides, Carcinoges chlorinated aliphatic	Implemented characterisation plan	Other	0	0	0
4	Sommarco Salvatore	3001A513	Corso Italia, 91	Acerra	NA	Private	Productive activity				Productive activity	0	446439	4531619
5	Ex F. lli Costa	3001A536	Loc. Marchese	Acerra	NA	Private	Dismissed activity				Productive activity	0	446148	4531566
6	P.V.C. Agip - ENI N. IT59353	3001A528	Via Benevento	Acerra	NA	Private	Fuel service station				Fuel service station	0	446036	4530910
	Terracciano Sabato	3001A545	Contrada Area di Settembre	Acerra	NA	Private	Productive activity				Productive activity	0	446579	4530500
7	Leonardo Spa (Ex Alenia Aeronautica Spa)	3057A511	Viale dell'Aero-nautica	Pomigliano d'Arco	NA	Private	Productive activity	Soil/ Groundwater	Metals, Cartinogens chlorinated aliphatic	Implemented Risk Analysis, Monitoring Groundwater	Productive activity	392520	448573	4529594

FIGURE 4: Existing organic waste flows in the case study area (UNINA graphics).

bris from small household works, done without administrative requirements or executed by poor construction companies);
2. C&D waste recycling sites (disassembling, reuse and zero-km selling), aimed at extending the life cycle of construction products and materials;
3. Inclusion of organic waste disposal sites into public and private spaces (and roads), aimed at promoting friendly-users waste collection sites in streets and household condominiums;
4. Design of treatment plants for recycling of organic waste. The aim is to avoid the concentration of big treating plants into hyper-specialized spaces, for facilitating social acceptance, merging new sustainable public spaces with operational infrastructures of waste;



1. Afforestation along the road infrastructures: linear afforestation along the existing and scheduled infrastructures recovering CDW on new railway shipyard using compost as new and desertified soils improver along the infrastructures.

2. Protected natural reserve: creation of a protected natural park; vehicular traffic restrictions; delimiting of a natural "border" to define the perimeter of the park.

3. Experimental recycling point: creation of an experimental waste collection centre in the abandoned parking along the Asse Mediano infrastructure; selection and first treatment of waste by a "Km0" recycling plant located on an adjacent wastescape; installation of electricity production technologies from kinetic energy generated by vehicles.

4. Ecological re-functioning of the productive area (PIP area): reuse of the Acerra PIP area with environmental and ecological purposes; wetlands to reclaim the water of Regi Lagni and allocation of compatible productive functions connected with the shopping centre.

0 0.5 1 1.5 Km

5. Memorial Park: creation of a "local memory" park in the locality of Scafatella (former landfill and Church).

6. Densification of functions around the shopping mall areas (Le Porte di Napoli): functional and settlement densification into the shopping centre area and trade qualification using the presence of the high speed railway station.

7. Recovering of the abandoned rural buildings and reuse of the public facilities; develop of widespread accommodation.

FIGURE 5: Proposed masterplan: New lands strategy (Graphics UNINA TEAM 2018).

5. Locating new eco-districts and green infrastructures within the Master Plan, aimed at placing soil production into the waste supply-chain, so that new artificial soils could represent an effective, response within landscape re-development operations.

2.3.3 Innovative products: designing artificial soils

The design of artificial soils, thanks to the reuse of construction debris, is aimed at implementing the products typologies coming from C&D waste recycle. New technological soils are part of the proposal of green peri-urban infrastructure targeted at providing ecosystem services and at raising the level of the existing living conditions. The proposal refers to the typically War World II bombing debris management, where C&D waste was used as hard soils, while excavated soils as well as composting of organic waste treatment will be combined for realized top soils (Figure 6). These new soils will be seeded by pioneer plants such as the Arundo Donax and other local species. Arundo Donax, especially, has been selected because its soil remediation capacity (Kennenk & Kirkwood 2015; Bonfante et al. 2017).

The research focused on techno-soils for implementing “green-infrastructure” and “new soils” as models for testing a sort of “new recycled product”. The study especially deepens the opportunities of new green border-belts, as a sort of "green-grey infrastructure" along the existing motorways, which can also host areas of C&D waste collection, and first treatment areas of post-construction waste (Figure 7).

3. DISCUSSION

Co-design is more than simply sharing of and transacting on resources, risk and reward. It refers to specific culture both about technical tools and social innovation (Manzini, 2015). It is about integrating across different value nodes throughout the ecosystem and thereby creating new markets and more effective business models, which wouldn’t exist otherwise (EU 2016). Hence, the renewing of the existing behaviours and patterns (technological, socio-political, environmental and economic) represent a key target for implementing circularity. Especially, circularity has to merge collaborative processes to produce increasing consciousness, and many types of responses according to different contexts and categories:

- Products-related innovation, as the so-called eco-innovative solutions (including techno-solis), to implement circularity;
- Process-oriented innovation, as the development of new decision-making models, collaboratively building interactions and connections within un-expected actors;
- Services-proactive innovation, as the ultimate goal is the mixing between competences and opportunities, in order to increase circularity feasibility.

Circularity is an urgency for urban planners and decision makers. The design experience produced by Naples research group starts from local scale analysis, looking at the site-specific problems/ objectives/ priorities for pro-

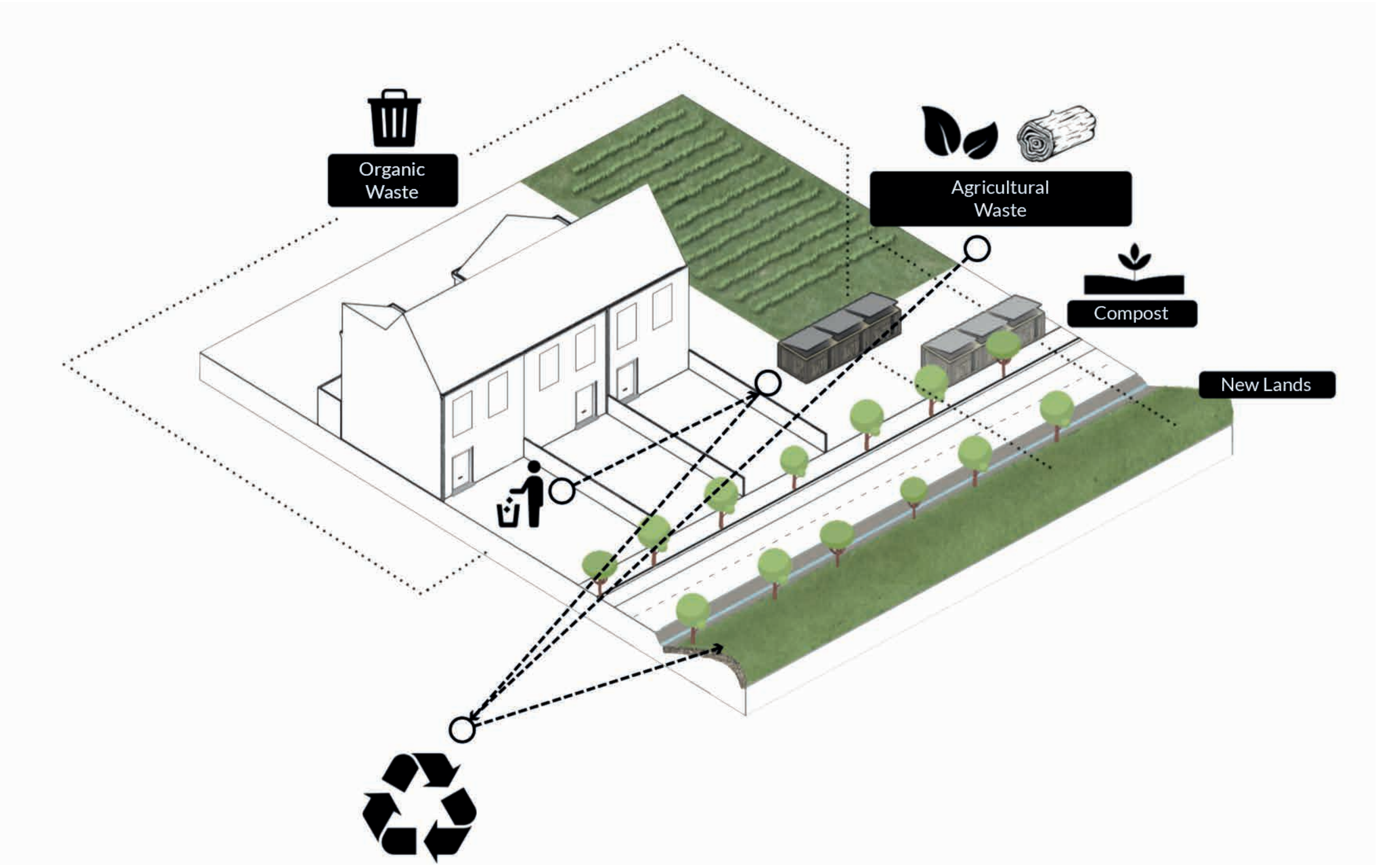


FIGURE 6: C&D Waste recycle process (Graphics UNINA TEAM 2018).

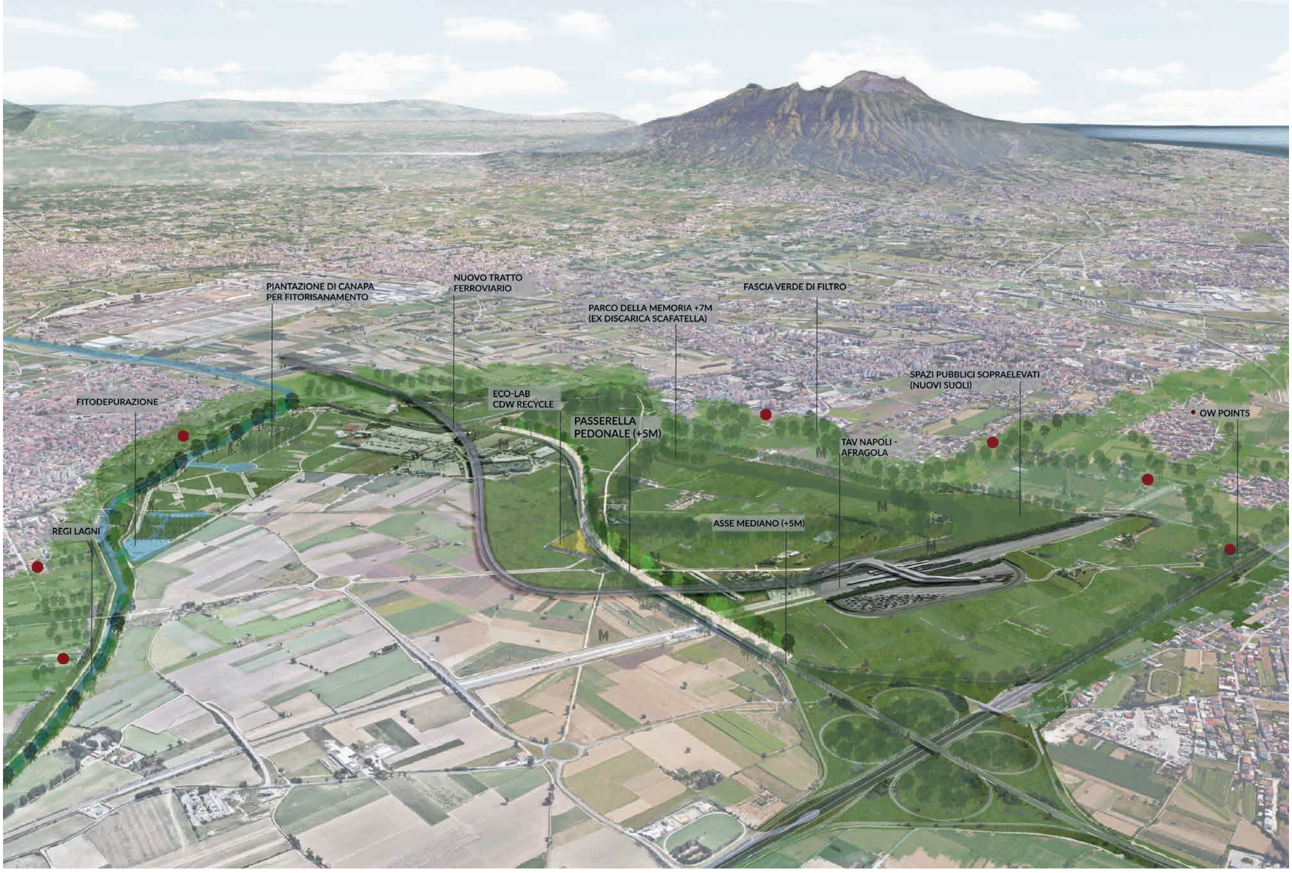


FIGURE 7: Peri-urban green infrastructure (Graphics UNINA TEAM 2018).

ducing simple and transferable solutions. In this case, the mapping activity is crucial for reaching a common awareness of peri-urban problems, and for recognizing opportunities and criticalities at local scales. Further, circular and multi-scale processes generate effective proposals for short supply-chain based on the local capacities of actors and stakeholders, enhancing embedded skills and visions. In addition, the analysis of waste flows together with the map of existing wastescapes provided an operational framework to apply innovative strategies and technologies to facilitate a sustainable transition towards better territorial conditions of welfare, liveability, and cooperation around stakeholders.

In order to do this, PULLs achieved a common understanding that there is no real empowerment of stakeholders without the availability to put themselves at stake and to take action in the process. Within this research, stakeholders' participation has been considerd the precondition for co-creation of solutions capable of activating circularity and change models.

Further, the Living Labs (LLs) philosophy is in line with the shift from a product-oriented economy towards a service-oriented economy. LLs rely on Public-Private-People-Partnerships (PPPP), as citizens and local associations are considered as an important source of knowledge and experience for the innovation process (Innovation Alcotra, 2013). This collaborative approach among actors defines specific "enabling conditions", supporting the identification of operative tools and facilitating decision-making processes.

The combine C&D waste and organic waste into new artificial soils represented a low-cost opportunity to activate an incremental decision-making process capable of designing operational models for circular economy applied to both the selected waste typologies and peri-urban landscapes. The loop of decision-making process becomes an action of legitimacy for its achievements, as well as positive feedback which builds trust among the participants, while wicked problems can be driven out through new collaborative and cooperative processes.

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AUTHORSHIP

Marina Rigillo and Enrico Formato conceived the presented idea. Enrico Formato developed the theory on wastescape mapping and performed the GIS-Based maps. Marina Rigillo developed the theory on recycling C&D waste as techno-soils and the short supply-chain as co-design outcomes. Michelangelo Russo supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

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[1] The main problems/challenges identified in the overall process are:

- Campania waste emergency;
- Criminal economy competing with the public waste management;
- Transition from Province to Metropolitan City with the consequent ongoing change;
- Institutional difficulties of overcoming sectors in order to co-design policies;
- Lack of shared knowledge between the sectors and towards citizens;
- Mistrust of citizens towards public institutions;
- Suspicion on the proposals of reusing waste;
- Proliferation of wastelands and wastescapes (D5.3 Eco-Innovative Solutions Naples).

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CISA

BAMBOO STADIUM. THE ARCHITECTURAL REHABILITATION OF THE FORMER OLUSOSUN LANDFILL, LAGOS (NIGERIA)

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ABSTRACT

With an ongoing growing population of around 21 million people, Lagos, the capital of Nigeria, struggles not only with how to deal with its waste but with garbage sent illegally mostly from the United States and Europe. The former Olusosun landfill, the largest waste dump in Africa and one of the largest in the world, used to receive about 3,000 to 5,000 tons of trash per day, filling the dumpsite almost to its near capacity. After the local government decided to close the landfill, the city has started to search for solutions to rehabilitate the site. In an effort to include an anchor program, the stadium becomes the natural meeting point for the neighborhood: an evolutive, flexible and transformable infinite bamboo based-unit structure. In response to new much-needed regards towards waste, bamboo resources seeded on the site become the local building material. A mix of social spaces, dedicated to enjoying the sport on game days, as well as dwellings and local public programs to be occupied all year by the local community, blend in a small-scale system. Finally, the aggregation can grow in each direction to meet all needs of various situations, with potential multiplication of the system at the scale of the neighborhood or city.

1. INTRODUCTION

> *"By 2025, […], the waste produced by cities around the globe will be enough to fill a line of rubbish trucks 3,100 miles long every day."*
>
> *The World Bank, 2019*

Today, all urban areas have one big thing in common: the global issue of waste. Every year, our world produces more than a billion tons of garbage, which it incinerates, buries, exports and, not enough, recycles (Sieff, 2017). While the major cities continue to expand at a preposterous rate, so must their capacity and ability to reverse wasteful habits and begin adopting a more efficient and sustainable lifestyle. It is expected that approximately 70% of the world population will live in cities by 2050 (The World Bank, 2019). As a result, we all need to start taking into consideration alternative design and development models to allow the emergence of sustainable programs and, in effect, cities, and territories.

Lagos, the Nigerian megalopolis, is estimated by some to represent the fastest-growing metropolis in the world, with a rate of enlargement from a population of 7 million to over 21 million in the past decades. Until recently, there was a seemingly easy fix and Lagos handled its waste by relocation, being simple enough to drive waste outside of town to the 100-acre Olusosun dump site, beginning in 1992. Though the landfill was once far from any urban activity and direct human interaction, the site has somehow become the heart of the neighborhood, raising numerous issues, while starting to become a lifestyle for the local community (England, 2017; The World Bank, 2018). Educational, residential, industrial, medical institutions and religious buildings now circle the site (Sieff, 2017).

Earlier last year, the Olusosun landfill was finally shut down by the local government, after a fire has broken out in March 2018 (Ugbodaga, 2018), and the site was assigned for redevelopment as a public park and urban green area.

In this phase, the approach of the project should encompass an anchor program that merges new attitudes relating to waste. Waste is not defined only by its presence inside landfills or hidden alleyways. Instead, it penetrates the urban environment and its core, creating broken and unprecedented urban landscapes. Imminent architecture gestures need to be reflected in an open-minded attitude, in the development of open structures, with a mix of uses, and in facilitating a strong interdisciplinary design process (van Lohuizen, 2017).

The project proposes a novel compositional organization that reconsiders the place of the stadium and transforms the entire site into the local supply of fast-growing

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easy-to-use building material: the bamboo. Plans to rehabilitate the site include the stadium as the main anchor program – this massive structure, known only to be wasteful in its resources, with a limited lifespan, and so inconsistent in usage, which has confronted numerous critical issues.

Working at the small human scale, to the larger scale of the city, the project Bamboo Stadium searches to become a part of the community, a porous entity, serving both as a world-class sporting facility and the local community.

2. INTEGRATING DESIGN. NATURE, MATERIAL & STANDARDIZATION

2.1 Lagos and the Olusosun landfill

Although having different perspectives, most developing countries have huge issues when it comes to waste management, finding it hard to achieve a sustainable implementation of the various human activities and life cycles of the resulted products. The megalopolis of Lagos, Nigeria, has been continuously exporting trash in the last decades to the 100-acred Olusosun landfill (Sieff, 2017).

2.1.1 Urban growth

As the city's port continued to grow, its slums and skyline continued to spread along the muddy coastline and inside the territory. Now, the city is well expanded beyond Olusosun, and the dump now finds itself in the center of the city, surrounded by a fully-formed neighborhood, with hospitals, schools, churches, restaurants or dwellings just over its precipices. The former landfill is directly connected to the main highway, the city's standing traffic jams becoming the first witnesses to the overcrowding stashes of trash (Figure 1).

Being the center of a global conversation, the continuous growing urban population has come to outnumber that of rural areas, in the hopes of a better life. Lagos remains one of the most representative cases. "Population corridors" have derived, merging crowded cities into new forms of human settlements. As Africa's largest metropolis, its population is growing at a rate of 600,000 people per year, with an average density percentage reaching 6,900 people per square kilometer. Infrastructure, housing, working wages, and social programs struggle and often fail to meet the overpowering expectations.

Moreover, unlike its Chinese or Brazilian megacity counterparts, Lagos is faced with drastic social segregation, still concentrating wealth in the hands of a tiny minority of the population. About 80% of the workforce is part of an informal economy where individuals are trading products and services without any supervision or aid. Hence, the landfills have become a lifestyle and source of a minimum living wage where people are scavenging garbage and doing business in informal means, like in kiosks on the side of the road and local markets (Howden, 2010; Sieff, 2017).

Rapid waste is one of the results of rapid urbanization. Lagos produces 0.3% of the total waste of the world's cities, meaning 11,000 tons out of a total of 3,5 million tons. Adding to that the migration of individuals from rural areas, slums run out of usable land, causing an overflow of trash into the swampy areas and even the use of garbage as livable land and construction materials.

2.1.2 Former status of the Olusosun landfill

Before its closure, the former Olusosun was by far the biggest of the city's landfills. With towers of garbage 10 stories tall and an endless cue of trucks arriving to unload, Olusosun used to shelter over 4,000 people living or working inside its premises.

Though everything may look like a total eyesore, the landfill managed to create inside a local community, with people living in tentlike structures on top of the trash, surrounded by daily social activities. However, as the stack of waste has grown, its area has become associated with the city's darker side. But this didn't stop people coming from all over the country to work there.

The recycling became an increasingly profitable business, in the 1990s and early 2000s, and thousands were drowned to the industry, despite the working conditions, in a continue hope to eliminate at least some of the trash, and welcome foreign investors (Sieff, 2017).

After its closure, as the site has been subject to many fires, the landfill became a source of the potential development of the entire area, as well as a chance to a more sustainable approach to waste. Local plans to rehabilitate the landfill include not only the park but also infrastructure beneath to harness methane emissions from the waste and transform it into energy (Cocks, 2013), improving the country's electricity deficit.

2.2 Designing with nature. Bamboo

In light of the current situation, the project tries to reveal how architecture can be shaped by and is responding to ecological thinking at the present moment. With a preference for resource and building materials, infrastructure over typology, landform over building form, the system prevails over individual objects. The approach seeks to reflect a broad reconceptualization of building materials in a blunt relation with nature, as opposed to only structural attributes.

There is a local leading effort to start using the bamboo areas and turn them into a reliable source of building material (Mussau, 2016). By transforming the site into a local supply, the project proposes an evolutive system – from a bamboo forest and stadium to a checker-board infinite pattern, composed of built blocks and yards, alternating between each other.

2.2.1 Bamboo resources in Nigeria

About 80% of the Nigerian population depends for their livelihood on the resources of flora and fauna that can be found on the territory of Nigeria. About 20% of its forest resources fall into the tropical rainforest area, out of which bamboo is one of the non-wood resources that remains untapped. In the past decade, a growing awareness has been noticed, due to the current socio-economic context, with an increase of the natural resource depletion, worsening economic climate and an inability to afford imports. The recent attention highlights the benefits of bamboo especially in developing areas (Ogunwusi & Onwualu, 2011). Despite

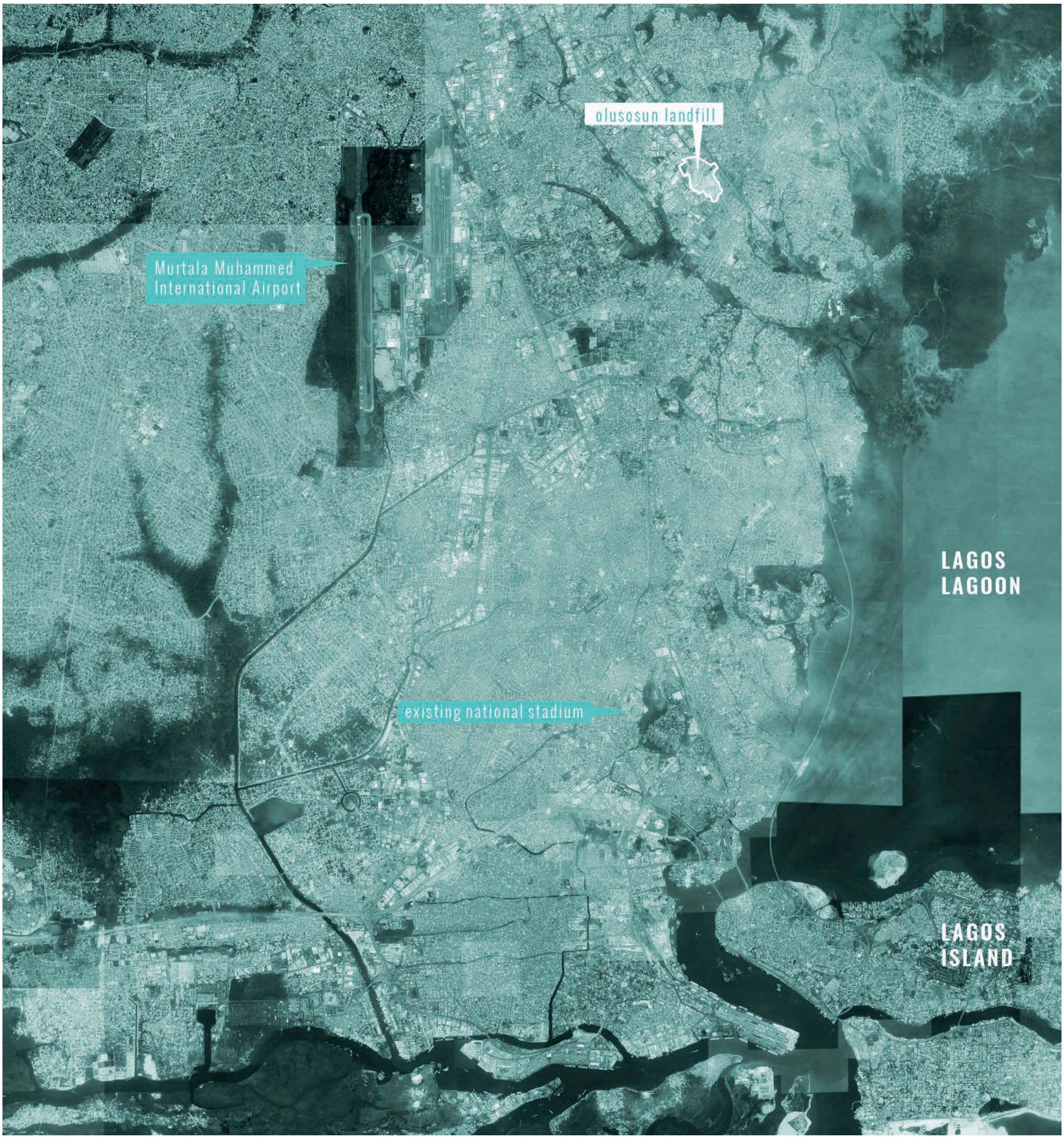


FIGURE 1: Position of the site inside the Lagos urban area (Source: https://www.archoutloud.com/uploads/4/8/0/4/48046731/waste_competition_brief_180907.pdf).

a lack of acknowledgment in the protective and productive aspects of bamboo, exploitation, and utilization have yielded directly, having an impact at a micro level, benefiting to the economical disadvantages of rural communities in Nigeria. We believe that bamboo has a real capacity to impact urban context, especially particular cases where ecosystems have been already altered.

The Nigerian economy has been traditionally dominated by crude oil resources. However, the presence of bamboo – a highly versatile resource that can grow almost in any kind of climate and thrive in worst soils – can become a real solution. Moreover, in the context of Olusosun, it can provide both a clean and renewable energy alternative in the form of charcoal briquettes and wood for domestic and industrial use, while mitigating the effects of former usage through rapid reforestation, slowing soil erosion and repairing the damaged ecosystem. Also, bamboo acts as a large-scale carbon sink, each plant being able to have a double intake of carbon dioxide than a tree. Moreover, it offers an immediate and fast-growing building material that can directly include the direct participation of the local community on the construction site.

Currently, Nigeria hosts multiple varieties of bamboo. The species can attain a height between 14-20 meters at maturity with a girth of about 20 cm. Processing native bamboo can provide a secure business in terms of construction materials. While facing a decrease in terms of total forest estates, from 10% in 1996 to 6% in 2010, a quickly growing resource would solve the imminent wood shortage in the next years. Besides, some species of bamboo can attain maturity in only 3-4 years, which makes it incredibly accessible in comparison with other available resources (Ogunwusi & Onwualu, 2011).

Also, it is said that the bamboo industry could earn Nigeria $22bn annually, making the scheme not only viable for the Olusosun site but for the entire city and country (Ffan, 2003).

The Bamboo Stadium inserts itself at the interior of the site not only in terms of programs and activities but arises from a primordial gesture of planting the bamboo forest. In this way, the site becomes its resource, while taking the time to mend the consequence of the last decades. With a fast growth speed, the structure of the stadium and its surroundings consist of bamboo canes weaved together, forming highly resistant repetitive structures.

2.3 Material & standardization

Bamboo grown on the entire site becomes the dominant building material: transformed into standardized arches that will bear the platforms and roof-structures, between yeards and bridges (Figure 2). Patterned units make the construction process extremely efficient and cost-effective. The building act becomes possible in-situ, offering the flexibility to change the form, add or retain pieces on short notice. Looking forward, a local grow and support of the direct participation of dwellers in the design work can raise awareness and repel the soil, reduce carbon emissions or heat in the process.

The design is an assembly of modular building-blocks, that contain different functions of the site. Each block can connect to its neighbors or develop onto multiple modules, offering a continuous space inside and out, varying between interior and exterior space.

With the appearance of the stadium, the area can rapidly grow in popularity as a recreational area for Lagos citizens, an international sports center for tourists and fans, as well as local work and meeting space for the local community. Bamboo Stadium sets up to promote a healthy and ecological co-existence of the neighborhood with the natural environment (Figure 3).

With all parts standardized and with the possibility of an in-situ fabrication, the construction process becomes extremely efficient and cost-effective. It also makes the construction on-site flexible to add certain areas or alter the programs on short notice, and it offers job opportunities for the dwellers and local inhabitants.

2.3.1 Phasing / Development

Starting from the current state of the former Olusosun landfill, the project proposes multiple phases of development. We took the bamboo cane as a starting point and developed an entire forest to cover the site and mend the consequences of the past activities which took place on its perimeter. When the first lot touches maturity, a modular system is developed around the main unit: four bamboo arches organized on the perimeter sides of a square. Adding further units, the bamboo structure grows in each direction, offering a great amount of flexibility to react to different situations (Figure 4).

The entire structure sits on the existent soil. The units work as normal walk-paths inside the forest, gardens, special yards and to create interior spaces for the program.

While reacting both in scale and functions to the activities happening inside, the project addresses the critical issues of stadiums caused by inconsistent usage and limited lifespan. While not being used for sports events, the massive structure of the Bamboo Stadium remains a lived space, acting like a porous entity, incorporating all kinds of different programs inside its perimeter. The architectural gesture acts against the disruptive size and limited shelf-life of stadiums, maintaining an endless hum at the interior. With an interweaving of architecture and landscape, the structure can expand or withdraw depending on the event taking place inside.

2.3.2 Multi-purpose & flexibility

Stadiums are an icon for a community and business enterprise, soccer remaining the No. 1 sport in the world, with the largest international fan base. The local populations find pride in attending matches but, moreover, often within 10-20 years, the infrastructures become almost impossible to reuse. If not well maintained and with an offer larger than the traditional stadium program, the infrastructure risks abandonment, becoming unsafe for the events.

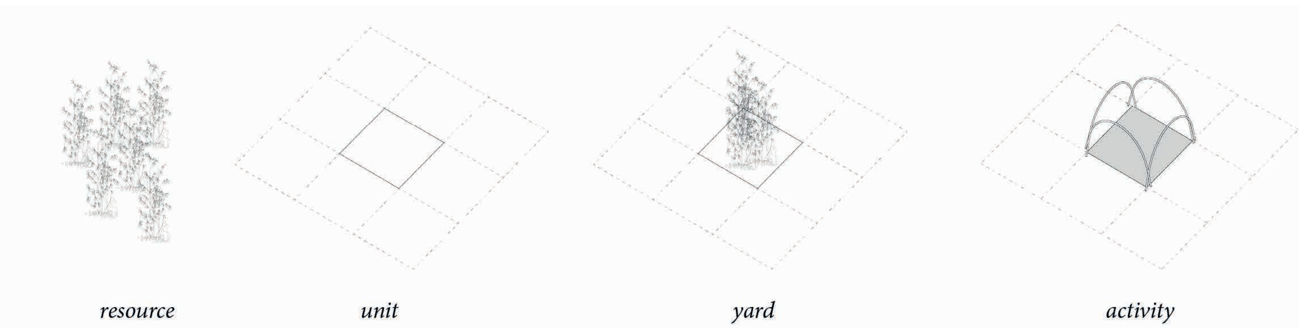


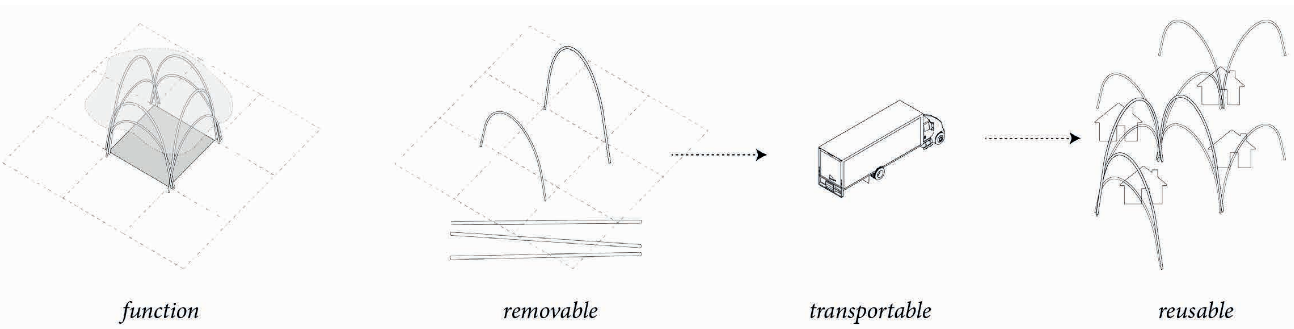
FIGURE 2: Method and options diagrams (continues in the next page).

FIGURE 3: Aerial view.

Generally, stadiums are used for only a couple of hours a day, for a few events a year, becoming a strain especially developing countries, such as Nigeria. So, the purpose became the implementation of supplementary permanent programs, that could accommodate activities and events year-round. The former Olusosun dump becomes a city center within the local neighborhood (Figure 5).

Bamboo Stadium gathers inside a mix of the stadium typology and a park, mixed with various other functions. Like a checker-board, the building-blocks and yards alternate with one another, hiding in-between gardens and different functions. Each module is filled with various functions, from dwellings, educational programs, public programs (cinemas, theaters, workshops, restaurants, etc.), sports courts, to playgrounds and markets with local shops (Figure 6).

We took the traditional form of market and introduced it at the interior of the stadium, exactly around the soccer field, in the stadium gallery. The structure is thought to make the entire intervention an area where the public and visitors can spend their time, no matter their background. The diversity of activities and programs happening inside opens the site to an infinite of situations and needs, making the proposal also viable for implementation in different



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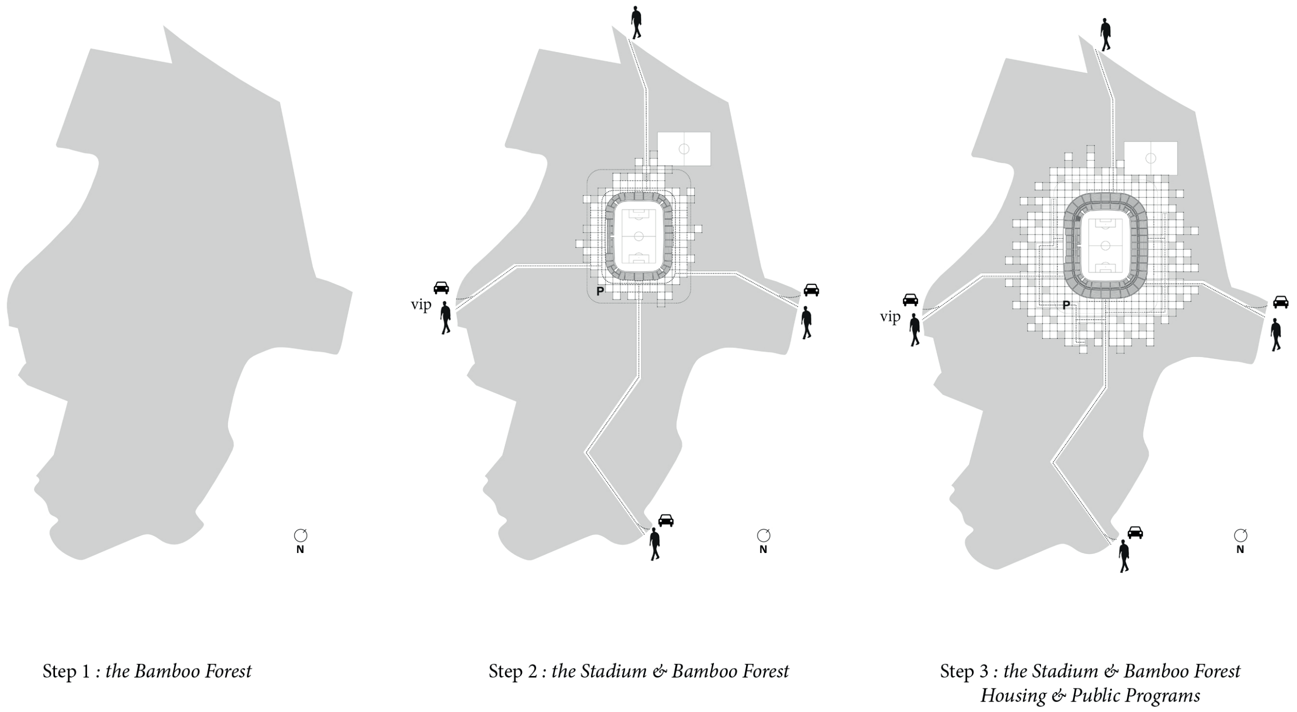

FIGURE 4: Phasing diagrams.

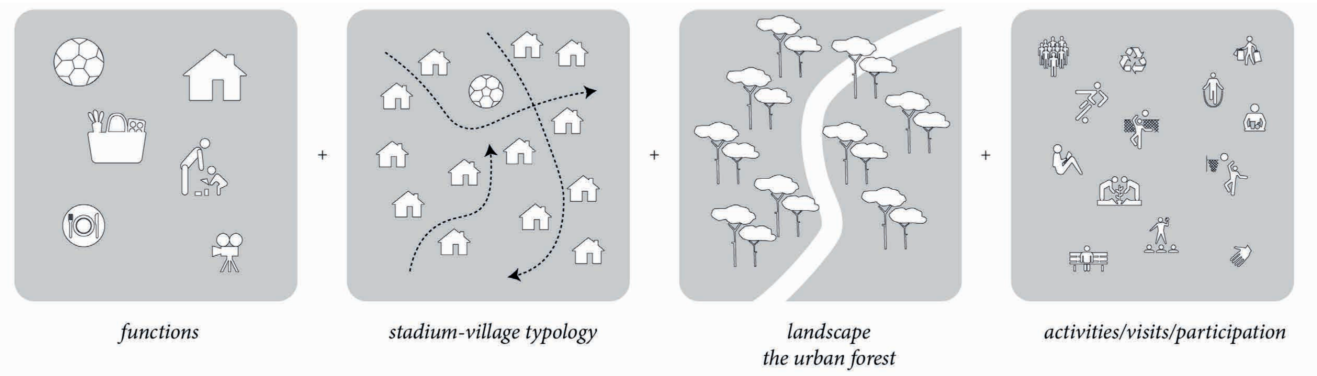

FIGURE 5: Conceptual diagrams.

locations. Bamboo Stadium becomes a model and methodology of intervention on similar sites.

2.3.3 Participation and Curiosity

After the fire and closure of the former landfill (Ugbodaga, 2018), many people remained without a job and minimum wage to live and provide for their families. By seeding plants on the site, the site not only creates an ecological environment for future structures and local building material sources but it gives inhabitants the possibility to become the main designer of the buildings. With an infinite potential of growth, bamboo construction sites offer an endless possibility of teaching dwellers ways to build, creating workshops and offering much-needed jobs. In a search for a balance between architecture and nature, such a system could directly address the issues of urban growth and fast development, finding a viable alternative to provide for a growing population.

2.4 Stadium-village typology

Given the looming transformation of the former landfill, the proposal seeks to return the football game to its roots as a natural meeting place for the local community, without forgetting the worldwide public. While avoiding an iconic and monumental structure, the ensemble presents itself as a network of small-scale units that create diversity and unexpected connections. Taking into account the dwelling issue Lagos is facing, the village typology offers the possibility to introduce flexible and easily-erected housing units, together with public facilities: market, school, cinema, sports courts, local shops, restaurants or workshops.

The perimeter of the stadium becomes a blend of social spaces, dedicated to the fans for enjoying the sport on game days, as well as to the local community, extending the urban fabric with programs to be enjoyed 365 days a year (Figure 7).

Architecture needs to be explored. The landscape and surprising connections between the modules create a special and personal bond to the place, leaving space for all kinds of possibilities. With a deep understanding of the local culture, a core responsibility of the project represents the creation of specific functions and activities that are familiar for the local community and demanded by it. In any possible scenario, the stadium and its infrastructure tackle with its identity and the temporal aspect of multi-usage and a phased approach of the site.

The infinite grow and mix of spaces offer an example of sustainable and conscientious development of a former landfill, the site embodies the organization of a village and a tool for social change. Its specificities and typology can play a huge role in the psyche of the local community.

The day-to-day needs of the bustling neighborhood become part of the proposal, becoming a familiar experience for the inhabitants and a unique one for the visitors. The common routines of everyday life are introduced in a cycle that includes recycling, housing, public needs, and leisure. Informal markets and kiosks, dwellings, workshops, teaching classes, cinemas, traditional restaurants and bars, sports courts, all meet inside in personalized spaces, in the unique context of an already build the local bamboo structure (Figure 8).

3. MODULAR SYSTEM. TRANSFORMATION & AFTER-USE

The stadium generates the plan of the system, in terms of economics or urban thoughts of orientation, zoning, and infrastructure. The aggregation can grow in any direction by adding further units, to meet all needs and demands of various situations.

By creating a blank canvas, the system opens up to the influence and speculations resulted from the needs and self-organizing gestures of the community, leaving a simple-to-use material to be interpreted in any way possible.

3.1 Modular system

With prescribed dimensions, the aggregation of modules can evolve in any aspect. The weaved bamboo arches follow the geometric rectangular design, covering the given soil and determining individual structures or components that can be connected. At the interior of each structure, spaces can occupy a single unit or expand into a bigger space and cover a greater surface, depending on the specific needs. The alternation between the outdoors and interior universes creates hidden spaces, and particular atmospheres depending on the positioning inside the system (Figure 9).

The beauty of this modular architecture consists of the liberty of the inhabitant, who decides which component can be built, replaced or added without affecting the rest of the system. The human hand is directly involved in the architectural gesture of building and creating this stadium and its surrounding components. As much as the bamboo stands as the main actor of the proposal, the human presence stands at the same level of importance.

This bamboo system is characterized by functional partitioning into discrete scalable and reusable modules. The functions stand at the interior of each module

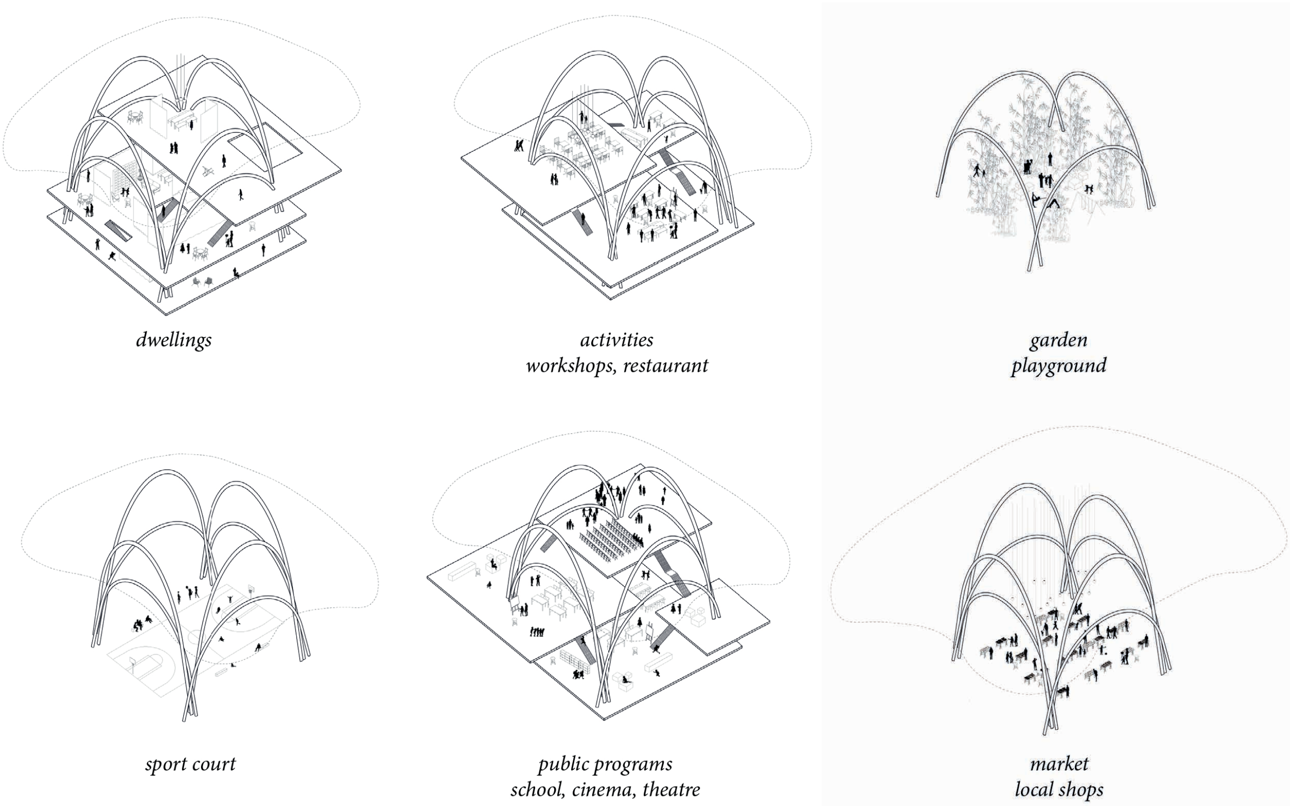

FIGURE 6: Programmatic diagrams.

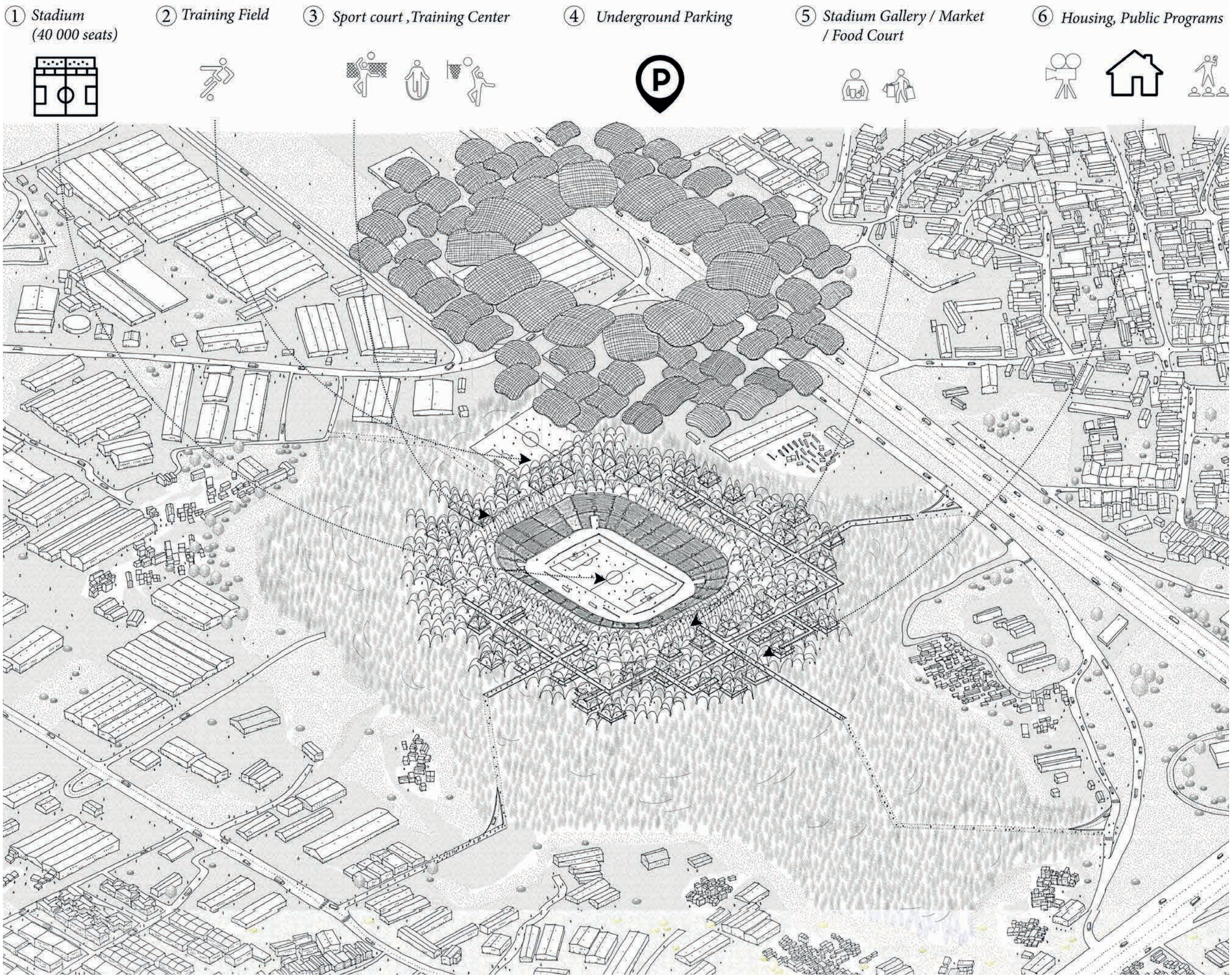

FIGURE 7: General axonometric.

on a succession of platforms made out of the same raw material. Being a very versatile material, bamboo makes as a base for many interventions, such as structural elements, platforms, pathways, bridges or even walls. The flexibility of the proposal offers dwellers the possibility to integrate bamboo into their own daily lives and adapt it to each need and use. Bridges pass on top of the gardens connecting platforms and functions between them, new contexts waiting to be discovered at every corner. Bamboo pathways also pass through the thick bamboo forest, connecting the stadium to the surrounding circulations and areas.

Passing from the public to semi-public and even private areas, the Bamboo Stadium follows the gestures and customs of its users.

3.2 Transformation and after-use

Visitors and dwellers strolling through the park and between the structures are constantly surrounded by nature and home-grown resources. The system addresses an important topic of fast-developing countries, and it creates a path where nature, architecture, and people live in an ecological coexistence.

In the aftermath of a local or international football match, the structure will transform into a communitarian ensemble of programs. Its capacity and already designed modules' dimensions pass easily back and forth between the needed functions. The sequel can be continued, if desired, by its expansions at the scale of the neighborhood or the city. From dwelling to sports courts or public programs, Bamboo Stadium can represent a starting point to start thinking architecture as a process and not as a fixed form (Figure 10).

The proposal should help to populate and develop other areas of Lagos and not only, in a mindful and sustainably way. Due to the specificities of bamboo, structures remain easily transformable and movable, while they offer an infinite number of possibilities of usage. Combining units, the system can envelop different sizes and typologies of programs, temporary or permanent, with a structural behavior strongly dependent on the current fashions and needs.

The modules are transportable and can become a model for differing contexts, being not only a response to Olusosun's specificity but one that could also envision ways for architecture to evolve in different ways to gain rele-

FIGURE 8: Stadium gallery | Market.

FIGURE 9: Sport court and training center.

vance in facing the world's growing toxicity and its crossing relationship with inequality.

4. CONCLUSIONS

There is no doubt that the consequences of waste go far beyond our immediate imagination. Through our proposal, we believe that architecture should become more of a process, than only a final object. Until recently, the approach towards waste has been somehow neglected but the sector is becoming an increasingly significant player in terms of urgency, especially in the context of the ecological crisis we found ourselves in.

The sustainable approach of the Bamboo Stadium explores transforming the Olusosun brownfield into a bamboo forest that would provide the raw material for building a future stadium and community gathering space on-site. Despite the traditional presence of stadiums at the interior of communities and cities, we call for much bigger social values. The environmental impact of bamboo and its benefits as raw material, its positioning in-situ and the possibilities of recycling are completed by the benefits of social interaction, cultural cohesion, and rehabilitation of the community.

Providing direct access to resources, promoting a direct dialogue between architecture, inhabitants and an ecological and sustainable environment, Bamboo Stadium forges the possibility of long-time maintenance of one of the biggest symbols – soccer – by integrating it as a polarizing program for a new village-typology development, where both formal and informal functions can occur as it continues to grow into an infinite sea of possibilites.

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FIGURE 10: Public programs.

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CISA

REHABILITATION OF LANDFILLS. NEW FUNCTIONS AND NEW SHAPES FOR THE LANDFILL OF GUIYANG, CHINA

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ABSTRACT

The enlargement of a modern landfill may provide an opportunity to intervene with large-scale projects and thus restore spaces for community use and potentially providing an added value. Based on these premises, the intervention on the Guiyang landfill in China has been developed focussing on the possibility of future reclamation of the site under construction during the design stage by applying an approach that takes into account future use from a technical and, more importantly, economical perspective from the outset. The design proposal has been developed following analysis of these elements: landscape and territory (predominant features of the area, naturalistic features to be preserved, optimization of the interrelationship between the adjacent areas and functionality of the territory); analysis of the residential, infrastructural and productive systems (fundamental in ascertaining the size of the catchment area of potential users). The landfill mining intervention planned in the area allows a more efficient operation of the landfill and has been studied to redesign the site in terms of morphological shapes. Indeed, the project suggests the use of the mass of waste as a plastic element for the reconstruction of a redeveloped landscape according to the shape required by the new configuration of the area. In view of this consideration, in this case study, the typical shape of a landfill is abandoned and the site has been reshaped according to the design of the Chinese landmarks in the surroundings. The area has been conceived as a new green space and defines the role of the landfill site as an Environmental Education Centre and a recreational urban park for public uses, located close to a highly urbanized area. This project design was developed in the context of the ROLES initiative funded by the Italian Ministry of Foreign Affairs in the framework of the Scientific and Technological Cooperation Agreement between the Government of the Republic of Italy and the Government of the People's Republic of China. ROLES was coordinated by Raffaello Cossu (University of Padova, Italy) with the collaboration of Roberto Raga (University of Padova, Italy) and Dongbei Yue (Tsinghua University, China). ROLES (Remediation of Old Landfills for Environmental sustainability and final Sink) proposes an innovative approach to landfill reclamation, analysing in depth the issue of functional requalification, i.e. the possibility of enhancing the valorisation of landfill surfaces for specific uses aimed at ensuring environmental and landscape sustainability.

1. INTRODUCTION

In designing or remediating a landfill, a common approach consists in concealing the facility from view and from the public conscience. Landfill is an eyesore which society would prefer to ignore. However, to merely conceal a landfill is not a recommended strategy as society should be forced to acknowledge it exists, what the implications are, and why it is destined to remain. Moreover, the transformation of a large piece of land into a green mound having scarce value for the surrounding community is not an effective solution (Gowar, 2016).

Landfills have long been viewed as highly engineered spaces driven by economic, technical and health concerns, whilst giving scarce consideration to aesthetics or design – other than concealing them from view. These sites may however represent an opportunity for development through application of landscape architecture aimed at highlighting waste issues in current society (Engler, 1995).

The role of the architect is to determine the conditions,

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problems and challenges of the site and to identify current or future users, assessing the most favourable approach and design best suited for the site concerned. Analysis should unfailingly represent the first step and underlying basis for all projects (Grudziecki & Buachoom, 2016).

A landfill might be integrated into its topographic and ecologic environment instead of remaining an island – set apart, and should be seen as design opportunity and not just a place we isolate and ignore (Jenkins, 2016).

The development of new structures on top of landfills is associated with a series of challenges, largely due to the composition of these facilities. Therefore, transformation of landfill sites is closely linked to factors including waste composition and age, degree of compaction and local climate. Taken together, these determinants will establish the design limits and dictate the type of structure to be built on the landfill (Grudziecki & Buachoom, 2016).

The majority of landfill transformations are related to closed plants, although reclamation works performed on a landfill will have a far greater chance of success when studied and developed during the stage of active management of the landfill (during the construction stage, waste deposition or at the time of a potential extension) (Artuso et al., 2018). Indeed, the use of new wastes as a plastic material with which to mould the shape extends the pool of potential uses assigned to the project, and provides greater freedom in reinventing the final configuration of the area, in addition to facilitating important budgetary savings in terms of material to be delivered to modify the structure of the site. These concepts are however deemed extremely innovative when compared with common practice as they dictate a change in the terms of the project: we are no longer the designers of mere landfills, but rather of community spaces (Artuso & Cossu, 2018a).

The requalification of a landfill provides an opportunity to undertake qualified territorial reorganization work in which the procedures applied in plant management and redevelopment of the environment may constitute a key factor in effective rezoning of the area. The available options geared towards renewing the functional status of the area undergo a decision process to assess the most appropriate end use in terms of territorial reorganization, impact on the landscape, environmental sustainability and public consensus (Artuso & Cossu, 2018b).

The case study of Guiyang landfill has been studied and developed in line with all the above principles.

2. PRELIMINARY ANALYSIS

2.1 General location, current planimetric layout and waste body characteristics

The landfill, identified as a case study, is located in the Guizhou province, south-west of the People's Republic of China, and is located close to Guiyang, the capital province and important metropolis of almost 4,500,000 inhabitants. The land is largely mountainous with plains to the east and south and hills in the western part of the province (Figure 1).

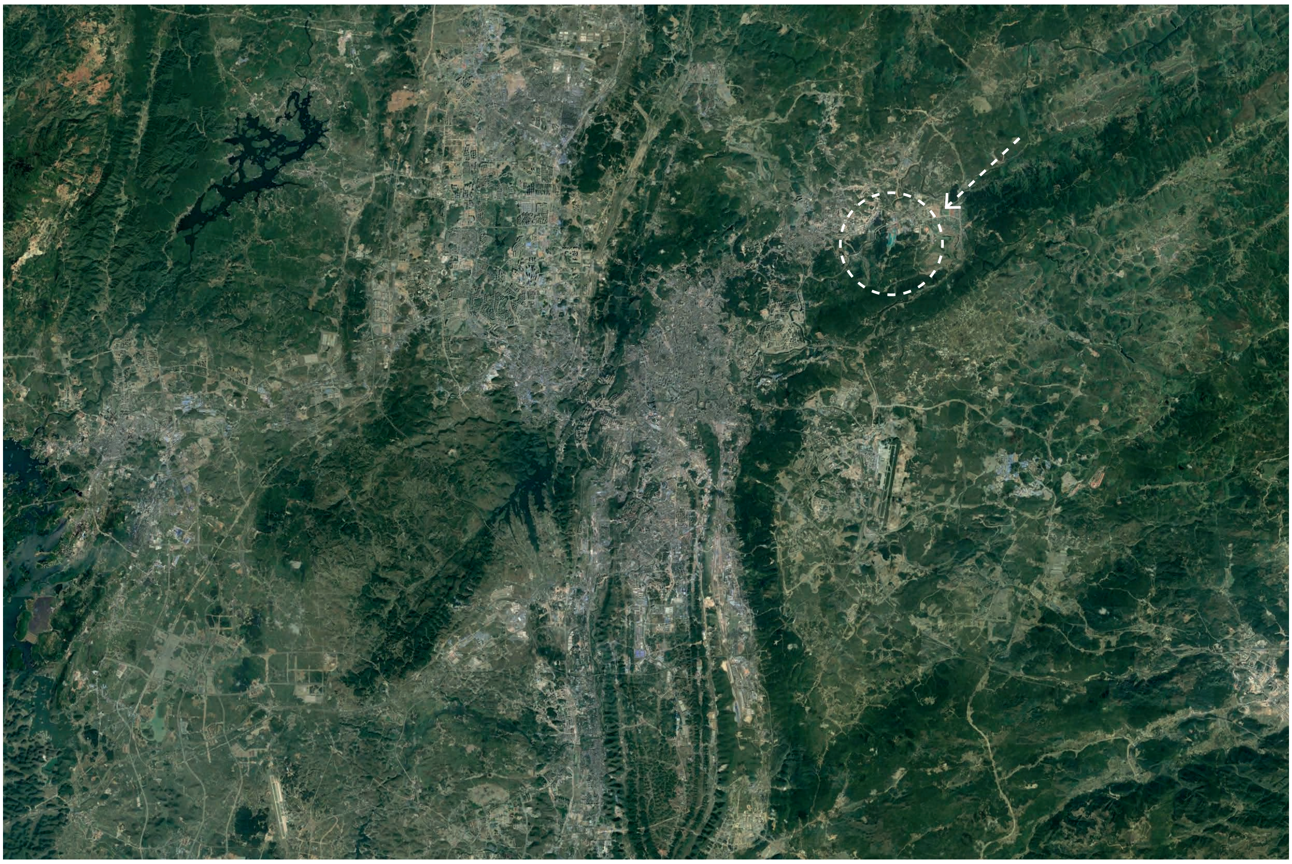

FIGURE 1: Orthophoto of the city of Guiyang and identification of the area for intervention.

More precisely, the study area is located in the west part of the metropolis, on the boundary of an industrial and productive area and in between a new expanding area and an uncontaminated natural area of woodland (Figures 2-3).

The study domain comprises an extensive surface area on the east side, indicated as an area for waste storage. This section could be considered for possible expansion of the landfill with a view to a wider development of the area. In the immediate future, this area could be employed as a selection, sorting and temporary storage point for materials excavated by landfill mining. Subsequently, it could be exploited for the construction of new landfill sectors in line with the intention to dispose of waste according to a morphology established by the general design.

The main vegetation is arboreal with a predominance of pine forests. The area is flanked on the west side by the railway. Figure 4 shows the current layout of the area.

The landfill has an average height of approx. 25-30 meters above ground level, with an altitude of 1090 m above sea level. The landfill is currently operational. It is expected that approx. 10% of the existing landfill volume will be affected by a landfill mining project, in the area identified in Figure 4 with the letter "B". The landfill mining work envisaged will facilitate the creation of new volumes in the existing landfill and be linked mainly to the removal of deposited wastes, to the potential separation of fractions with recovery of materials and/or energy, and disposal of the residues in a new landfill. The work will require preliminary in-situ aeration treatment in order to stabilise the waste mass and allow excavations to proceed safely. As described subsequently, the landfill mining work, to be carried out solely on a small section of the landfill, will afford the possibility to build up waste embankments in line with a specific design with a view to future re-use of the site. The area concerned is currently closed by a final HDPE cover that will be removed.

2.2 Landscape area of reference: environmental dominant elements and landmarks, green system and protected areas

An analysis carried out using geolocation tools available on the web identified a series of natural signs typical of the area that are considered unique landmarks in the landscape. In particular, the terracing, used for the cultivation of sloping rice, is a distinctive feature of the area. This cultivation technique marks the territory by drawing strips of different shades of green subjected to chromatic changes according to the seasons (Figure 5).

Another landmark characterizing the landscape is determined by the mountainous hill system in which reliefs appear as isolated pinnacles deeply engraved by river valleys (Figure 6).

Several protected natural areas have been identified close to the study area. Today, the forest pavement of the Guizhou plateau has been largely replaced by secondary shrubland or by scattered forest associations consisting of

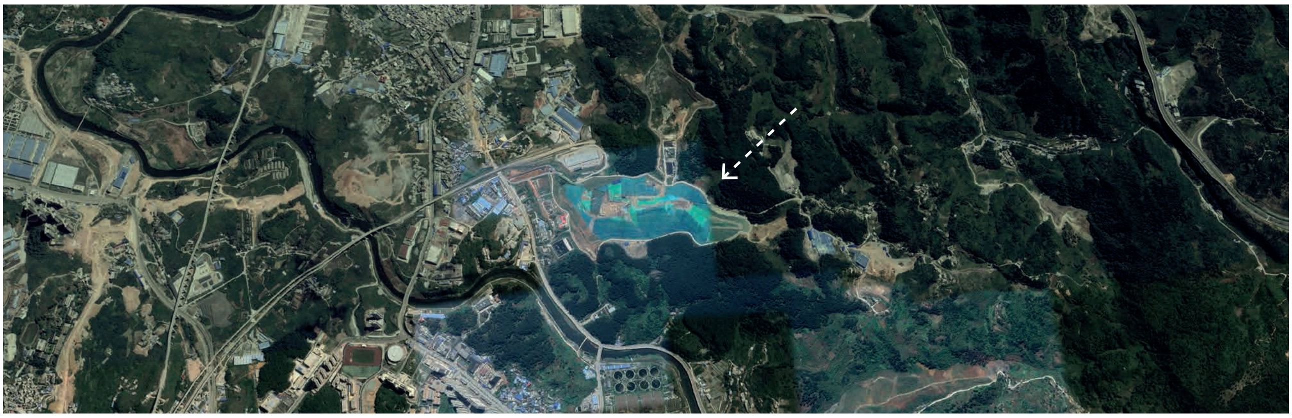

FIGURE 2: Orthophoto of the area highlighting integration of the plant into the original forest.

FIGURE 3: View of the landfill towards the surrounding forest and towards the city.

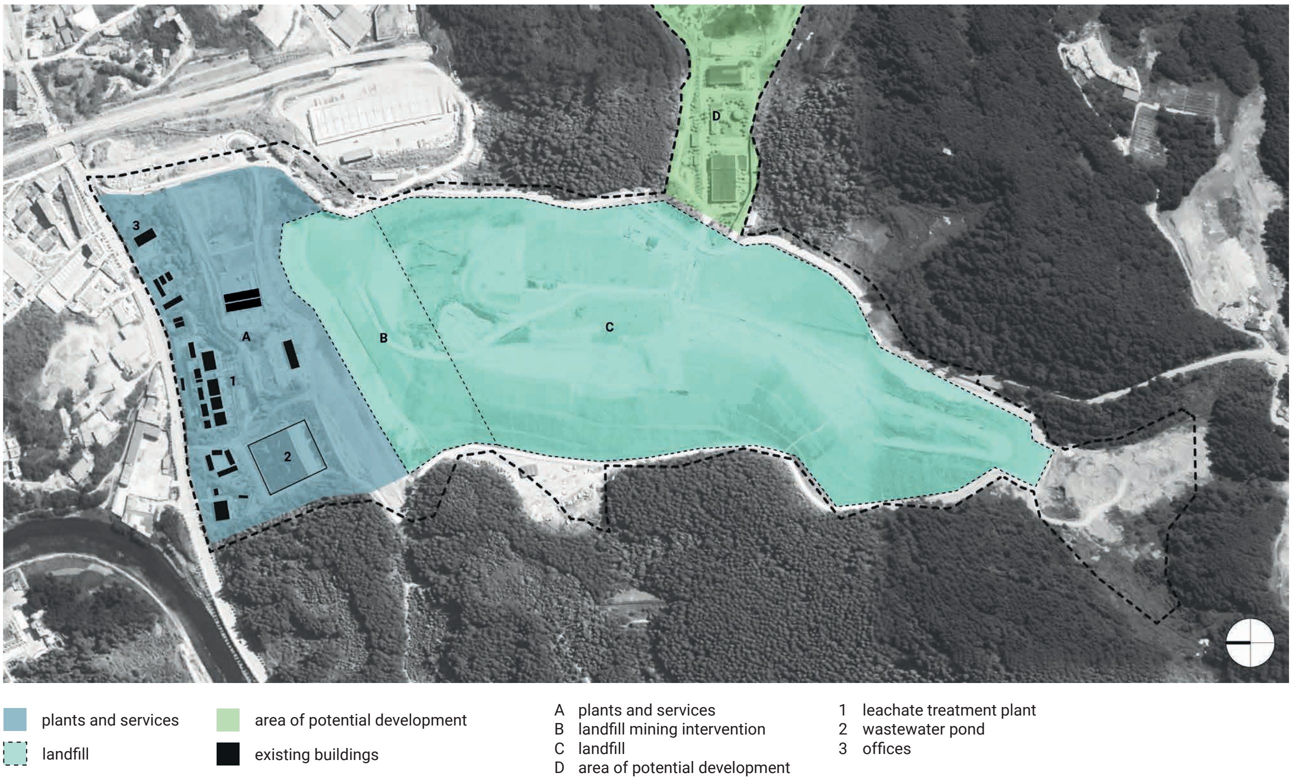

FIGURE 4: Orthophoto showing a schematisation of the current status and identification of the operational areas.

species belonging to the Ericaceous family. Patches of original forest remain within protected areas, but elsewhere it has almost completely disappeared, with the exception of limited areas covering the most remote and inaccessible calcareous hills.

The overlap of the green system with the urban system highlights the availability of large areas of public green within the urban fabric, for a total area of 5379.71 hectares. These are mainly urban parks conceived as inclusions of natural forests within the city. Qian Ling Shan Gong Yuan, Guanshanhu Park, Chang Po Ling Forest Park, and Hotspring Park are some of the great "green lungs" inserted into the metropolitan fabric, for leisure use, sports and other activities.

On observing the study area in Figure 7 and imagining future development in the urban area resulting in an increased population, it is evident that the landfill is located in a strategic position suited for use as a green area for citizens living in the north-east zone of the city, featuring the same standards proposed in the large natural parks described above.

2.3 Analysis of the settlement system, identification of expansion areas and residential catchment area

This analysis probably represents the most important phase of preliminary characterization and facilitates an understanding of the extent of potential users of the area, taking into account distance from the main urban centres to be linked to the project.

FIGURE 5: Major Landmark: terracing as a characteristic and univocal sign of the Chinese agrarian landscape.

FIGURE 6: Typology of hilly and mountainous features with both isolated and grouped peak.

The landfill concerned is located in a highly urbanized area, close to a city with a high population density and, as already mentioned, forms part of a new expansion area (Figure 8).

The location of the plant allows us to hypothesize reuse of the area as an urban park for the new expansion area, where the concept of park is borrowed from the existing type, namely that of the natural biotope.

The overlapping of maps also allowed the landfill position to be related to the university and research centres in the city, with a view to considering the park a Centre for environmental education and sustainable research (Figure 9).

The proximity of an extended educational centre located in the northwest, less than 5 km from the planning area, increases the range of proposed activities for the park, in synergy with other educational centres in the city, hosting several higher education centres and large universities such as Guizhou University, Guiyang Medical University, Guizhou Normal University, Guizhou University for Nationalities and Guiyang College of Traditional Chinese Medicine. The province hosts approx. 200 institutes of natural sciences.

FIGURE 7: Analysis of urban green spaces and natural park.

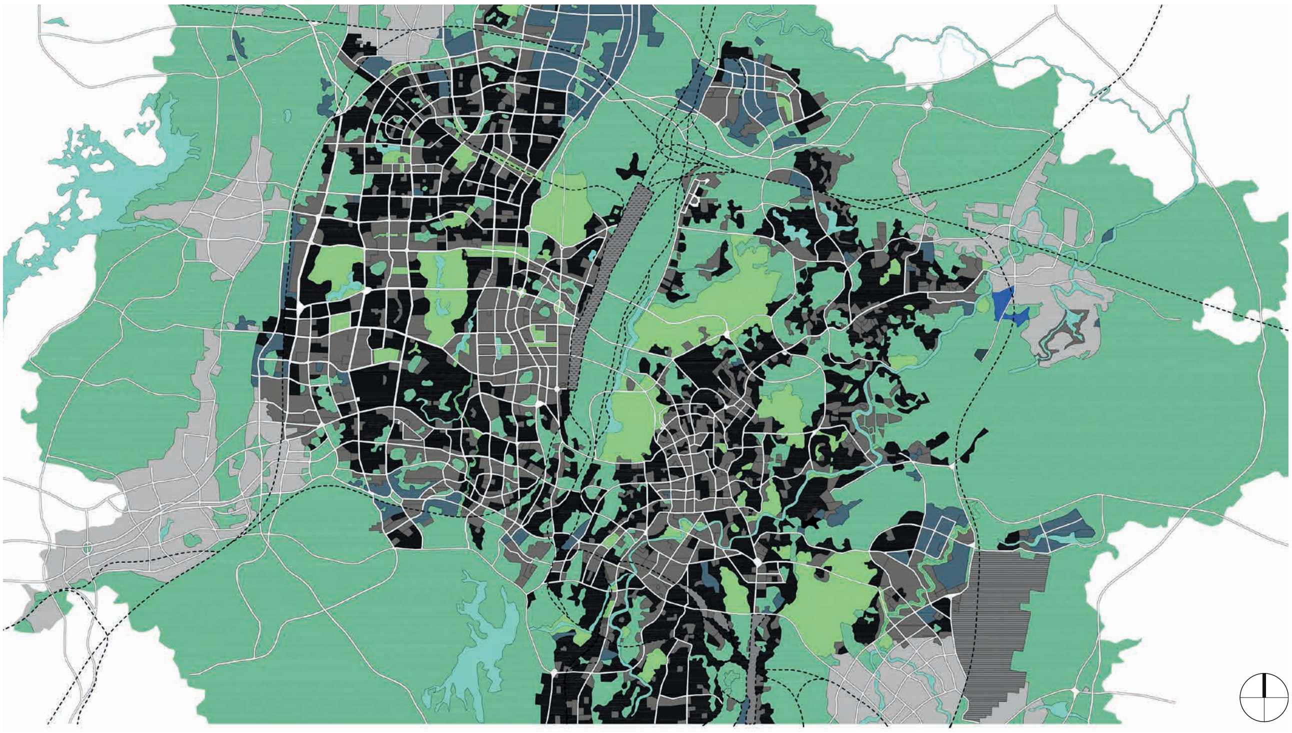

FIGURE 8: Territorial context.

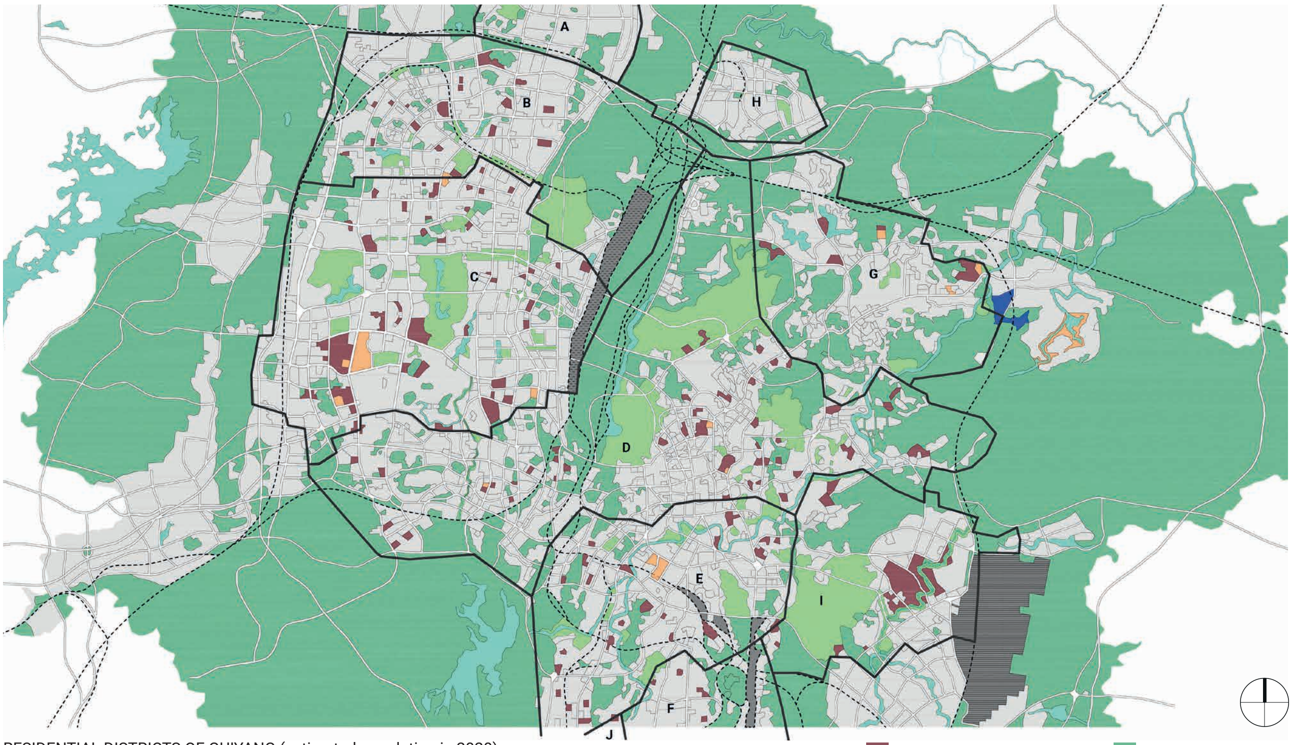

FIGURE 9: Analysis of the residential and infrastructural system.

The analysis reveals the scarce presence of sports facilities in the area adjacent to the landfill.

The proximity of an extended educational centre located in the northwest, less than 5 km far from the planning area, increases the possible activities to be proposed in the park, in synergy with this and others educational centre of the city. There are several higher education centres and great universities such as Guizhou University, Guiyang Medical University, Guizhou Normal University, Guizhou University for Nationalities and Guiyang College of Traditional Chinese Medicine. The province has about 200 institutes of natural sciences.

The analysis shows few services for sports facilities in the area adjacent to the landfill.

3. HYPOTHESIS FOR REQUALIFICATION OF THE LANDFILL AREA

3.1 Planimetry, volumetric features and general description of the area

Analysis of the aspects previously described represented the starting point for development of the requalification project; the final aspect to be achieved is shown in Figure 10.

The planned landfill mining project will only interest a portion of the landfill, allowing wastes to be re-disposed according to a well-established criterion.

The ultimate re-use of the area will be completed within a significant time frame and has been conceived to promote an immediate co-existence with the ongoing operations of active landfill management. Re-use of the area is intended to be implemented immediately, with subsequent sections being added once they become available. The overall project provides for the start-up of a series of future scenarios in the short, medium and long-term, ranging from the initial phase characterised largely by excavations and re-embankment of earth and wastes, to the final phase which will witness the development of construction works (internal viability, pathways, playgrounds, sports) aimed at promoting use of the entire area.

Assessment of the environmental aspects of the area identified the terraced cultivation of rice as the most characteristic landscape element of the area, which has been adopted as a connecting element between the most natural part of the park and the facilities area, including an environmental centre. The park will be comprised of a well-organized green area (the current facilities area), including a centre for environmental education, and a more natural area conceived as an urban forest in line with local parks used as a model.

Terracing is configured as a compositional element of landscape design and planted on different levels using a series of diverse species to create bands of different shades of green.

Terracing will be appropriately designed in terms of slopes, width, and passage space for earth moving machinery, in order to facilitate disposal of new waste and, ultimately, placing of a final landfill cover. Terrace width will be selected in order to allow people to carry out all the activities envisaged in the context of the park.

Terraces can be partially planted with medicinal plants traditionally used in Chinese medicine.

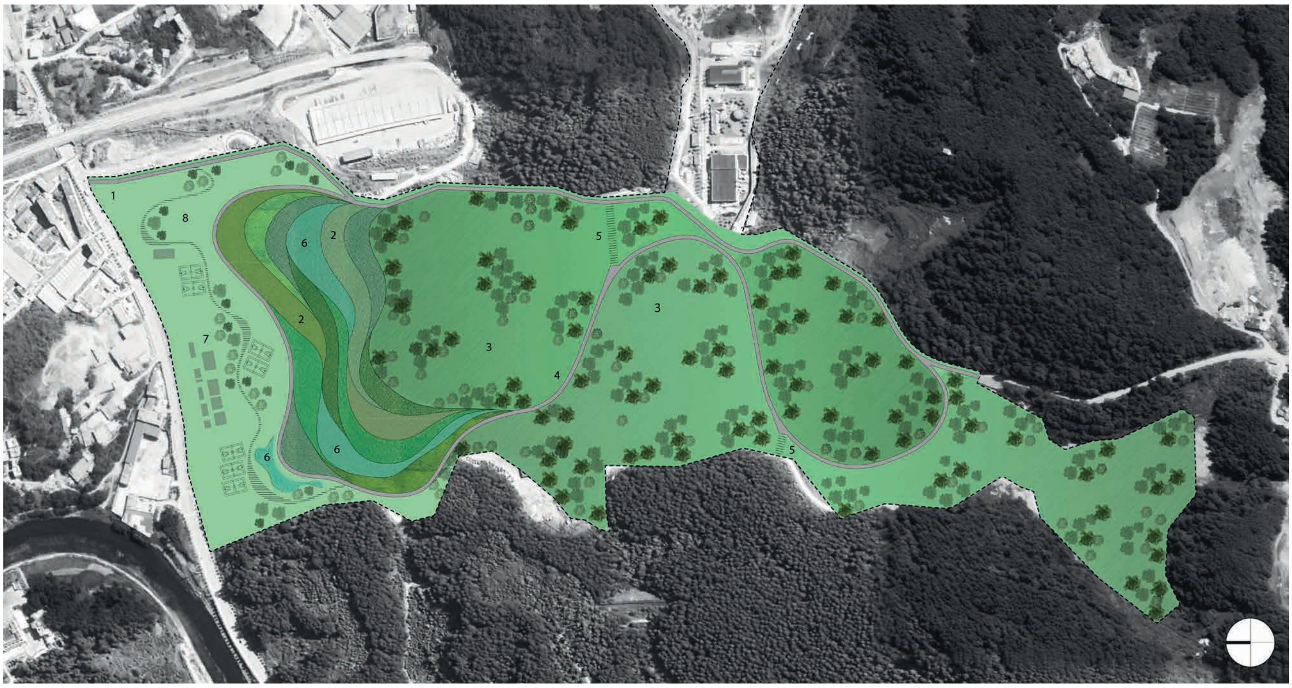

FIGURE 10: Map of the general project of the area.

Landscape requalification also provides for the creation of a wet area close to the plant. More precisely, it is suggested that excavation should be carried out to partially exploit the existing leachate collection tank, suitably modified to acquire a more natural shape.

The potential creation of a lake for the construction of a reservoir will be evaluated; indeed, the latter, in addition to serving as a catchment area for rainwater, could contribute towards re-naturalization of the site and park.

A re-naturalized lake significantly enhances the environment, acting as a pleasant stop and observation point at any time of the year; it allows creation of a real aquatic garden, with a strong naturalistic imprint, which would be quickly populated by a variegated aquatic microfauna (butterflies, swallows, dragonflies, frogs, salamanders). The lake would as a storage tank for the irrigation system in addition to increasing the value of the landscape.

3.2 End-use destinations for the area and the Environmental Centre

The project for functional restoration of the landfill, characterized by successive phases, foresees a functional reuse of the entire area as a research and environmental education park, conceived as a large "open-air laboratory", in the context of which each area has its own specific function.

This proposal stems from analysis of the territorial, social, landscape and cultural aspects of the area, but which takes into account enhancement of the site also in view of its potential scientific value acquired over time as a landfill, and the possibility of positively exploiting some features of the plant.

The end result will be a well-equipped area from an ecological point of view to be used as a place of environmental dialogue where experiences, resources, development and activities are shared (Table 1).

Although the functions provided may differ, they are all linked by the common target of "100% recovery", conceived as recovery of materials, energy, water and land. Therefore, the park, conceived as a leisure space to serve the city, acquires a social and educational role aimed at promoting environmental awareness rather than delimiting the area merely for recreational purposes.

The final project would include all existing lots, the landfill area interested by landfill mining and the service area and related buildings, including the plants. The area of potential expansion inside the property that is not currently exploited (indicated as "D" in Figure 4) could also be included.

The requalification project is integrated into the territorial context, respecting the morphology of the surrounding landscape and recreating continuity of the space in lines and shapes. Furthermore, the requalification project establishes the original function of the territory by increasing its value and distributing in a composite manner a plurality of functions: educational, social, cultural (environmental protection awareness) and recreational (green areas for technical visits).

From a technical-scientific point of view, the area affected by the environmental requalification project is aimed at recovery of a landfill area through construction of a multidisciplinary research park of potential interest both for the population and technical-scientific concerns associated with universities (collaboration with laboratories, thesis students, research), research centres (including foreign ones), farms, companies, pharmaceutical companies, etc.

Buildings housing the plants are readily adaptable for use in the Environmental Education Centre, conceived as the "eco-sustainable" purpose-designed heart of the park (including green area, paths, furniture, benches, etc.). Indeed, the design project envisages a green area in which recycled materials will be employed. Benches, pedestrian paths, play areas will be built and assembled using recycled plastic or wooden materials, some of which created by the park users. The area would thus become a sort of large outdoor laboratory with areas dedicated to recycling techniques. Spaces are envisaged for construction of the objects, and artistic laboratories (both outdoors and inside the Centre) - Figure 11.

A dedicated space could also be provided for thematic conferences and seminars. The park could be made available to associations, public concerns, consortia, schools, competitions and other events.

The purpose of the park will be to demonstrate that waste, if properly managed, can have a second life. In this perspective, materials originating from separate collection will be recycled to form objects for games, decorative elements, sculptures, coloured aggregates for paths, etc.

From an energy requalification point of view, recovery of the biogas produced within the landfill will be used in the lighting of the park.

This requalification project and creation of a green area is aimed at restoring the original forestry cover of the Guizhou plateau that has largely been replaced by a secondary scrubland.

A free design of the green is therefore proposed, with associations of forest species typical of the seasonal tropical forests (*Sterculia, Erythrina, Ficus, Eugenia and Helicia*) or secondary forests (*Albizzia, Rhus, Cornus, Liquidambar*), present at latitudes similar to those of the landfill.

The possibility of inserting artificial tanks in the terraces to re-propose a typical rice field landscape will be evaluated.

Short sections of bamboo forest will be designed at selected points along the paths within the project, in order to underline the oriental atmosphere. Bamboos grow rapidly in height, filtering light and wind, yielding unique light and sound effects. In this context, the bamboo forest will represent an element of acoustic ecology, intended to reduce noise pollution and therefore in line with the sustainability concept of the park.

4. FUTURE PERSPECTIVES: PROJECT-STRATEGIC INDICATIONS

The municipal solid waste landfill should be integrated into the design project to maintain a functional use rather than its originally intended use. It should not be viewed as a mere designated use of the area, but as a process of development heralding the advent of "new designated uses".

TABLE 1: Structure of the environmental centre. Brief description of the possible activities within the park.

ACTIVITY	COMMENT
	The environmental centre is envisaged as a leisure centre focused on the new practices of everyday life, immersed in a low-tech technology universe that employs natural in construction of devices through sustainable processes respecting the pre-existing natural equilibrium. Numerous events can be organized: repair workshops for small household appliances, conferences on environmental sustainability, natural cosmetics courses, workshops on the recovery and recycling of objects, gardening, art exhibitions, etc ... The centre surroundings will be developed to provide a pleasant area in which to carry out outdoor activities, with the possibility of using the adjacent wet areas, and will form the gateway to the natural park. In line with the philosophy of the project, organic waste produced inside the Centre (for example Bar) will be composted and used as an agricultural soil conditioner in the park.
	All planned activities will be aimed at involving first of all schools (primary and secondary) and university students, in addition to the general population. The Centre will be equipped with specific areas for workshops, seminars, practical lessons designed to cater for a series of indoor and outdoor activities.
	The park as a whole is designed to promote a culture of recycling and increase environmental awareness amongst the population. Accordingly, some elements within the area may be manufactured using materials recovered from landfill mining activities, as well as through the contribution of park visitors themselves. Lookouts, stopping points and equipped areas, air-and-wildlife watchtowers, benches, sensory paths can become practical topics to propose and develop in the context of competitions, workshops or various activities with a view to ensuring the local community becomes an integral part of the requalification process. The park project is developed over time and also realized through the contribution (intellectual and manual) of visitors themselves to boost a sense of belonging.
	In an extremely natural context, sports can be practiced on fitness itineraries in the equipped areas. The park will be crossed by dirt tracks or paths made from natural materials to promote a full usability of the area. Once again with a view to reusing the materials found on-site (wood, stone, etc.) gym stations along the fitness itineraries and bike and mountain bike routes will be realized.
	The architectural quality of the buildings clearly contributes towards enhancing the pleasurability of the project. The language of architecture and an appropriate choice of shapes and materials will promote the salience of spaces and functions, in addition to providing a more complete image of the entire environmental park. To reduce the economic investment on the buildings and adhere to the philosophy of the whole project, it may be of interest to assemble a series of cargo containers, exploiting a versatile construction system that is well suited to the needs of the park. The containers, assembled and revisited from an architectural point of view, could be proposed as supporting spaces for Centre activities and, in view of their modularity, could be extended as required. In this way the space can be used to meet a range of varying needs. These ideas may indeed prove useful as, in the majority of cases the empty containers are stored one on top of the other in huge dedicated areas, with no further plans for reuse.
	Several experimental activities ranging from phytotreatment to greenhouses fed with biogas may be developed. An infinite number of experimental activities aimed at providing alternative energy strategies or sustainable water management may be devised and established within the area.

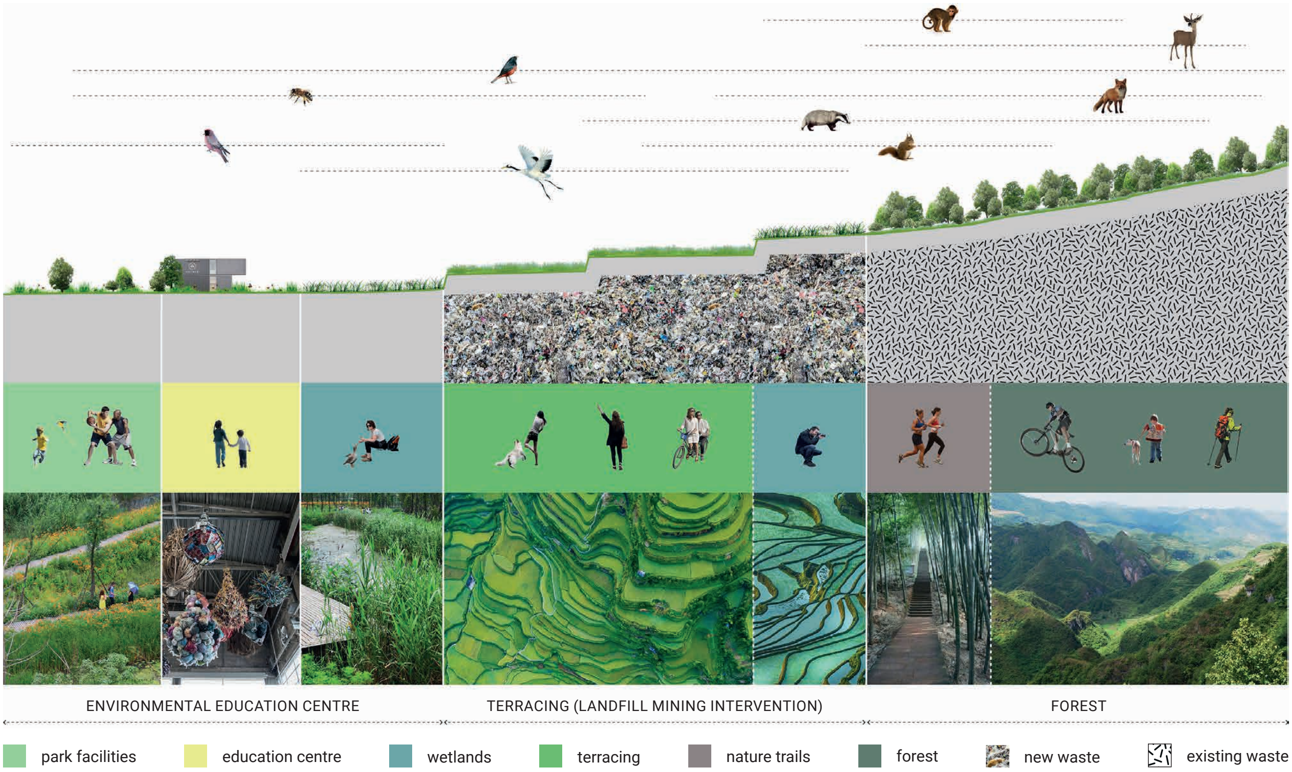

FIGURE 11: Conceptual section.

The project-strategic indications referred to in this final paragraph are intended to provide a series of ideas to be evaluated and investigated in a possible future phase of the project:

- RECOVERY OF BUILDINGS AND EXISTING WORKS: Proposal of a graphic-architectural restyling project to improve the visual impact of buildings through a minimal repercussion on the built-up area (for example applying giant alphanumeric lettering on the fronts of prefabricated buildings). The use of large numbers and colourful letters painted on portions or corners of buildings would, at limited cost, render prefabricated concrete buildings more aesthetically pleasing, as well as contributing to the legibility of spaces and functions within the systems. Ideas for improvement of structure presentation may include: giant lettering used as signs or "displays", the use of coloured paints on portions of fronts, numbers printed off-scale on high-speed doors, "poor" recycled materials to be used as a wall covering. Properly renovated containers could be used, in line with the philosophy of the park.
- WATER RECOVERY AND CONTAINMENT: Study of the entire rainwater containment and collection system providing for the recirculation of rainwater as water supply for the park and irrigation. Provision of a collection tank with the dual function of storing and creating a wet area to complete landscape intervention, useful in promoting the repopulation of fauna;
- PLANNING OF AN IMMEDIATE SITE RECOVERY: Landscaping during landfill aftercare, making the facility better visible and open to visitors. Creation of a welcome point for the public through identification and optimisation of suitable existing spaces not currently in use. Devising of an itinerary for a complete guided tour of facilities. Routes within the area will be studied in order to not hinder vehicle operations and activities and ensure visitor safety. Itineraries will be realized using horizontal signs set out on the ground using large stripes and coloured arrows, and foresee the use of small fences, docks and / or sidewalks, stop areas to guarantee maximum visitor safety. Routes will be appropriately signposted and explanatory photographic panels provided in areas not open to the public for safety reasons. Routes within the Centre will be designed to ensure ready accessibility and usability of the area, with the possibility of crossing from one selected itinerary to another. The fenced green area near the exit will be integrated and used as a space for outdoor lessons in the summer season, educational workshops, etc.

5. CONCLUSIONS

Downstream of the outcomes of preliminary territorial analysis, the planning and design project has been developed with the aim of fostering a harmonious insertion of the intervention in the local context, in respect of the morphology of the surrounding landscape, and recreating the essential forms and lines of spatial continuity. This project for reuse of a landfill will restore the territory to its natural vocation, moreover providing an added value and meeting the requirements of the local community by bridging a potential gap in the lack of infrastructures. Furthermore, it will provide a series of educational, social, cultural and leisure facilities to attract potential users.

The design concept will moreover promote a positive outcome and economies of scale, bearing in mind the economic feasibility of the transformation, and will strive towards creating an "exportable model" for use as a reference project in similar contexts.

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FREDERIC-BACK PARK, MONTREAL, CANADA: HOW 40 MILLION TONNES OF SOLID WASTE SUPPORT A PUBLIC PARK

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ABSTRACT

The City of Montreal, Quebec, Canada, took over the management, in 1988, of a former limestone quarry that was also used as landfill site. The surrounding population of this site, located in a densely populated area, was exposed to many nuisances related to the rock extraction and transformation and to the landfilling activities. So, the main goal of the city was to rehabilitate this degraded site, build a public park and give it back to the population. The site's total area covers 192 ha. From this surface, 72 ha were devoted to the landfill. Over the years, 40 million tons of municipal solid waste have been landfilled. Building a park on such a large site that still produces landfill gas and leachate involves several major challenges. The priority was first to control, with high efficiency, the landfill gas and the leachate to minimize environmental risks and impacts. In parallel, a process involving design workshops, research, testing, brainstorming and topographical models was launched in order to develop the Master Plan for the park construction. The Master Plan provides the framework for teams working on the project, sets the guidelines for the site's rehabilitation and phase-by-phase transformation based on the principles of sustainable development. The park construction was initiated in the mid nineties. Nowadays, 48 hectares are already open to the population. The Frédéric-Back Park will be finalized around 2026 and will then be completely accessible to the public. This is the result of a close collaboration between the Department of Parks and the Department of Environment of the City of Montreal in order to meet the needs of both past and future functions of this rehabilitated site.

1. INTRODUCTION

The City of Montreal, Quebec, Canada, has set ecological transition as one of its main priorities. As part of this ambitious process, the Frédéric-Back park (Figure 1) represents a flagship project to demonstrate how this priority can be expressed in a major concrete action. This park is being built on top of the City of Montreal's 40 million tons landfill site. It shows how a highly degraded site can be given back to the population to provide a better life quality.

The park is located on a 192 ha piece of land. According to Ethnoscop (2013), some quarrying limestone activities were initiated on those rural lands during the middle of the 19th century. Because of Montreal expansion, needs in stone blocks, crushed stones, and concrete were increasing. This is why during the fifties, activities were diversified on site by adding a cement kiln and an asphalt plant. So the quarry became a major employer and its neighborhood got developed quickly to provide housing to the workers. With time, the growing city reached this former rural area which is now densely populated with 8 700 persons/km^2 (Figure 1).

Landfilling operations were initiated in 1968 by previous owners who were also exploiting the limestone extraction and the related industrial activities. At that time, there was no regulation on landfilling in the Province of Quebec. Therefore the landfill was not initially designed to prevent environmental impacts, risks and nuisances for the surrounding population. For example, walls and bottom of the old quarry were not made water tight before landfilling. So there is a hydraulic link between local aquifers and landfilled waste. As a result, there are potential risks of groundwater contamination by leachate and potential risks of lateral landfill gas (LFG) migration through unsaturated rock fractures and soil porosity.

During the seventies, the already dense population reacted to the many nuisances as odors and vermin from the landfill and asphalt plant, noise and vibrations from rock blasting and the intensive trucking related to rock, crushed stones, asphalt, concrete and waste transportation. The

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complaints and social pressures inherent to those impacts and addressed to local public administration increased to such an extent that the City of Montreal decided to expropriate the company owning the site. Because of the long administrative and legal process, the expropriation became effective in 1988. Quarrying and related industrial activities then stopped but the landfill site kept being operated. Even with 26 million tons of waste already buried, the top of the site was still considerably lower than the natural ground surface which would have made it difficult to control run off water. Even though the site was to become a park, the priority was to minimize environmental risks and impacts and to ensure progressive closure. The following few years focused on this priority.

In parallel the city administration tasked the Service des grands parcs, du Mont-Royal et des sports (Department of Parks) to turn the site into a park and coordinate the work. A major initiative was then launched to determine the best way to proceed, in collaboration with the Service de l'environnement (Department of Environment) and the Ministère de l'environnement et de la lutte contre les changements climatiques (MELCC - Ministry of Environment and the Fight Against Climate Change). The process involved design workshops, research, testing, brainstorming and topographical models in order to develop the Master Plan for the site as a whole, which was adopted in 1997. That Master Plan, which is illustrated in Figure 2, provides the framework for teams working on the project, sets the guidelines for the site's rehabilitation and phase-by-phase transformation based on the principles of sustainable development. It defines the site mission and assigns 153 hectares to a metropolitan park and 39 hectares to businesses, environment-related industries and world-class cultural and sports institutions.

The landfilling was pursued until 2009 over 72 ha area with a depth up to 75 meters. It took five more years to complete the final cover.

Since the beginning of the park construction work, 48 ha have been finalised and open to the public and the rest will be progressively developed. There are a vast number of users that appreciate the vastness, the natural aspect and the biodiversity and fauna already present on site. The construction of the park will be finalized close to 2026 and it will then be completely accessible to the population.

This paper presents the steps of the metamorphosis of the landfill site into Frédéric-Back Park, since its take over by the City of Montreal. It first describes how it was made safe for the surrounding people and for the environment. Then it presents concepts and objectives behind its transformation into a park. It finally exposes the main actions taken to meet the needs of both past and future functions.

FIGURE 1: Frédéric-Back Park location in a densely populated area of Montreal, Province of Quebec, Canada.

2. AN ENVIRONMENTAL REHABILITATION

2.1 Landfill gas management

In 1988, the collection system was under designed. It was made of 40 vertical collecting wells and one 5100 m^3/h centrifugal blower (Héroux and Turcotte, 1997). Moreover those first wells were all located in a small zone which was covering about one fourth of the area devoted to landfilling. Many evidences of LFG atmospheric emissions and lateral migration were showing the inefficiency of the collection system. This is why the City of Montreal has made huge investments and efforts to control LFG. During the next 10 years, the collection system was gradually upgraded to reach 300 vertical wells, five 6800 m^3/h rotary lobe compressors and close to 20 km of collector pipes. Wells drilled close to the quarry walls were spaced 40 m apart to obtain an efficient control of LFG lateral migration while the wells located in the center part were drilled approximately every 60 m. Based on the results of an extensive environmental monitoring program (this program is described by Héroux, 2000) and the measured performance of the existing wells, 85 additional gas wells were added to the collection system from 1998 to 2007.

In order to estimate the efficiency of the gas collection system and make appropriate decisions regarding how it should evolve and how it should be operated, many research projects were carried on over the years:

- LFG surficial emissions (Héroux et al., 2010, Fecil et al., 2003);
- LFG generation and flow (Lagos et al., 2017, Héroux, 2008, Nastev, 1998);
- Methane biological oxidation (Héroux, 2008);
- LFG lateral migration (Franzidis et al., 2008, Nastev et al., 2003);
- Optimization of LFG collection (Héroux, 2008).

Those studies provide valuable measured data that permits to estimate a LFG collection efficiency reaching 95%, using a mass balance. This mass balance takes into consideration gas collected, surface emissions, biological oxidation, and lateral migration. This 95% efficiency is in the high end of what is reported in literature. For example, many authors report efficiencies that can reach 90% (Wang et al., 2020, Sun et al,. 2019, De la Cruz et al., 2016). Some others report that it can reach close to 100% (Ayodele et al., 2020, Lee et al., 2017, Spokas et al., 2006), depending of the phase of the landfill, the type of final cover and the extension of the gas collection system. Montreal site is in the aftercare phase, it has an extensive LFG collection system with a high density of wells, and its gas impervious final cover is completed. In this context, the estimated 95% LFG collection efficiency, based on data gathered on field studies, is consistent with efficiencies reported in the literature.

It was also possible to evaluate that a minimum of 150 wells would be required to keep this efficiency in the long run. Those projects have also motivated and contributed to the design of a 820-metre-long soil ventilation trench, built in 2006 and 2007 in the overburden along the north side of the landfill site. This trench is a LFG lateral migration control infrastructure that is designed to be operated passively or under vacuum.

Since 1996, collected LFG is compressed and burned in a power plant to produce electricity. At first, technology used consisted of a boiler, a steam turbine and an alter-

FIGURE 2: Frédéric-Back Park Master Plan.

nator with a total electrical capacity of 23 MW. With the decrease of LFG generation, a technological change was needed so in 2017, three LFG combustion motors were installed to replace the previous technology. Those motors produce up to 4.8 MW of electricity. Residual thermal energy of both technologies has been used since 2005 to heat the TOHU's building and since 2018 the Cirque du Soleil international headquarters, both located very close to the power plant. The TOHU is a non-profit organization that has a double mission: 1. promote circus arts by staging shows in a large circular theatre and 2. provide a welcoming pavilion and animation of the park.

The LFG collection system is planned to be maintained and operated for many decades. This is why it is integrated in the park design.

2.2 Leachate management

As mentioned earlier, prior to the beginning of the landfill operations, the bottom and walls were not rendered impervious. Therefore, there is an existing hydraulic link between aquifers and waste materials. The geological formations in and around the sanitary landfill site are of sedimentary rocks composed mainly of calcareous rocks with mostly horizontal layers, which vary from 10 cm to 100 cm in thickness. Groundwater moves through a network of cracks. Besides the stratification joints, three main sub vertical diaclases networks have been identified. In this area, groundwater is found at an approximate depth of 5 m to 10 m and its flow direction is N-E, towards Des Prairies River (Bériault and Simard, 1978). Hydraulic conductivity of the rock that was measured close to the site. It varies between 10^{-8} m/s and 10^{-5} m/s (Héroux and Dubois, 1994).

However, dams and crushed stones drainage canals were built to facilitate the flow of the leachate towards a pumping station made of two wells. The maximum flow of the leachate reaching the pump is approximately 1 800 m^3 per day. Such a flow allows for the creation of a depression cone the size of which is sufficient to direct the groundwater to the landfill site. That cone of depression makes groundwater flow in the landfill site and prevents groundwater contamination by leachate. The good quality of the groundwater around the site and the direction of the hydraulic gradients demonstrate the efficiency of the leachate control system. Since the groundwater that flows in the waste dilutes leachate, its chemical load is lower than what it is generally observed in landfill sites. However, it is important to note that a substantial part of the waste remains saturated.

When recovered at the pumping station, the leachate is then treated by oxidation to reduce its sulfide content prior to its disposal in the public combined sewers. Since the oxidation chamber was underground built, it is completely hidden from the view of the park users. From there, the treated leachate is sent to the sewer and reached the sewage treatment plant of the Montreal agglomeration. Because of a recent regulation modification, the treatment process must be revised in order to reduce leachate's ammoniacal nitrogen concentration. In this context, a new treatment plant will be in operation within the next two years. The leachate control and treatment are planned to be maintained and operated for many decades. The park is designed consequently so pumping wells and pipes are accessible for operations and maintenance.

2.3 Final cover

The design of the final cover was done according to several conception parameters. Its desired functions were prioritized as follows: 1) control of LFG 2) rules and bylaws 3) costs, 4) potential and future utilization, 5) geotechnical requirements, 6) maintenance, 7) control and management of leachate (Tremblay et al., 2001). The global selection process is described in detail by Tremblay and Héroux (1999). The design choices were, among others, based on results obtained on three one ha test plots that were constructed and instrumented to test some final cover concepts under field conditions. Tremblay et al. 2001, present the main results, of those experimentations.

The components of the final cover are the following, from the top to the bottom:

- Top soil (0.15 m): It is a mix of compost made on site out of leaves collected in the city parks and ramial chipped wood;
- Protection layer (0.45 m): It is a coarse excavation material that comes from Montreal's vicinities excavation works. It gives a mechanical protection to the underlying layer;
- Capillary layer (0.45 m): This layer is made of silt that comes from Montreal's vicinities excavation works. The capillary barrier effect occurs at the interface between two materials having different textures, permitting the finer layer to remain permanently close to the maximum effective water saturation. In this way the capillary layer is impervious to LFG flow and air infiltration;
- Filtration layer (0.10 m): The filtration layer is composed of close grading sand on top of a nonwoven geotextile. The function of this layer is to prevent the loss of the capillary material through the underlying drainage layer;
- Drainage layer (0.3 m): This layer is made of crushed stone, bricks, concrete and asphalt that are recuperating from road and building renovation or demolition. Its main function is to collect LFG that is not collected by the gas wells.

As it can be noted in the previous description, the only layer of the final cover made out of virgin materials is the filtration layer. All other components are built with recycled materials such as leaves, wood chips, excavation material or crushed construction and demolition waste..One of the main concerns regarding the park construction was to plant some trees on top of the final cover without compromising its capacity to achieve its functions. For example, would the root systems of the trees enter in the capillary layer and drain out the water which would increase its gas permeability? To answer this question, a plantation test was realized. Trees of 50 mm diameters were planted in 2005. Seven years later a field study of the root system of some of those trees was achieved utilizing a high-pressure air blow gun to remove soils around roots and rootlets without breaking them. Density of the final cover layers was also measured using radiation-type densimeter. Figure 3 shows two pictures of the field work involved in this study.

The main finding of this field study is that the roots don't penetrate the capillary barrier because its density is too high. This observation is reassuring with respect to maintaining the final cover's integrity and functions. However, as the root system remains shallow (it is confined to the protection layer) trees are more sensitive to high winds and are likely to uproot.

3. THE PARK'S MASTER PLAN AND ITS CONSTRUCTION

3.1 Master Plan - mission & objectives

The mission set out in the Master Plan is to create an environmental technology complex around a vast green space, turning the industrial past of the site into an asset and demonstrating the knowledge and skills required to develop and maintain such a project. The objectives are as follows:

- Encourage knowledge in environmental rehabilitation by establishing a site dedicated to environmental research, experimentation, innovation and education;
- Offer park activities oriented to the environment, sports, recreation and culture;
- Enhance the quality of life of Montreal residents in cooperation with the community, institutional and business partners;
- Help protect and improve biodiversity in Montréal;
- Contribute to the social and economic health of the community around the park.

3.2 Design concept

Based on the theme of metamorphosis, the Master Plan focuses on three characteristics of the site: Vastness,

FIGURE 3: Root cleaning with a high-pressure air blow gun (up) and cleaned roots (down) in the protection layer.

Environmental engineering and Unusual experiences. The site is divided into eight sectors, four in the Crown, the upper plateau that forms the site perimeter, and four others in the Centre, the excavated quarry and its natural features (Figure 4).

The Crown, which has been opened to the public since 1995, encompasses the cultural, sports and industrial-com-

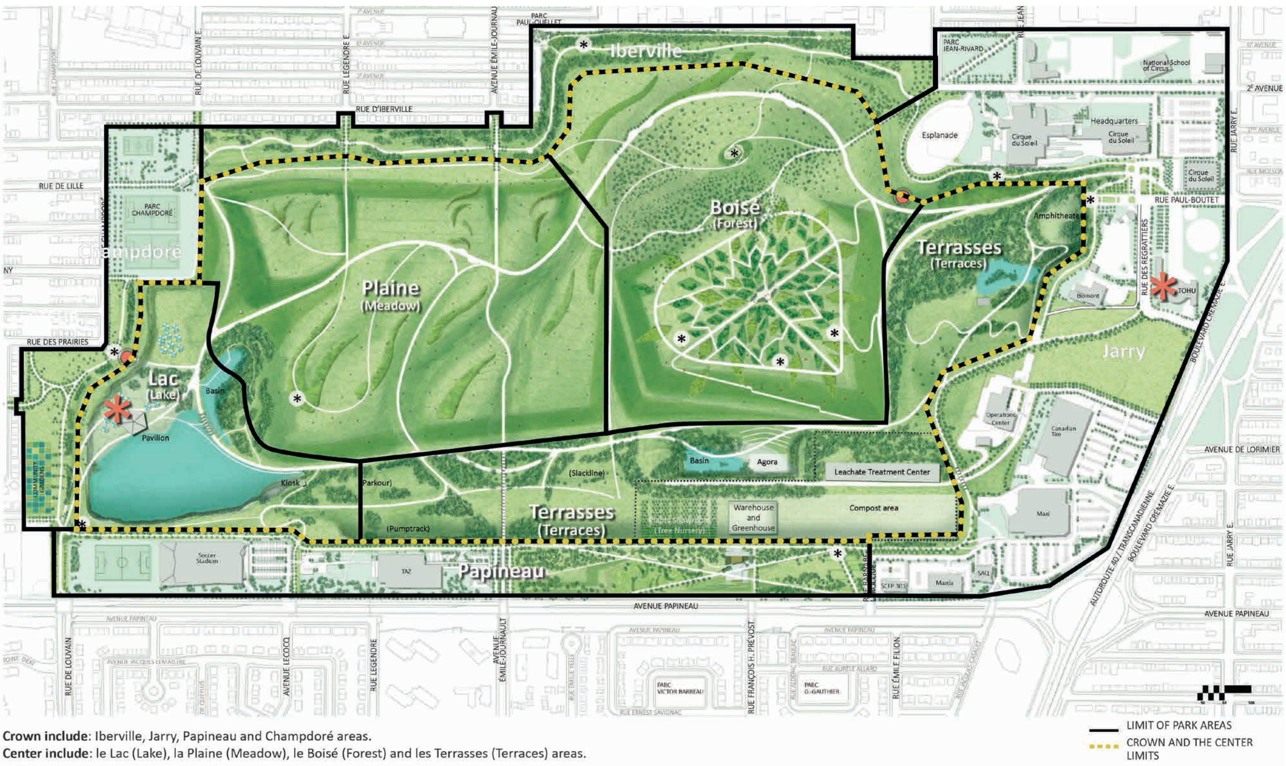

FIGURE 4: The various areas of the park.

mercial poles, the 17 entrances to the site, the Papineau (Figure 5), Champdoré, Iberville and Jarry sectors, and the 5.5-kilometre multi-use pathway that links them all together. It also includes the welcoming pavilion, businesses, and culture and sports institutions, the Parvis (which showcases the Centre), community gardens, three belvederes and several rest areas. Recent improvements include lighting, parking, washrooms, picnic areas and urban fixtures, as well as planted areas.

The Centre forms the middle of the site. It includes the area that was stripped out during quarry operations, and the landfill site. The Centre is divided into four sectors whose specific aspects, features and design are reminders of the site's past uses: the refreshing lake surrounded by limestone cliffs recalls the quarry; the windy plain, with its hilly slopes and grassy fields, evokes the landfill area; the secluded wooded area marks the current naturalization phase, with artworks dotting trails shaded by groves of trees; and lastly, the terraces connect with the urban context and provide unusual recreational facilities. There is a network of pathways and trails for walking, biking, cross-country skiing and snowshoeing, as well as street furniture, a pavilion for water-based activities, an agora and a natural amphitheatre for scheduled and spontaneous events. There are also picnic areas, naturalized retention basins, site-specific fixtures, and fun sports facilities. All these elements help to enjoy the vastness, unicity and historical nature of the site (Figure 6).

3.3 Design criteria

Given that the site's development is taking place in stages over many years, principles were established to guide the designers and ensure a coherent approach between the sectors and within each phase of construction. Four main principles were defined:

- Intervene with a sustainable and environmental approach;
- Emphasize the genius loci of the site and its unique nature;
- Offer a site that is welcoming, safe and accessible;
- Encourage research, education, innovation and creativity in site design, activities and management.

More than 50 actions derive from these principles, including the following:

- Ensure ecological management of runoff and storm water, as well as waste materials;
- Promote the use of renewable energy;
- Use recycled waste materials to create the park;
- Focus on public transit and active modes of transportation to access the park;
- Create pathways that are inviting and easy to use in every season;
- Create vistas around the park to incite visitors to go towards the centre;
- Showcase the history of the site and offer views of Montreal landmarks;

FIGURE 5: The Crown, sector Papineau.

FIGURE 6: The Centre: open section to the public of the secluded wooded area during summer time (up) and winter time (down).

- Encourage research and technological innovation;
- Create facilities that will foster activities in relation to the environment, education, recreation and culture (Figure 7);
- Strengthen visitors' social and environmental awareness.

3.4 Timeline and costs

Figure 8 shows the construction sequence of Frédéric-Back Park which the main milestones are listed as in Table 1.

The park's construction costs, financed by the Montreal Agglomeration, are estimated at 350M CAD, with 120M CAD already spent for the previous phases. Other municipal investments of 60M CAD were made for municipal facilities, with another 100M CAD to come. Meanwhile, the private sector on site has invested 106M CAD in its facilities, with another 150M CAD announced for the next five years.

4. THE NEEDS OF BOTH PAST AND FUTURE FUNCTIONS

Transforming Frédéric-Back Park is a complex act that demands a bold, creative and innovative approach. Creating a park on such a large landfill and opening it to the

FIGURE 7: Various activities organized in the Frédéric-Back Park.

public while the buried waste is still decomposing and releasing LFG and leachate is a highly unusual endeavour. It has taken vision, perseverance, ingenuity and courage to develop this green space, as well as an exceptional collaboration between two municipal departments (parks and environment), with some support from the MELCC, experts from the private sector and specialized contractors.

4.1 Opportunities and restrictions

The project offers unique opportunities and interesting reminders of the history of Montréal, including three kilometers of cliffs created by the removal of limestone used to build the city. It also offers spectacular vistas of the downtown area and local landmarks, as well as views overlooking the park. In addition, naturalized retention basins encourage the already astonishing biodiversity on the site, and the environmental monitoring equipment can also be used for educational purposes. Lastly, phase-by-phase implementation has allowed for ongoing feedback and adjustments. Despite the opportunities, the site presents considerable constraints. This is why, significant restrictions must be taken into consideration for the project, amongst them:

- Unpredictable soil movements caused by the subsoil;
- Ensuring careful daily management daily maintenance of the LFG and leachate generated by the decomposing buried waste;
- Dry and clayey soil for planting with dry and windy conditions, which limit the type of plants that can be used;
- The need to quickly evacuate runoff water away from the landfill area, which affects the vegetation planted there;
- The difficulty to ensure security of the lower enclosed site surrounded by over 3 km of cliffs, with little visibility from the street (Figure 9);
- Limited public transit services and parking spaces in the area.

4.2 Rules and regulations

The park construction is regulated by many government levels. Obtaining the required various permits was a complex task.

The MELCC is responsible for regulating sanitary landfill sites operations and closure. It is also responsible for the construction on top of such sites. Moreover it regulates for natural habitats, undesirable plants and plans of water. All construction actions must thus be pre-authorized by this ministry.

The management of wild animals is handled by a provincial law, while the protection of bird species is governed by federal legislation. This has an impact on work timelines, and involves mitigation measures that increase the project's complexity.

Frédéric-Back Park and the landfill are part of Greater Montreal, the 16 boroughs located on the Island of Mon-

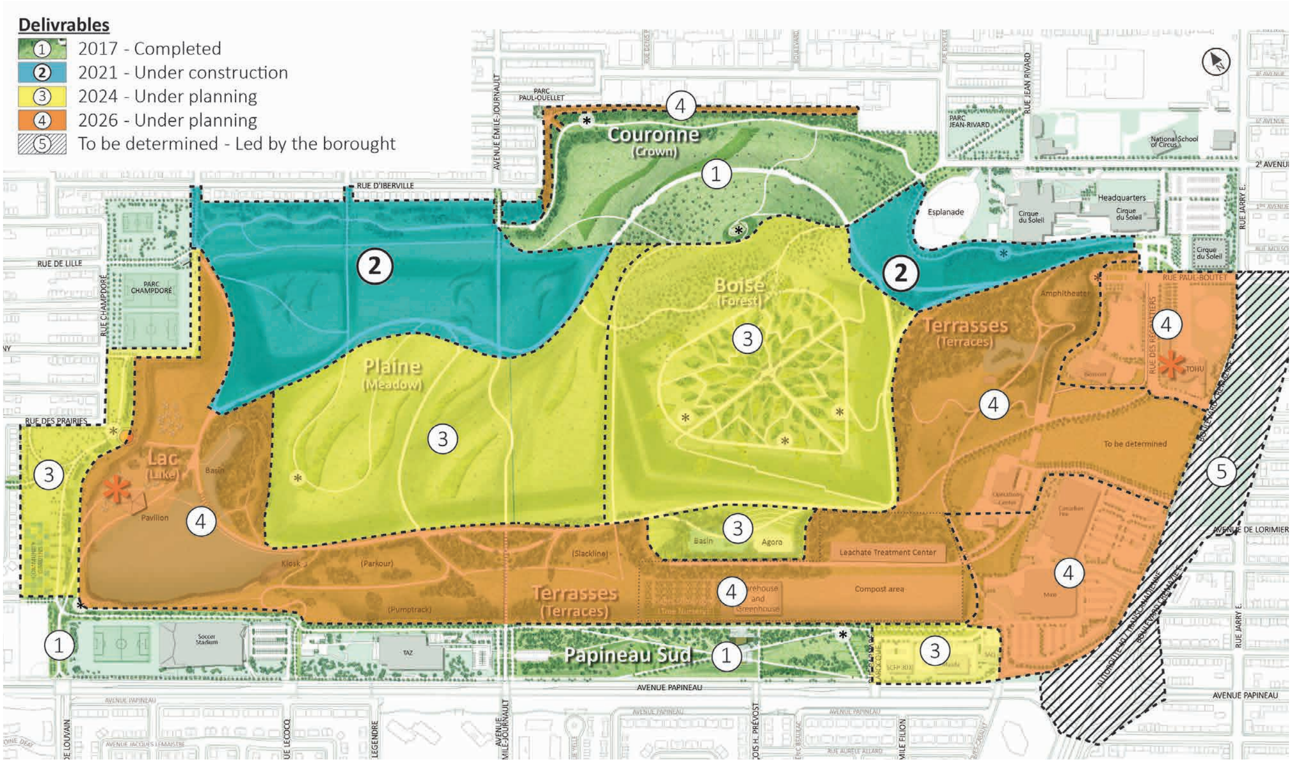

FIGURE 8: Construction sequence of Frédéric-Back Park.

tréal, including the City of Montreal. The funds for managing and developing the site come from this administrative unit, which means that the impact of the park effectively extends beyond the City of Montreal.

Furthermore, the City of Montreal is responsible for various issues that affect the site: sewer discharge quality, air quality, public safety, etc. Activities related to park design and subsoil monitoring require approval from eight different municipal departments (water, environment, public safety, culture, buildings, infrastructures, and boroughs for the urban development plan and permits).

4.3 Issues Management

A management strategy has been drawn up to limit the scope of some of the issues identified over the course of the project. The following are six examples of issues and solutions devised to reduce the risk of problems:

- To reduce costs and protect the environment, materials have been recycled for appropriate uses within the park. The storage of such materials is only authorized on 15% of the park area. Every six months, the planning of stored materials and operations is updated to ensure safe access to the materials without interfering with truck routes on the site;
- The sequence of each phase of work must take into account the safety of both visitors and workers, as well as storage capacity, runoff patterns, improvements to the underground environmental monitoring system, the boundaries of each work site when several contractors are working at the same time on site, etc;
- The sectors opened first for technical reasons allow walking, observation and simple enjoyment, but the demand is high for activities that are presently inappropriate due to the subsoil composition. The animation team offers pleasant activities that do not impact the newly constructed areas while the planning and communication team promotes an interest in the later phases of the park, where more intensive uses will be permitted;

TABLE 1: The main milestones of the design and the construction of Frédéric-Back Park.

Years	Realizations
1988	Site management is taken over by the City of Montreal
1988 - 2014	Consultations and elaboration of the Master Plan adopted in 1997 / Construction of the Crown (30 ha) and its multi-use linear trail / Establishment of businesses, industries and institutions on 45% of the perimeter area / Adoption of a sustainable development chart and design guidelines / Authorization from the provincial ministry to start developing the Centre
2015 - 2017	Construction of the park's block 1 (19 ha), including part of the Centre
2018 - 2021	Construction of the park's block 2 (24 ha), planned to open in 2021 Updating of the Master Plan and design guidelines (2020)
2022 - 2026	Construction of the park's blocks 3 (35 ha) and 4 (45 Ha)

FIGURE 9: Securing the cliffs.

- Human-wildlife cohabitation is a goal for the park, but the social acceptability of some animals on the site is a complex issue. To facilitate cohabitation, design planning is done to achieve a balance between the areas opened to humans and the areas assigned to animals. This is complemented by educational and awareness-building activities, along with guided tours by wildlife experts to help visitors understand the role of wildlife in the ecological balance of the park;
- In 2000, a project with local citizens was realized with an international artist: huge circles of flowers were created in the unopened area, symbolizing the pollination of the site. These circles were to stay there for a few years but the following year, a major soil collapse required corrections and the circles had to be eliminated. To avoid deception and frustration amongst participants, the City explained the situation and proposed to donate the flower plants to the local population, asking them to pollinate the whole neighbourhood. Citizens still send us pictures of the donated plants in their backyard;
- The planting conditions in the park are difficult and plants must be young and small to survive and grow in such harsh conditions. At the same time, people want to use the park and do not realize the impact their presence has on plants and seeding. This is why we provide extra attention to the plants in the first 3 to 5 years, like a nursery, by isolating certain planting beds, resowing grasses and ground cover every year, planting more densely at first then transplanting to respect space needed, etc. These actions are time consuming but help citizen appropriation and maintain the interest for the park.

4.4 Creativity at its best

The following are some examples of the City's creative response to the site's realities.

4.4.1 Sustainable actions

Over the years, many actions were developed to promote sustainable development of the park. Here are some of these:

- A sustainable development charter was drafted specifically for the park;
- The fence separating the area open to the public from the closed area under construction is installed over crowd control barriers, which means it can be relocated easily when needed;
- Native plants are used to reduce maintenance, watering needs and to foster biodiversity (ex.: planting corridors dedicated to monarch butterflies and pollinating insects, ecological niches for threatened species on the site, etc.);
- The centre of the park is a zero-waste area;
- Park activities are organized with a partner (la TOHU) who has a local hiring policy;
- Two sustainable mobility hubs will be created on the site in 2019 and 2021 to encourage active, environmentally friendly and sustainable trips to the park, and reduce dependence on cars;
- Given that leachate and LFG will be produced for sever-

al more decades, the proposed facilities and equipment are modifiable and evolving to ensure their usefulness throughout that time;
- For each new design phase, presentations and information sessions are organized with elected officials, the general administration and citizens/partners to sustain everyone's interest and involvement in the project;
- Since 2005 guided tours of the site are offered to adults, senior citizens, students of all ages, and day camp children to heighten awareness for sustainable and ecological changes in their own life.

4.4.2 The spheres

Before opening the central area of the park to the public, the LFG collection wells needed to be protected. This is why the spheres were designed with practical and aesthetic functions in mind.

They first provide an easy access to the LFG collection wells for monitoring and adjustments.The round shape helps the case's integration with the rolling topography. The three windows that allow the passage of air prevent the entry of insects and rodents. The spheres are covered with a phosphorescent film that absorbs UV from the sun during the day and releases it at dusk, echoing the starry skies. At night, a flashlight can be used to 'draw' on the surface without leaving any permanent marks. Some spheres are shown in Figure 10.

4.4.3 Selective plant material

A variety of planted landscapes is encountered when travelling through the park; species are determined by the thickness of the planting soil, added on top of the final garbage cover. With rain as the only water source, the selected plants have to be hardy, drought tolerant, and offer seasonal interest. Given the environmental mission of Frédéric-Back park, native Quebec plants that can handle the difficult conditions of the site are preferred to create natural wildlife habitats. They also contribute to reduce urban heat islands. Through these actions, the park helps the City of Montreal to meet its goal of improving biodiversity in its territory.

4.4.4 On-site material reuse

In the development of Frédéric-Back Park, major emphasis has been placed on recycling and recovering of old materials. Ultimately, nearly five million tonnes of material will be reused instead of going to landfill or being burned. Here are some examples: The soil used to build the park is a mix created on-site with recycled materials (earth and sand from other construction sites, compost from the fall leaves collected by the city, tree-pruning waste). It is less expensive and more ecological to produce the soil on site than to buy it from soil suppliers.

Before any work can be done near a cliff, and to prevent rock falls, the cliff must be made secure. This operation creates rock debris that is collected and crushed, then reused as a sub foundation and foundation for the park's pathways and roads. Boulders are reused as well to build retaining walls and steps, to create seating along pathways, etc.

Ash trees attacked by the emerald ash borer and cut down by the City of Montreal are retrieved, planked and

FIGURE 10: The spheres are designed to protect the LFG collection wells and make part of the park experience.

thermo-treated then used to build custom furniture for the park (Figure 11). This wood is also considered to be used in future buildings, signage, activities.

The granite edging and paving stones stored on site for some 15 years are being used to construct irrigation ditchers, to create rest areas and to delimit crossroads in the pathway network.

A small nursery was created on site to receive suitable plants removed from other city parks or surplus plants from the municipal nursery. These plants are the first ones to be used in areas under construction.

4.4.5 Biodiversity

Many animal species live in Frédéric-Back Park and some are considered rare, vulnerable or threatened. To help them survive and to enhance biodiversity, park improvements include specially designed habitats such as bird houses and perches, pollinator, monarch butterfly and coyote corridors, a marsh for amphibians and aquatic birds with nesting areas, and so forth. When wildlife is affected by design elements, the design is modified. For instance, decals will be added on glass railings to avoid bird collision, bird injuries are prevented by modifying the ignition of the LFG flare, etc.

4.4.6 Ecological storm water management

In Frédéric-Back Park, rainwater is controlled and directed along the surface to keep it from seeping into subsurface waste materials and generating leachate. The hilly topography of each watershed (there are 3 on the site) quickly channels water to ditches leading downhill to a retention basin. This technique is more environmentally friendly and less expensive to build and repair than standard techniques. It also resists better to soil subsidence, does not need protection from freezing, and nurtures biodiversity. Ultimately, the retention basins for the south and west watersheds will be enlarged and naturalized to create interesting wildlife habitats; the north watershed will have a filtering first flood marsh where water will be cleaned before being directed to the lake, where activities such as canoeing, pedal boats or kayaking are considered.

4.4.7 Zero waste promotion

The park is built on 40 million tonnes of waste that was landfilled over more than 30 years. The vastness of this park really marks the imagination and therefore helps bring citizens to realize how much waste is produced by the human kind. This very special environment creates awareness to help promote the zero-waste concept. Also note that to create even more awareness it is planned not to install waste receptacles in the Centre. Instead, people will be asked to carry any waste they produce onsite to the perimeters of the park (the Crown) where the specific waste receptacles are installed. To incite users to dispose of their waste in this manner and to explain zero-waste-concept, educational panels will be strategically installed where users are most likely to produce waste, for example, in picnic areas.

5. CONCLUSIONS

The City of Montreal is in the process of converting a large landfill into the Frédéric-Back Park for the benefit of

FIGURE 11: Ash trees attacked by the emerald ash borer being used for furniture.

the population. This process was initiated 35 years ago and should be completed by 2026. It is the result of a close collaboration between the Department of Parks and the Department of Environment of the City of Montreal in order to meet the needs of both past and future functions of this site. Montrealers already enjoy the areas of the park open to the public every season of the year to engage in pleasant recreational activities or take part in festive events at this stunning venue with unique views of Montreal.

The site development has been supported by seven different administrations since the beginning of the project because it represents a win-win goal for the best ambassadors of the park, the citizens themselves, and the other stakeholders.

Many presentations regarding this project have been made to local, national and international forums over the last 25 years. Also, more than 40 papers have been published in general and specialized journals within Canada and internationally. Every year, the park receives 80 to 100 requests for technical visits from national and international delegations. Moreover it received many prizes and recognition, among others a Merit prize, in 2004, from The International Award for Liveable Communities and a Gold Medal Award from Expo Shanghai 2010 - Environmentally Sustainable Projects.

Frédéric-Back Park is Quebec's most ambitious environmental rehabilitation project in an urban setting to date. It's an ongoing experimental lab based on creativity, innovation and know-how in environmental technology. This project helps position Montreal as an innovating city and offers municipal residents an original park they can be great pride of!

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IWRECKS PILOT SCENARIOS: REDUCING WASTE AND AVOIDING THE THREATENING OBSOLESCENCE IN ARCHITECTURE

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ABSTRACT

Obsolescence is something deeply linked to the production of waste, from the scale of small technological devices to the scale of urban stuff. The obsolescence of urban built environment, made by large buildings, vast areas, and even whole districts, is of course a more complex phenomenon to manage, if compared to the programmatic obsolescence of technological products. For this reason, intervening on the acknowledgment of the abandoned or decommissioned building, both in terms of highlighting a sort of heritage component and their reusing potentials, can mean a reduction in the number of buildings to be demolished and therefore in the production of rubble and waste. These topics have been dealt with in two research projects carried out at the University of Padova. The former (2017-2018), DATA_Developing Abandoned Transurban Areas[1] aimed to propose sustainable future scenarios and develop ground-breaking strategies for the development and economic boost of scattered urban areas, focused on a territorial and urban scale to investigate effective regeneration practicability related to the location of the artefacts and the settlement situations around them. The latter (2018-2019), iWRECKS_Industrial Wrecks: Reusing Enhancing aCKnowledging Sheds[2] essentially focused on the architectural scale aimed to provide innovative transformation visions to professionals, entrepreneurs, investors and citizens coping with the reuse of abandoned industrial buildings. Upgrading abandoned industrial sites and buildings has proved again to be a central issue in political and urban-focused debates in Italian north-eastern areas, particularly so in Veneto.

1. INTRODUCTION

The recent global economic crisis has worsened and highlighted the impact of shrinking productive activities such areas have been subjected to since the 90s. This has led to a “cumbersome” legacy as far as both the presence of useless over-built areas and economic losses are concerned: Veneto has been engulfed with increasingly empty and scarcely appealing industrial buildings, either owing to their being situated in suburban and rural areas, or to the poor quality as regards their construction-related, architectural and energy-efficient features.

According to the real estate report for the year 2019, published by the Territory Agency (Agenzia del Territorio, 2019), in Italy there are about 800,000 industrial buildings. Among them, about the 60% are located in the north part of the Country (Emilia-Romagna, Friuli-Venezia Giulia, Veneto, Liguria, Lombardy, Piedmont and Valle d'Aosta), while the remaining 40% is distributed in central, southern regions and islands. In Veneto Region 93,678 industrial buildings are estimated (12% of the whole national park), an amount that places Veneto as the second Italian region in industrial estate. In Veneto there are about 11,000 abandoned industrial buildings, accounting for about 3,9 billion euros of unused resources, rising to 7,9 billion if the satellite activities resulting from upgrading said buildings is to be reckoned (Confartigianato Veneto, 2017). Such data should be crossed with soil consumption, which in Veneto is the country`s highest: in 2013 8.4% if compared with Italy as a whole (ISPRA, 2015).

Such industrial wrecks, clogging a slackening economic context, become a relevant challenge for an area that has always relied on productivity as its strong point – first concerning agriculture, later industry.

Notwithstanding the fact some moves may hint at a greater global awareness of the issue, if compared with the past, (the Regional Law concerning Soil Consumption[3] is the latest, though not the only one), it is necessary to further activate suitable steps leading to positive assessment of the empties and to upgrading several impaired urban and environmental contexts. Regulatory and technical instruments should in fact be backed up by the ability to

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foresee the features of the buildings and the areas, to devise groundbreaking shapes, usages and functions so as to further the resorting to their precious spatial, social and economic resources anew.

2. ACKNOWLEDGING INDUSTRIAL STUFF

In order to hope for and spark off a change in assessment and outlook (which is where projects start from when approaching unused or partially-used, end-of-life industrial and manufacturing buildings in suburban areas of modern towns), it is useful to construct (nay, to deconstruct) some wider arguments. Such arguments involve the perception and the awareness of shapes and relate to the cognitive abilities of people in general, not just of insiders or architects. Since the first stages of the analyses of the iWRECKS research project, during the first meetings with owners and stakeholders to sound their involvement and evaluate the case studies to be examined, the resort to different defining words by our counterparts has been noticed; only seemingly were they chosen unconsciously and automatically when referring to certain manufacturing buildings, storehouses and hangars. Some buildings were defined by their owners or by the ones in charge as "warehouses" or "storehouses", whereas others – quite indisputably – as "Cathedral" (for example one of the hangars of the SIT[4] in North Padua ZIP), or "Basilica" (applied to the Legnago, near Verona, former Montedison storehouse). The same applies to the former Cattle Market of Padua[5] (Figures 1, 2 and 3), located alongside Corso Australia ring road, though not examined in this research project; baptized by the local inhabitants "The Cathedral" (to tell the truth, it looks rather like a huge mosque than a cathedral, but this is another matter...), to the community and people`s committees (there is even a Comitato Cattedrale Davanzo) it has become a recognizable urban fixture that should by all means be preserved, beyond and independently from often restrictive and counter-productive statutory environmental requirements.

Therefore, even before deciding by means of an architectural project to tamper with a building in order to prolong its shelf-life, it is obvious that well-known and established artefacts such as the Basilica or the Cathedral (there might even be the Tower, the Pyramid, the Cube and further wrecks simply not examined during this year of research) will be less liable to become obsolete. Actually, it sounds odd to refer to the pyramids of Giza as "former tombs", or to the Colosseum as a "former amphitheatre", or to the Eiffel Tower together with the wide mall stretching at its feet as a "former Expo area" (whereas immediately after the 2015 Milan Expo it was deemed necessary to set up the "Expo after Expo"[6] nation-wide team of experts, heavens know why).

This unwillingness – underlined by the habit of resorting to the "former" prefix – to overcome the function and abstract the form of things, which end up being defined according to their functional call, leads to a corresponding inability of the buildings themselves to adapt to new features and new lives. In this strange – though easily under-

FIGURE 1: The former Slaughterhouse (1968) of Padua, Italy, by architect Salce, now infrastructure and road waste municipal storage (photo by S. Antoniadis, 2018).

FIGURE 2: The former Slaughterhouse (1968) of Padua, Italy, by architect Salce, now infrastructure and road waste municipal storage (photo by S. Antoniadis, 2018).

FIGURE 3: The Former Cattle Market ("The Cathedral") of Padua (1965-68), by architect Davanzo, now infrastructure and road waste municipal storage (photo by Stefanos Antoniadis, 2012).

standable – hypothesis formulated by Sapir-Whorf[7] applied even to urban organisms, the destiny of buildings seems to be unsplittable from the language describing them, piling up cognitive and manipulative staples that condition any possible future re-purposing.

Re-purposing becomes in fact the typical solution for buildings and slices of town-areas no longer performing; it is in fact maintained that re-purposing should withstand the ticking forward of time. This research has tried to suggest alternative approaches, namely the visualization of formal rather than functional categorizations.

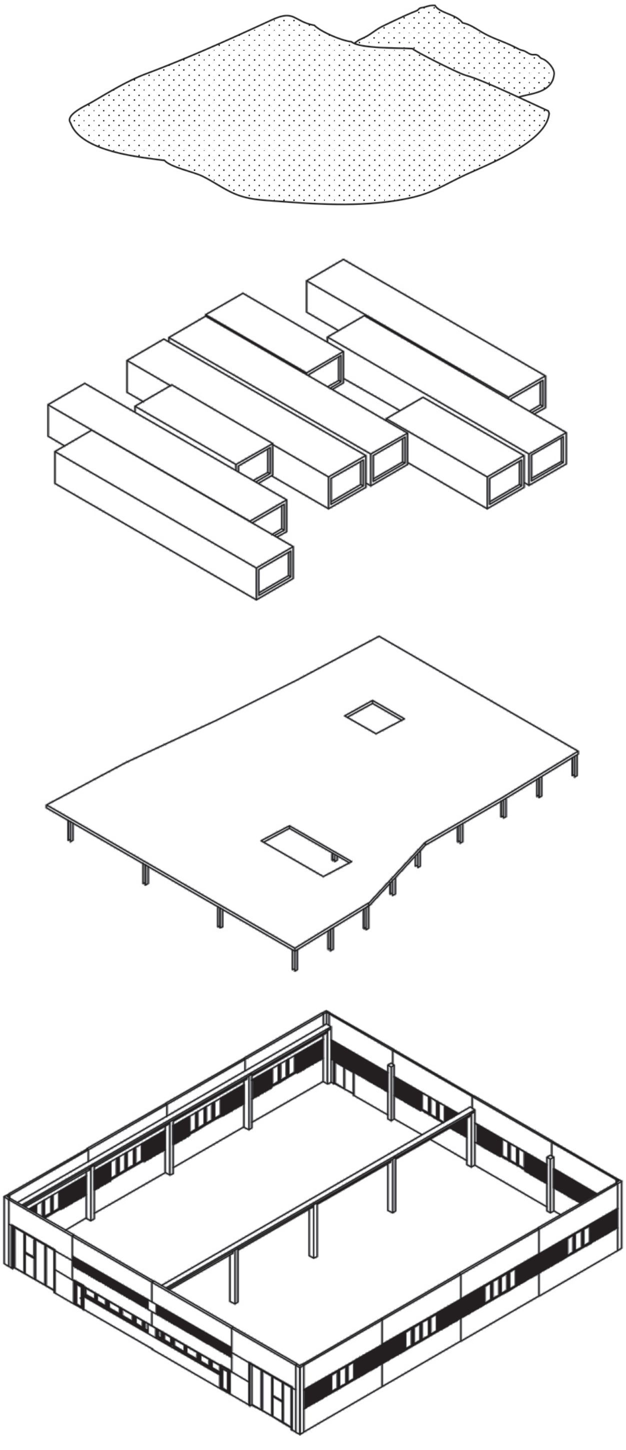

FIGURE 4: Formal elements for the industrial estate regeneration (scheme by iWRECKS, 2019).

Most of these industrial sheds were built starting from the post-war years using structural solutions able to guarantee large covered and easily adaptable spaces. According to the construction system, these warehouses can be classified in steel frame, precast or cast-in-site reinforced concrete structure. Sometimes prestressed precast concrete beams and masonry structures can be found too, but approximately the 80% of the Veneto region cases consists in the typical single-storey precast reinforced concrete buildings from the last decades (the constellation of small, medium and large "boxes" that dot the Po Valley landscape), eventually equipped with a mezzanine for offices.

The case studies selected exemplify both the different structural and material cases and various degrees of formal quality to highlight a complete suite of intervention criteria that could be usefully applied to broaden the range of options available: some belong clearly to the well-defined category of industrial archaeology (the Thiene end-of-the-XIX-century Facchinetti former button factory), some are striking cast-in-place-concrete buildings (referring to the huge former Montedison storehouse in Legnago, near Verona), there are also the large areas taken by the 70s vaulted sheds (the former Miralanza storehouses in the south part of the industrial district in Padua), the newly-devised small and medium-sized boxes of typical pre-fabricated sheds (one of the buildings of the SIT area in the north one) and the AMAT[8]. in the Veggiano industrial area in western suburbs of Padua) that prove to be the most widely present industrial buildings typology for the area.

The manipulations are meant to enact a new, flexible spatial set-up that can be applied in different ways, depending on the formal features of the context.

3. FROM WASTE INTO RESOURCE

Starting from the layout of the simple elements of the composition, an attempt has been made to analyse and organise them according to formal configurations consistently and suitably, depending on the case studies. The elements can accordingly be categorised as hollow parallelepids (S, M, L, XL boxes), either flat or folded planes, and heaps (i.e. mounds resulting from the piling up of suitably blanketed materials from demolitions and reclamations, which shape the features of the landscape anew), in order to identify a series of ad hoc (though at the same time flexible) strategies that may be applied beyond the case study (Figure 4).

Wherever buildings were high enough to allow double-height partitions, the choice has been to resort to a supporting floor on top of which the boxes were arranged, so as to employ two floors: the ground floor for services, the first floor serviced. An example can be the AMAT shed (Figure 5), but this also applies to most hangars throughout Italy. Precast roofing allows to obtain openings and patios by simply removing some elements (which has been suggested by surveying the state of decay of the hangar). The devised scenarios show how a quite ordinary set of pre-fabricated buildings can be transformed into a cluster of urban villas, or a lovely old-people home, or a school, or a co-working hub (Figures 6 and 7).

On the other hand, when the height forbids the creation of two habitable floors (for example the former Miralanza shed), the only floor can be reshaped creating lay-bies and shelves that can be easily turned into sports plates, skateboard tracks and MTB[9] Park indoor and swimming pools (Figure 8); this is highly cost-efficient, since no digging is required (no waste material produced); the equipment lies on top of the ground: beneath are arranged the servicing

FIGURE 5: The AMAT shed in Veggiano, Padua, Italy (photo by S. Antoniadis, 2018).

FIGURE 6: Transformation scenario for the AMAT shed (image by iWRECKS, 2019).

FIGURE 7: Transformation scenario for the AMAT shed; section (image by iWRECKS, 2019).

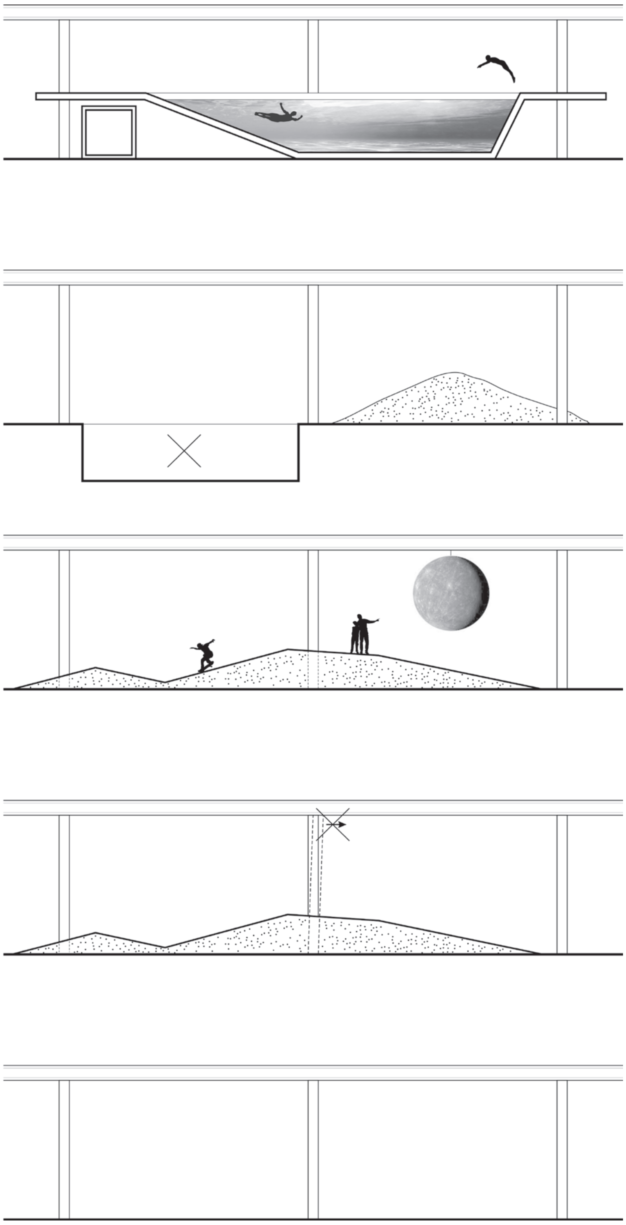

FIGURE 8: Formal, structural and waste management strategies applied to the typical industrial shed section (scheme by S. Antoniadis, 2019).

box-like elements (locker-rooms, toilet facilities, technical and pump rooms, etc.) (Figures 9, 10, 11 and 12).

Whenever the height is suitable, instead, the aptly-distanced boxes can afford the use of space at various levels: reckoning the available volumetric dimensions, the useful surfaces can best be employed; besides, they can even afford suitable observation points when the available space is special and stately as in a basilica (e.g. the SIT hangar and the former Montedison storehouse) (Figures 13, 14, 15 and 16).

If the building is rather small and its structure irregularly-cut (the reference is Facchinetti former button factory), placing in it various box-like elements and planes would create a clutter – even from a spatial point of view – rather than provide a solution. Here the box-concept may aim for a different, much bigger range, somehow reversing the container-contents formula, by partially "encasing" the original blocks and tracing a clear-plastic envelope, a winter garden, a communal space to be enjoyed together with the rebirth of the wreck, according to the devised upgrading of functions.

4. CONCLUSIONS

Spreading and multiplying these manipulative opportunities to all those similar instances that can be identified in the field of survey (help is provided by creating a map of the buildings that can be converted on GIS database) is indeed possible to figure a scenario of sweeping innovation involving whole areas, so far mainly devoted to productive or industrial activities. These items, mainly regarded as atopic, commonplace, ugly[10] and embarrassing, in their having become real stereotypes, have acquired the status of staple buildings, the target of systematic upgrading that can be easily shared. Uploading these multi-scalar and multi-criteria data in online platform such as the National Geoportal, the Regional ones or other territorial local offices webmaps could provide a sort of "transformability map" of the built environment to administrations and stakeholders' attention. An often only half-glimpsed potential that the research project, by elaborating new scenarios, means to bring to the notice of owners, decision-takers, law-makers and citizens, so

FIGURE 9: The Miralanza former storages in Padua, Italy (photo by S. Antoniadis, 2019).

FIGURE 10: Transformation scenario for the Miralanza former storages (image by iWRECKS, 2019).

FIGURE 11: The Miralanza former storages in Padua, Italy (photo by L. Siviero, 2019).

FIGURE 12: Transformation scenario for the Miralanza former storages (image by iWRECKS, 2019).

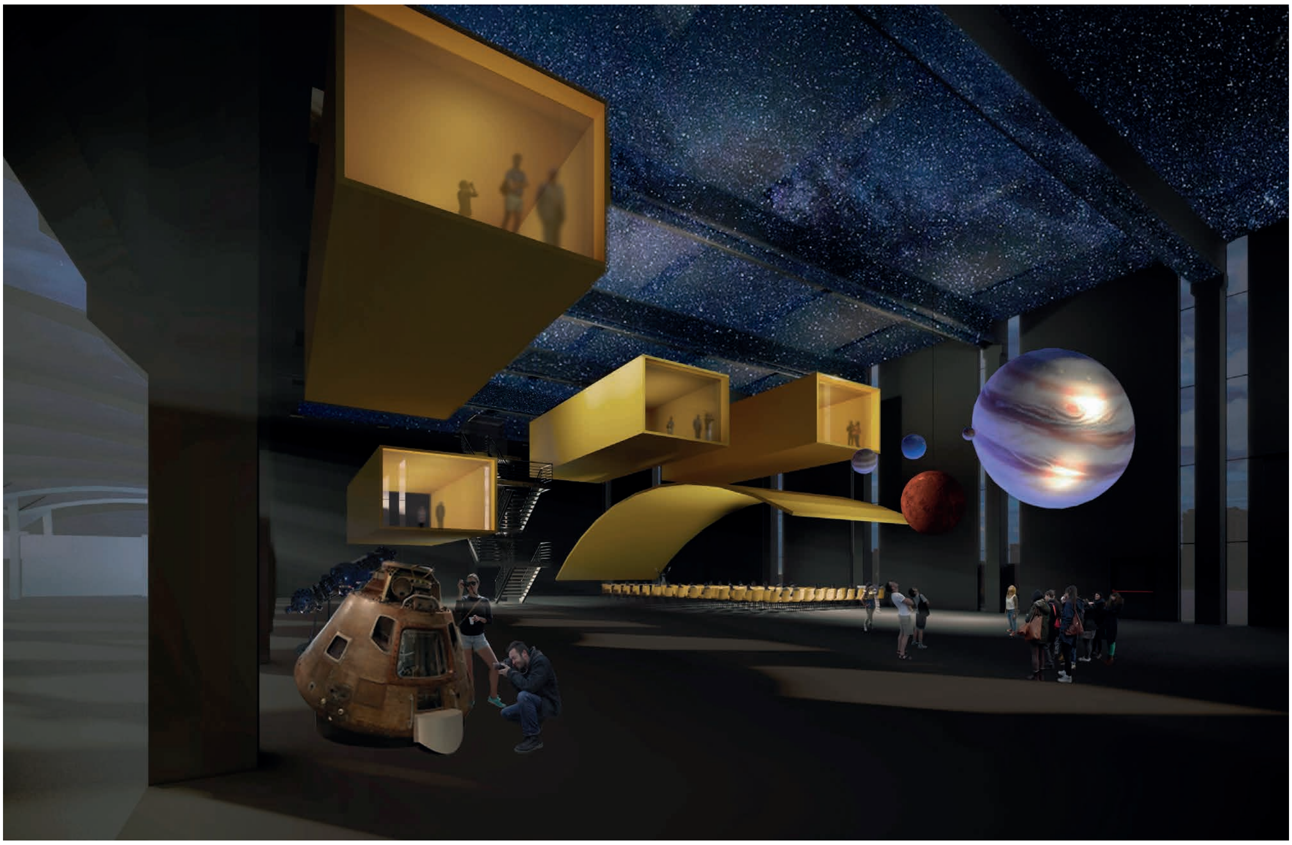

FIGURE 13: Transformation scenario for the SIT shed in Padua, Italy (image by iWRECKS, 2019).

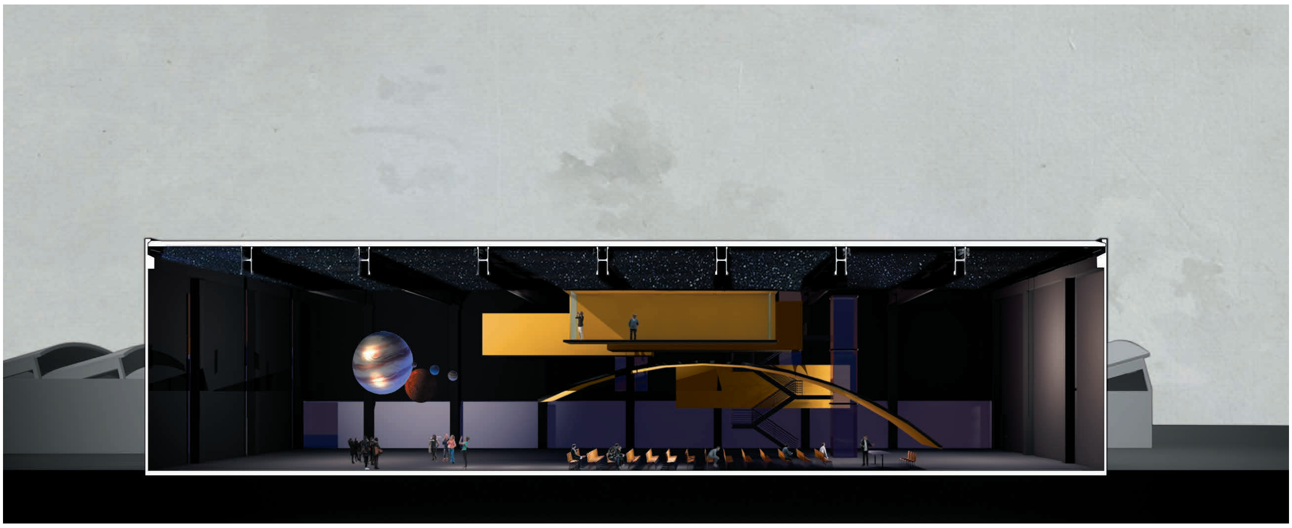

FIGURE 14: Transformation scenario for the SIT shed in Padua, Italy; section (image by iWRECKS, 2019).

as to improve an active awareness of contemporary landscape, with its failings but also challenges and potentials it affords. Last, but not least, such wrecks can be transformed even taking waste production and management into account: regarding abandoned industrial hangars as potential sources of so-far-not-foreseen transformations would mean a sharp cut in the number of buildings to be demolished – since written down as "unusable" – (and therefore in the amount of rubble). On the other hand, "cities have become very significant centres of consumption and transformation of resources [...] something that requires a dramatic rethinking about the energy systems that currently support our cities, but also the general organization and planning of urban areas towards sustainable forms." (Rosales-Carreon, 2018) Barring "refusing" progress – which is obviously unacceptable –, bearing in mind ours is a circular economy, "rethinking" is truly the first of viable strategies[11].

FIGURE 15: The Montedison former storehouse (the "Basilica") in Legnago, Verona, Italy (photo by S. Antoniadis, 2019).

FIGURE 16: Transformation scenario for the Montedison former storehouse (image by iWRECKS, 2019).

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[2] Regional Operational Programme 'Veneto' 2014-2020, iWRECKS_Industrial Wrecks: Reusing Enhancing aCKnowledging Sheds, DGR n. 11 05/01/2018, project code 2105-59-11-2018, funded by ESF. Steering Board: Stendardo L. (P.I.), Dias Coelho C., D'Acunto G., Lavagnolo M.C., Savino M.. Research Fellows: Antoniadis S., Bernardello R., Malesani R., De Stefani E., Redetti E.; Junior Research Fellows: Borin P., Gonzalez-Libreros J., Pristeri G., Siviero L., Spera R.; Visiting Fellows: Padrão Fernandes S., Silva Leite J., dos Reis Costa P.; Partner Companies: Archetipo, Arcoplan, Cimolai, Contec, Duff&Phelps Reag, Dal Zotto, Eco Avant-Garde, Expin, LTS-Land Technology & Services; Network Partners: Universidade de Lisboa, Università Iuav di Venezia, Assindustria Venetocentro, ZIP - Consorzio Zona Industriale e Porto Fluviale di Padova, AIAPP - Associazione Italiana di Architettura del Paesaggio, Centro Studi Usine, Fórema.

[3] no. 14 Regional Law, 6th June 2017 "Norms concerning curbing soil consumption and modifications of the no. 11 Regional Law, 23rd April 2004 Norms regarding monitoring land and landscape".

[4] SIT Group – Società Italiana Termomeccanica "La Precisa" (Italian Thermomechanical Society).

[5] Work signed by Paduan architect Giuseppe Davanzo (1921-2007), resorting to pre-fabricated technology in 1965-68 and abandoned soon afterwards.

[6] It was suggested by Oxway and Corriere della Sera and taken up by several Italian universities, research and professional groups: its aim was to prevent the 2015 Milan Universal Exposition site from becoming just a huge area fallen into disuse.

[7] Sapir-Whorf hypothesis, from the names of the linguist and anthropologist Edward Sapir (1884-1939) and of his henchman Benjamin Lee Whorf (1897-1941), maintains that not only each individual`s cognitive development is influenced by the language he/she speaks, but even that language determines thought and therefore existence itself.

[8] AMAT Srl – Technoshapes for Industry.

[9] MTB stands for Mountain/Trials Bike.

[10] It is appropriate to point out that buildings regarded as "industrial archaeology" are by no means the main object of our research, since the subject has been widely dealt with, enjoys a sizable literature and well-known approaches have already been analysed. This work deals with the numberless recently-built hangars on which regional arguments are focused, as well as with soil consumption and the challenges posed by upgrading.

[11] Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover are the Hierarchical R-ladder. From Rli (2015). Circular economy. From intention to implementation. Council for the Environment and Infrastructure (Rli), The Hague.

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PATRIMONIO PLÁSTICO: DECISION-MAKING PROCESS, FOR THE RE-USE OF AN INDUSTRIAL ARCHITECTURE IN MONTEVIDEO

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SDGs

ABSTRACT

This project is based on a research carried out between the Departments of Architecture in University Federico II in Naples and University of the Republic in Montevideo. The research is focused on the idea of re-using as a solution to trigger synergetic mechanisms among different entities and identities of the urbanscape. The core element of the study is Patrimonio Plástico, a decision-making process for the re-use of an industrial architecture, which deals with recycling waste and materials, such as plastic, containers, and abandoned spaces in the city. This multidisciplinary and multiscalar process translates into actions some targets of the Agenda 2030 SDGs, on a global scale, as well as the objectives expressed by different social groups at a local level, in order to identify the most suitable project, whose strategy has been assessed as economically, socially and environmentally sustainable.

1. INTRODUCTION

Patrimonio Plástico is decision-making process designed into a suburban area of Montevideo that shifts from the idea of transforming the waste into resource, and that one of giving new meaning to artefacts and places whose value has been underestimated.

The purpose of the research is to enhance the existing architectural heritage within a synergetic process that aims to convert the industrial building and the waste materials into a circular economy perpective.

Circular economy has been defined by the Ellen MacArthur Foundation (2017; 2019), as an autopoietic economy that radically transforms the standard production system - based on a massive natural resources exploitation and the profit maximization - into a detailed revision of the entire chain involved in production.

The re-use of waste from the several production cycles becomes a crucial issue to be achieved in terms of economical, social and environmental sustainability criteria, as it requires cooperation, sense of community and a wide enhancement of the existing.

In this contribuition the concept of waste is expanded and the action of space recovery concerns a wide range of elements that can be divided into:

- Abandoned or partially used industrial buildings located in areas that are subject to urban transformation;
- Marginal communities against those ones living in the city centre;
- Materials and objects considered "waste".

The re-use of the industrial architecture in the city of Montevideo may lead to a way to implement the circular economy model, by dividing waste from environmental resources such as land use, energy and materials, and by creating a shared social value (Porter & Kramer, 2006) thanks to its relationships with the social, cultural and economic history of the territory.

At this point supporting strategies that identify in this architecture vital elements for future transformations and see in the re-use strategy an urban solution to new economic, cultural and social values, becomes priority.

This contribution is organized as follows: the first section is dedicated to an accurate narration of the strong bond between the Aguada District and its industrial heritage, also mentioning the presentation of the industrial architecture as study subject; the second section presents the decision-making process developed through a multi-methodological approach (Fusco Girard et al., 2004) that combines different multicriteria methods (Ishizaka, 2013), chosen according to a site-specific selection, essential to identify the main stakeholders, whose projects and goals are expressed to make a comparison among the possible scenarios which can possible occur; the third section is dedicated to the results of this decision-making process and to an assessment of the economic, social and environmental sustainability of the scenario, able to mitigate the conflicts among the various stakeholders.

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The main purpose is to make explicit a methodological process which aims to define a strategy facing the existing conflicts and observing possible transformations from an economic, social and environmental sustainability perspective.

2. THE CASE STUDY

La Aguada, a neighbourhood not so far from the centre of Montevideo, belongs to those areas of the western coast of the city, like Arroyo Seco, Reducto, Bellavista and Capurro, that have faced till the first decade of the nineteenth century, the creation of several industrial plants leading the economy of the city, around which many working-class communities were born (Gilmet, 2001).

However, since 1920 the accelerated expansion of the city has led to an urbanization eastwards with consequent abandonment of the industrial headquarters such as La Aguada.

"*A de-industrialization process that has left in the cities and in the entire country [...] hundreds of empty factories, abandoned by workers and deprived of the machines that populated them*" (Massarente, 2019).

These industrial architectures, symbol of a prestigious past, appear today disused or underutilized (Chahinian Contreras, 2006). The relevant potential of these silent buildings is continuously undermined by urban planning that agree on their demolition against new residential towers, not interpreting the industrial identity of a district created to meet the demands of the machine and where there is no space for new residential communities at the moment, as they require infrastructure, services and entertainment.

Despite their widespread presence, the factories of Montevideo are not subject to relevant classification, except a list in the text "Patrimonio Industrial", written by the architect Lina Sanmartin (2009) as a proposal to adopt a future system-based information.

Among the factories of this area the Tsakos factory stands out (Figure 1). Particularly relevant for the relation established between port and city, it is the namesake of a Greek shipping company (Figure 2).

At the moment, the activity of Tsakos has considerably decreased, causing a significant reduction of staff, the underuse of available space and the need to be relocated for logistics reasons. Same story for many other factories in the country due to a process of de-industrialization which brought to a total or partial abandonment of the existing industrial buildings, causing their demolition sometimes.

Thanks to the studies carried out in the History of Architecture and Urbanism Department of FADU it was possible to trace the Factory Building Permits over the last century, the geometric reliefs and vintage photographs. The factory - built in 1910 - has a square plan divided into five naves with a pitched roof. Its massive size of about 6400 sq.m., occupies a whole lot in the neighbourhood.

The accuracy of the decorative details, the large bright windows and the size of the architectural complex highlights the popularity of the prestigious port in the early 1900s.

For the city of Montevideo, the the port plays a significant role as it is the engine of the economy of the country (Saldaña Fernández & García de Zúñiga, 1939), which still grows occupying strips of land with its monumental walls of containers.

The extension of the port area and the changes made over the past decades show a poor analysis regarding the link between this neighborhood and the bay, which has led to economic growth in the last century.

The overcrowded port infrastructures and the intense production of waste by boats (Lozoya et al., 2015) become the pretext to think in terms of recycling and to participate to a broader discussion about the growth of the city.

In these terms, from a suburban area in continuous transformation, where the port economy makes the rules and where identity is compromised by profit interests, La Aguada is re-shaped through brand new circular economy practices that are slowly appearing in Uruguay, aiming at the promotion of tangible and intangible resources of the territory.

Uruguay has been promoting the "Programa de las oportunidades circulares" since 2018 in partnership with

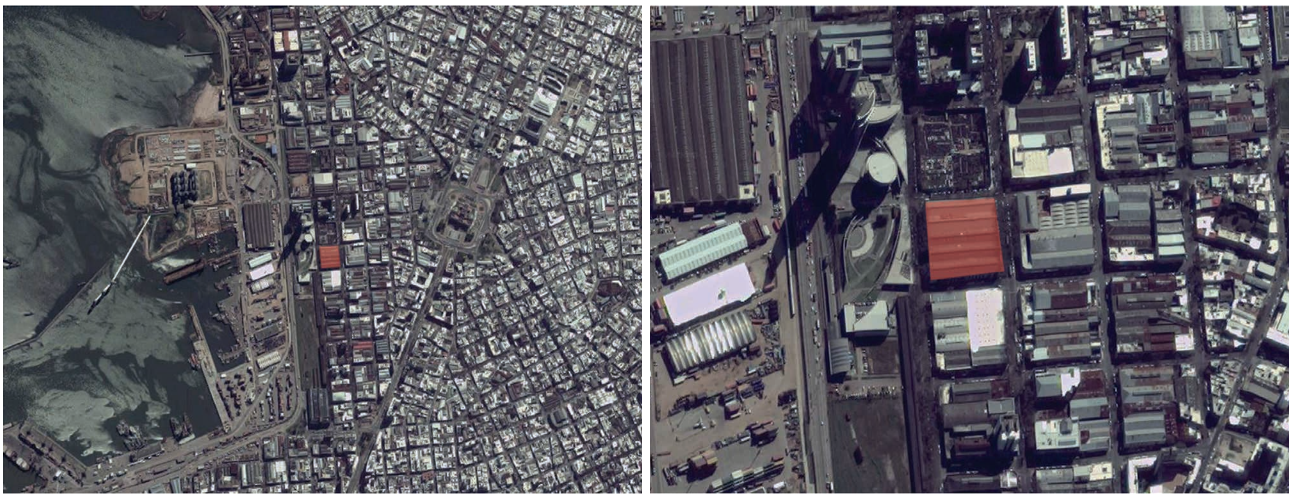


FIGURE 1: Aerial view of the Aguada neighborhood.

FIGURE 2: View of the Tsakos factory.

LATAM (Latin America's Circular Economy Forum) to launch production cycles in line with the principles of the circular economy, thus contributing to sustainable product development.

These practices highlight a growing sensitivity to recycling that finds its expression in re-use operations intended as a set of construction and/or re-use interventions of a building designed to respond to new conditions and new requirements (Douglas, 2006), but also as drivers of more comprehensive urban regeneration interventions with cultural, socio-economic and ecological objectives (Bullen & Love, 2011; Cantell, 2005; Conejos, Langston, & Smith, 2011; Yung & Chan, 2012).

The centre of this discussion is the rich industrial heritage of Montevideo. Restoring dignity to these forgotten architectures means "collaborating with time in its previous aspects, grasping the spirit or modifying it, stretching it out, almost towards a longer future; means to discover under the stones the secret of the springs" (Yourcenar, 1951).

In recent years, adaptive re-use processes have been promoted in Montevideo, transforming the former industrial buildings into gastronomic and shopping areas, such as Mercado Ferrando and Sinergia Design, or into informal spaces dedicated to sports and cultural activities.

These operations become opportunities to finally "think of the city and the landscape as a matter of life cycles, whose parts can be recycled" (Massarente, 2019). and returned to the community with new meaning.

3. METHODOLOGY

According to the definition of re-use intended as a driver for urban regeneration, there is an urgent need to involve the local community into the process of space regeneration and to get to know its requirements, in order to get positive results for the definition of new intervention strategies.

The methodology adopted, with regards of what has been said previously, consists of three main phases: knowledge, processing and evaluation (Figure 3).

The knowledge phase includes all data collected from the study of the district thanks to bibliographical texts dedicated to the industrial growth of the city, the first production sites and zooms on the La Aguada neighbourhood (Altezor, Baracchini, 1971; Alvarez Lenzi, Arana & Bocchiardo, 1986; Jacob, 1981; Mazzini A. Mazzini E. & Salmentón, 2016; Wonsewer, Igleasias, Buchelli & Faroppa, 1959), from the survey followed by photographs and interviews carried out in situ by companies, commercial activities, neighbourhood residents and leading figures of the social, economic and business urban scene.

The starting point of the research was an investigation of the elements featuring the identity of the district in La Aguada with its industrial heritage.

The critical study of this material, together with the inspections carried out, ensured the most completed vision of the artifact, with its history and its relationship with the surroundings.

FIGURE 3: Scheme of the methodological process.

The processing phase includes the analysis of these interviews through frequency analysis, equity analysis and the implementation of the Community Impact Evaluation (CIE) method (Lichfield, 1996; 2005). The interviews carried out in this phase are 14 and divided into three groups of stakeholders.

The first group of interviewees includes a large group of citizens able to provide an enlarged overview of the whole city, whilst the second group mostly focuses on the neighbourhood in terms of locals, and their business and commercial activities. The third group consists of important figures from the social, economic and business scene. Thanks to the Frequency analysis, it was possible to identify recurring concepts, words, phrases and define them as objectives to be pursued.

The most common objectives raised by the citizens, show the need of open spaces where spending free time and to be more safe. Indeed, the urban regeneration process is complex and polyhedric. Defining a complete and integrated vision of the actions to solve issues and improve economic, social and environmental conditions, requires strategies that involve stakeholders, each with its interests and objectives in the transformation processes (Cerreta et al., 2010).

It is necessary to define which are the social groups involved, i.e. the different categories of actors having a key role in the process:

- Municipal administration;
- Port Authority;
- University institutions;
- Local merchants;
- Locals;
- Local businesses;
- Cultural enterprises;
- Companies involved into initiatives for the re-use of plastic waste.

By defining the social groups, the new requests developed in the area for the promotion of the circular economy regarding the re-use of plastic waste, were taking into consideration. University institutions interested in the development of investigative research relating to the recycling of materials, were also involved. Starting from the collected data, five possible scenarios have been defined:

- Scenario A: New residences;
- Scenario B: Industrial hub and training centre;
- Scenario C: New residences, an industrial hub, training centre and cultural centre;
- Scenario D: Public space;
- Scenario E: Shopping Centre.

The five scenarios included a qualitative assessment regarding the equity analysis, and asked the social groups to express a rating going from "very good" to "very bad".

The application of the Community Impact Evaluation (CIE) (Lichfield, 1996;2005), a multicriteria and multiactor method that aims to define the convenience of complex projects based on the social preferences expressed by the various members of the community, allows comparing the general and specific objectives of the various social groups with the actions related to each proposed scenario.

The third and final evaluation phase deals with the analysis of the proposed scenarios starting from five indicators which are quality of life, environment, tourism, training and product innovation, chosen in order to be in line with a selection of the Sustainable Development Goals (SDGs), drawn up by the United Nations (2017) to address the challenges raised by climate change and to reduce any form of poverty or inequality, ensuring the long-term economic, environmental and social sustainability of human communities.

In this phase, the multicriteria methods of Weighted Summation and Evamix were implemented by the Definite 2.0 software (Herwijnen & Janssen 1988), in order to make operative an assessment that combines the preferences of each social group with the hard data recognized during the knowledge phase.

For the selected indicators, measurement units were identified, specifying whether the objective was to increase the value or not, and finally, in respect of each scenario, indicating its new value.

The Weighted Summation allows to know which scenario shows the needs of social groups by establishing a hierarchical order among the five indicators already identified.

The Evamix method gradually changes the weight of each parameter giving prioriy to one and placing the others on the same level.

These results have been integrated with the construction of a conflicts dendrogram, structured by the NAIADE method (Munda, 1995), taking into account the equity analysis carried out during the elaboration phase, in order to know the possible coalitions between the stakeholders involved.

The conclusion of the different assessments carried out with different methodologies, leads to the common preferability of scenario C (Figure 4).

The selected scenario is the engine of a mixed functional program able to accept multiple identities of the neighbourhood. Once the preferable scenario has been obtained, the final step is the evaluation of its sustainability by the assessment of the environmental, economic and social impacts.

The environmental impact, carried out by a Life Cycle Assessment, aims to calculate the equivalent CO_2 emissions produced by the plastic recovery process and its transformation by 3D printing which, as predicted by the scenario, takes place in the industrial architecture and makes a comparison between this, the incineration of the plastic material scenarios and use of virgin plastic.

The analysis of the economic impact, through financial investigation, considers construction costs, management costs and project revenues over a 20-year time.

Finally, the analysis of the social impact needs the comparison between the starting values of the indicators adopted, to analyze the context and the values created by the process. With regards to that, a reference is made to the indicators of Equitable and Sustainable Well-being (ESW) - a total of twelve indicators annually drown up by ISTAT.

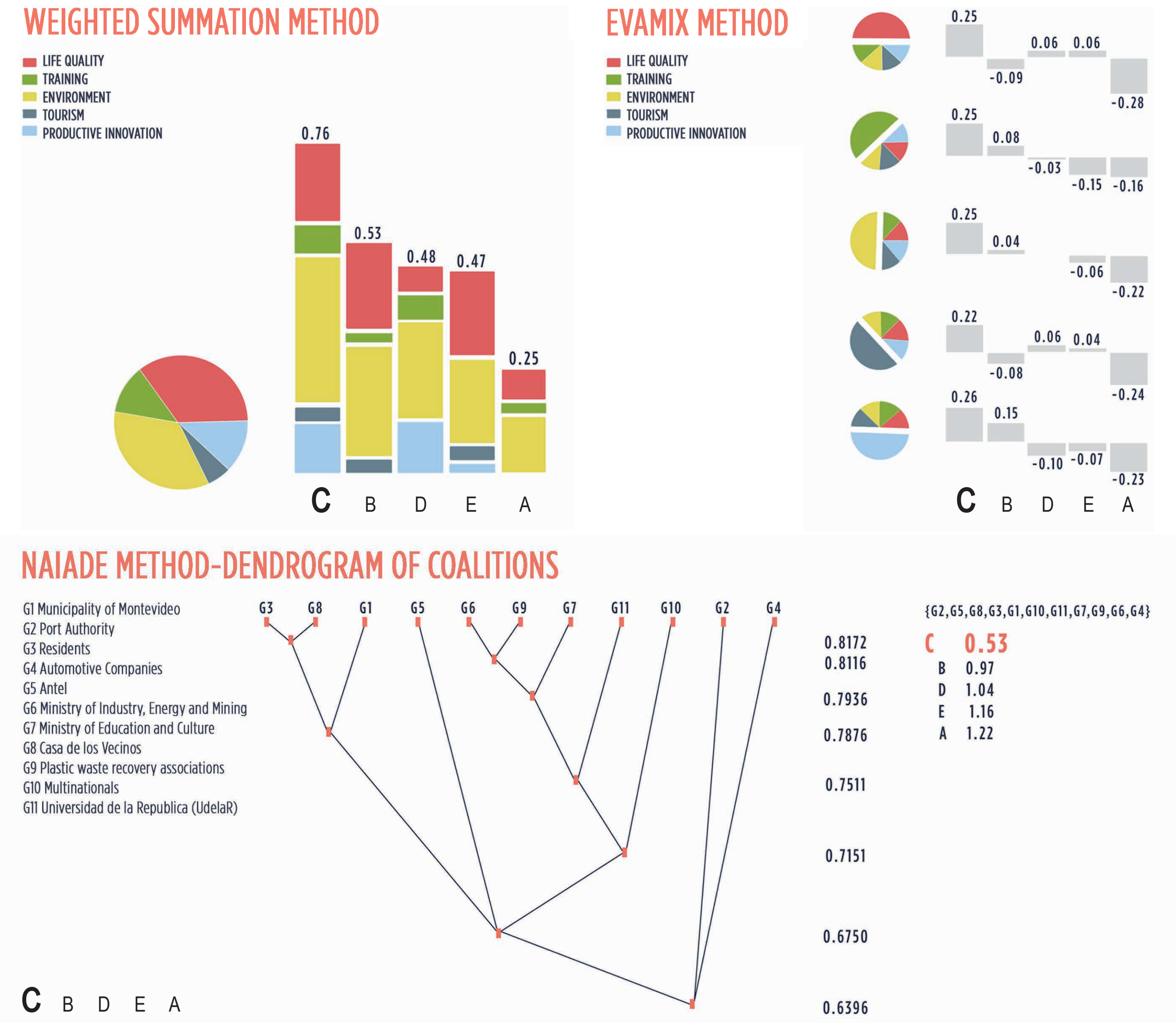


FIGURE 4: Graphs of the results of the evaluation methods Weighted Summation, Evamix and Naiade.

4. RESULTS AND DISCUSSION

Both the Weight Summation method and the Evamix method lead to the same result, demonstrating how scenario C meets the requirements of the indicators chosen and the objectives expressed by the stakeholders.

The NAIADE method, applied to solve internal conflicts, leads to the same result by demonstrating the possibility by scenario C to combine divergent interests into a single project proposal.

The elaboration of stakeholders' map is useful to highlight how the functional program of this scenario responds to the needs of the various actors divided into three main categories: promoters, operators and users (Figure 5).

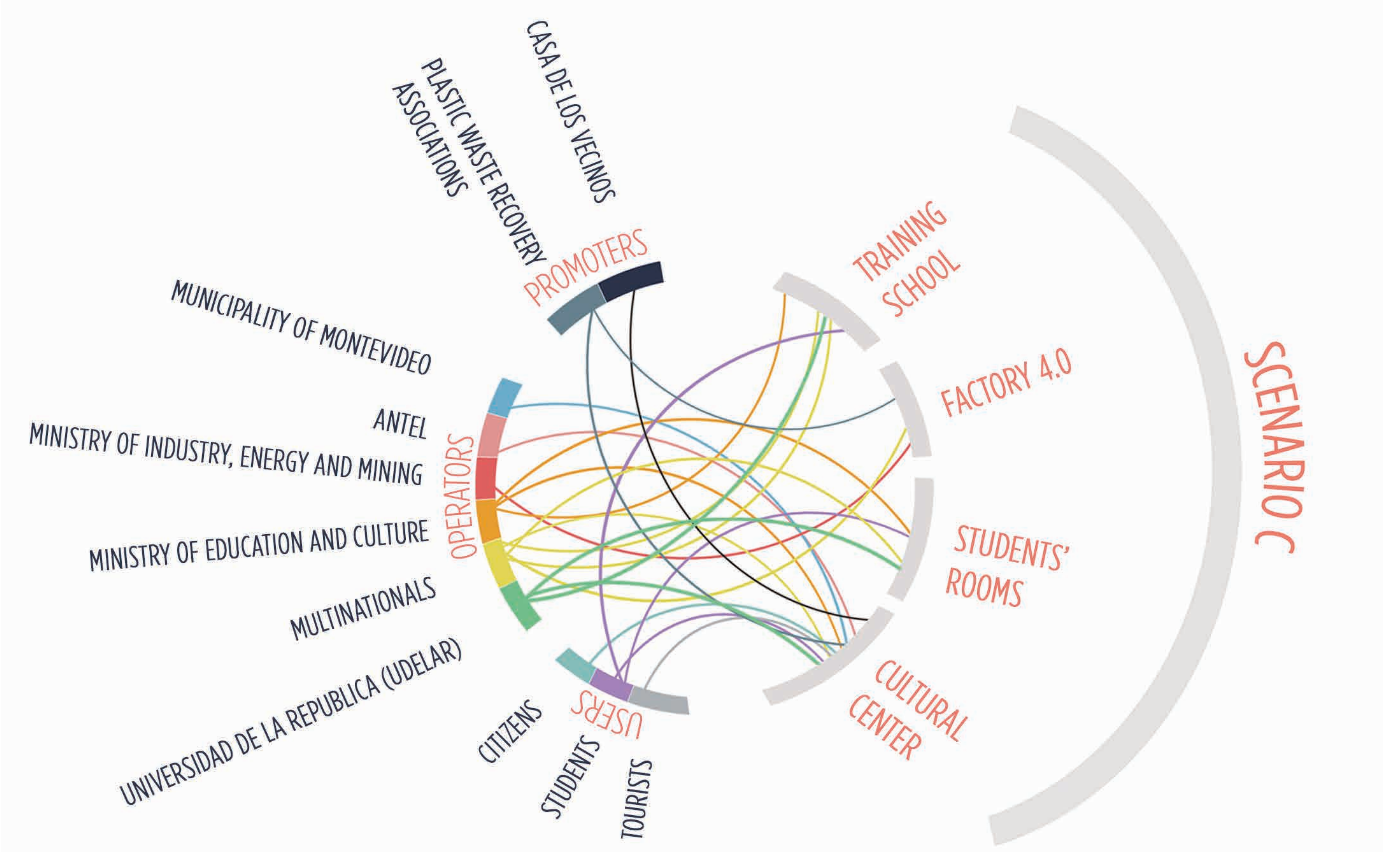
The result of the selected methodological process led to the definition of a democratic space that converts, according to the adaptive and creative re-use criteria, the current factory Tsakos into a cultural, training and production place (Figure 6).

The project proposal addresses the issue of what remains and "*although it may seem paradoxical, such permanence is what allows to appreciate the changes*" (Moneo, 1985). In this context, it is possible to think about the theme of recycling as a cultural process that transforms both the physical structure of the architectural object and the relationships that can be established with the material and immaterial context.

A new industrial 4.0 hub dedicated to recycling and processing PET plastic through the technology of the 3D printer, a training and scientific research centre, together with different leisure activities, gives back the space of the residual architecture to communities embracing new local virtuous processes (Figure 7).

The recycling of factory space happens in cooperation with the recycling of different materials (Figure 8).

First, the plastic, the symbol of the disposable use, is reconsidered according to the most recent technological advances as an architectural material, made to last.



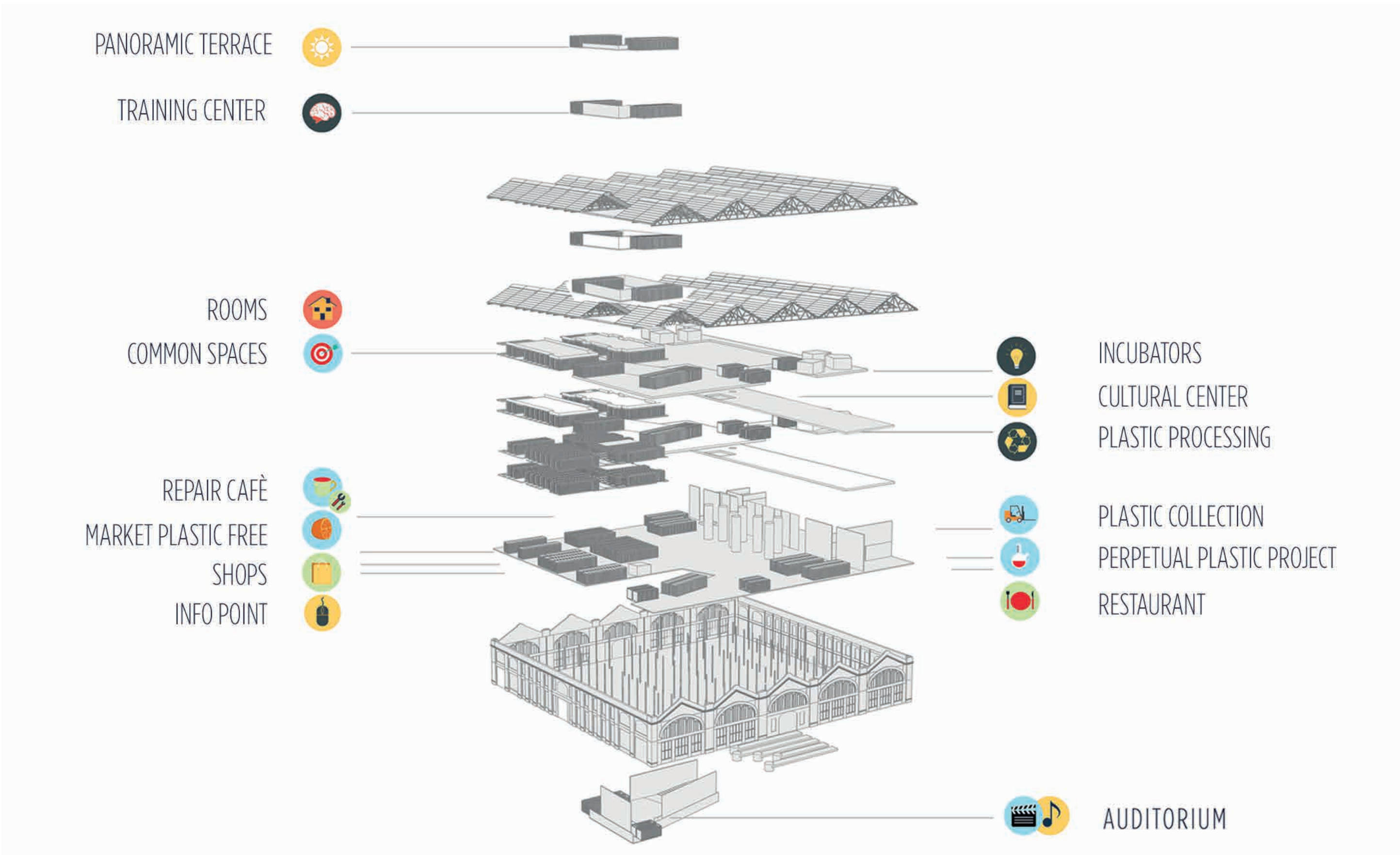


FIGURE 5: Stakeholders' map and a scheme indicating the functional program relating to scenario C.

FIGURE 6: In order: View of the new silos, containing plastic shavings, around which the public space is organized; View of the covered square overlooked by the silos and containers used in the project; View of the meeting space overlooked by the training centre and the exhibition path.

Through the collection and the processing, plastic becomes the primary material also for the production of spare parts for containers in accordance with the harbour enterprises demand or objects of common use commissioned by other users.

Even unused containers, coming from the near port, are re-used to define spaces, consolidate structural parts, articulate the space and the functions of the re-use project (Figure 9).

Reference is made to the international experience of many companies that assess innovative methods of waste materials recovery into a re-use in architectural design. Thus, the compressed plastic blocks, named Replast by the US company ByFusion, constitute the fifth stage of the auditorium on the ground floor; Miage sheets made of transparent and back-lit plastic by the Dixpari project, slide on rails in raw iron for the realization of the incubators of the research centre on the first floor; finally, the internal partitions of the residences for students, carried out inside containers, are made of structural walls achieved by the Mexican company Ecodom, whose thermal insulation is caused by the presence of solid compacted plastic waste (Figure 10).

Plastic is also an excuse to propose a model of social and creative enterprise that starts with the people to return to the people.

The factory space is open and permeable. On the ground floor, the interior space becomes space for the city, where people can stroll among shops, visit the "repair cafe", live experiences of the circular economy focused on plastic as the "perpetual plastic project" and enjoy performances and cultural events.

The “fast” experience of the ground floor is in contrast with a more intense experience on the upper floors, where you can visit the exhibition space of the cultural centre and the panoramic terrace.

All this is supported by continuous scientific research developed inside the incubator and the training centre, where students have accommodation and common areas.

The project, referring to the global goals for sustainable development of the United Nations, aims to build a sustainable community that fights against climate change, against all forms of inequality and any wastage.

The sustainability of this proposal is highlighted by the evaluation of the environmental, economic and social impacts, thus showing a reduction in emissions, a continuous gain in time and extraordinary positive effects in the community.

The Life Cycle Assessment considered the collection and the transport of PET, its transformation, its distribution and electricity and fuel to be used for the process. By comparing the proposed scenario with which demands the production of virgin PET and what provides the PET incineration at the end of the production cycle, it is possible to avoid 61 kg of CO_2 equivalent every week.

The economic impact analysis, through financial analysis, considers the data obtained from the investment amounts in architectural projects in Uruguay, the main open-source work platforms and the average cost of life in Montevideo.

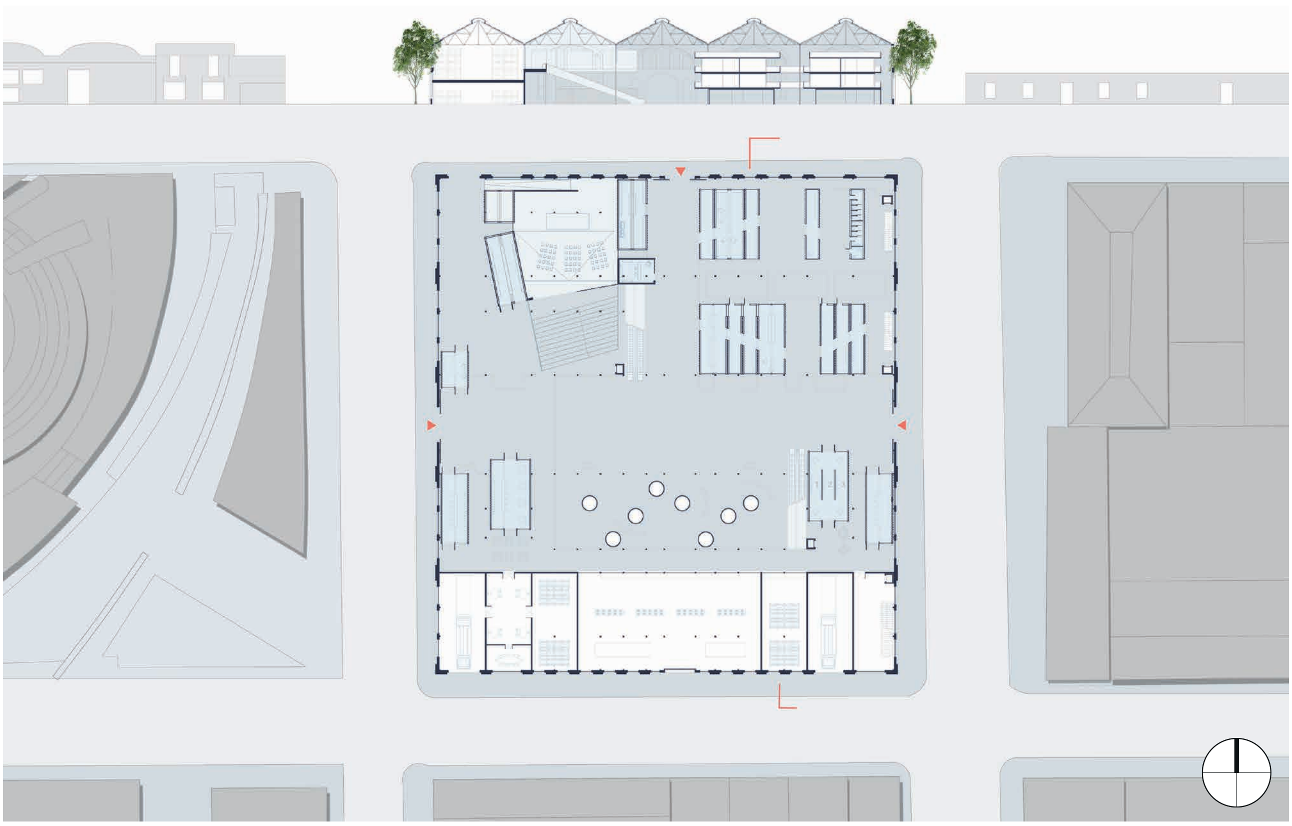


FIGURE 7: Ground floor plan highlighting the free covered space.

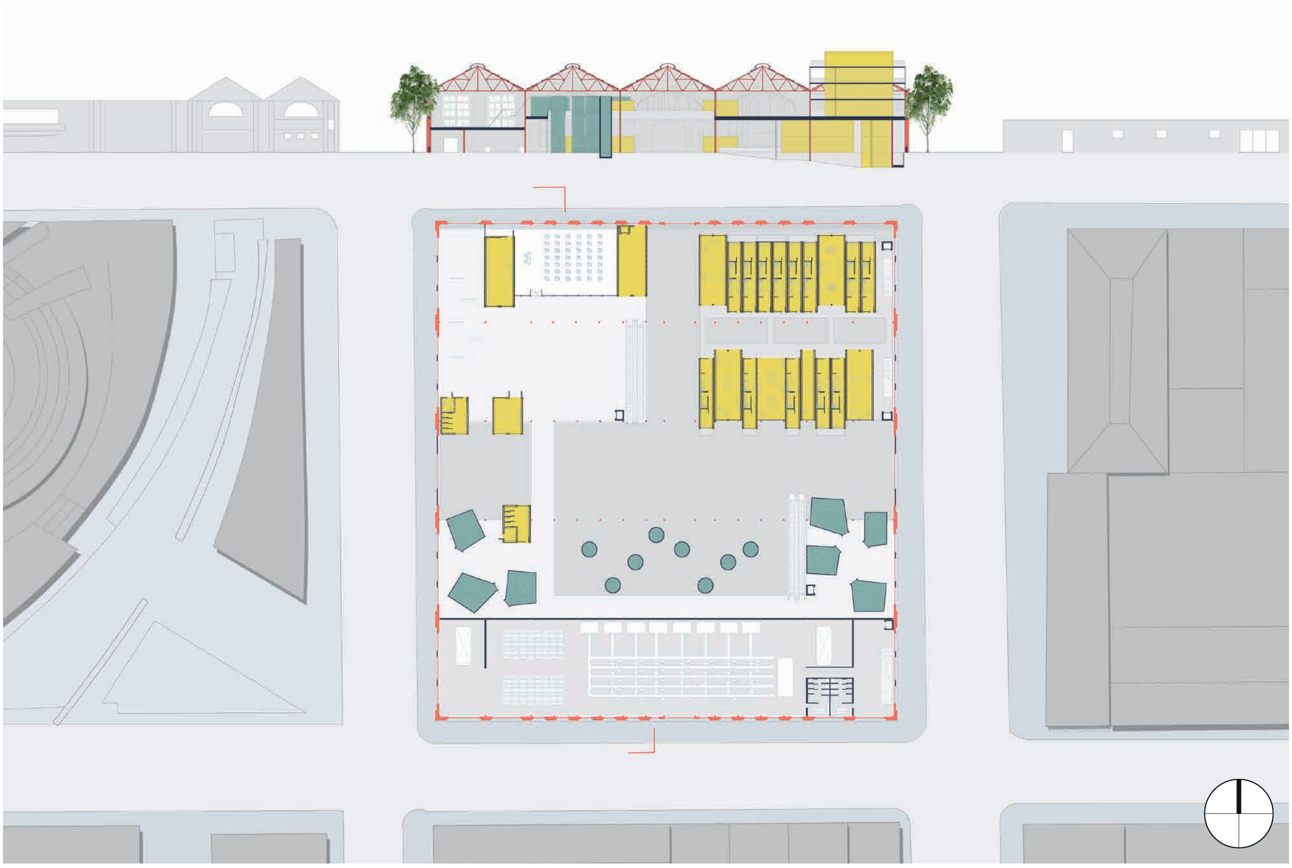


FIGURE 8: First floor plan highlighting the relationships between the different materials.

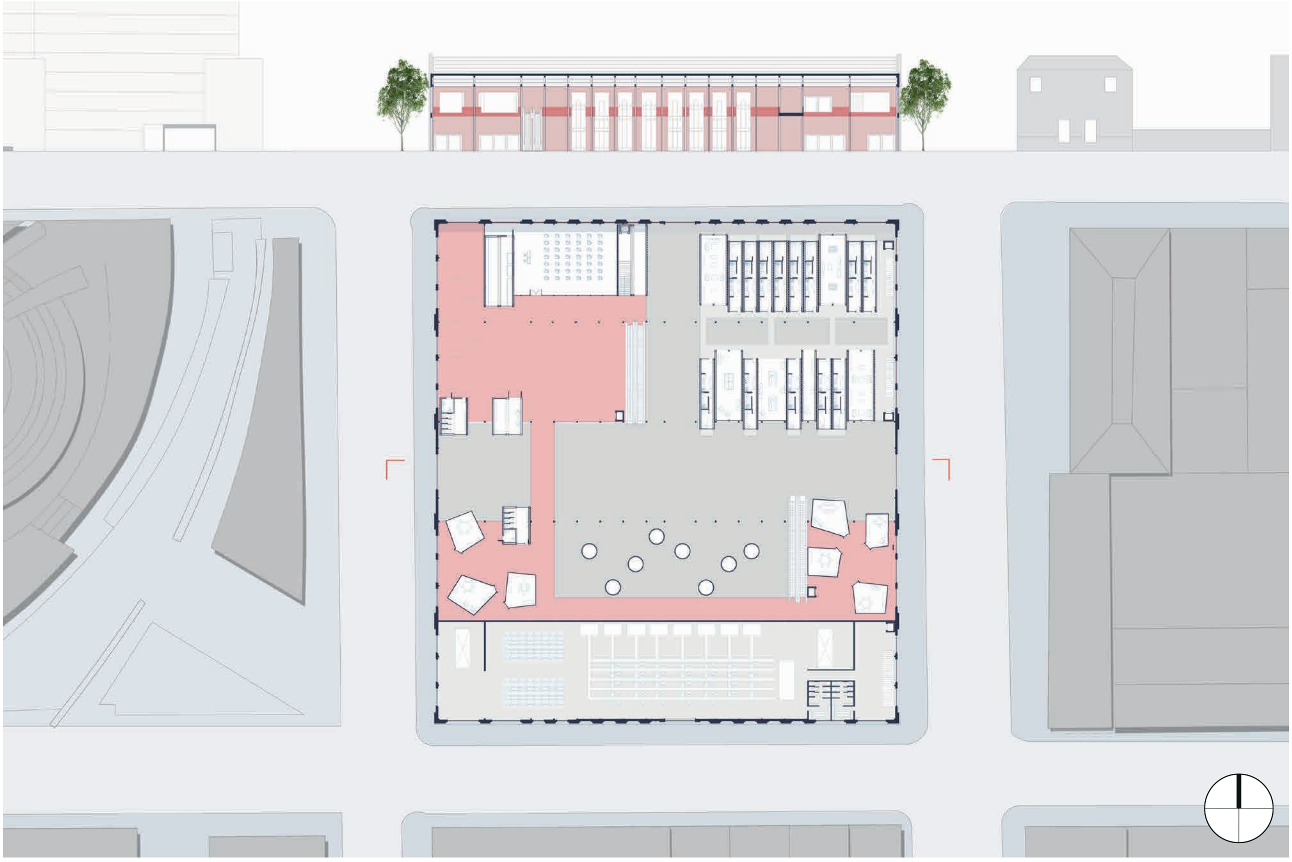


FIGURE 9: First floor plan highlighting the meeting space overlooked by the training centre, the exhibition path and the incubators.

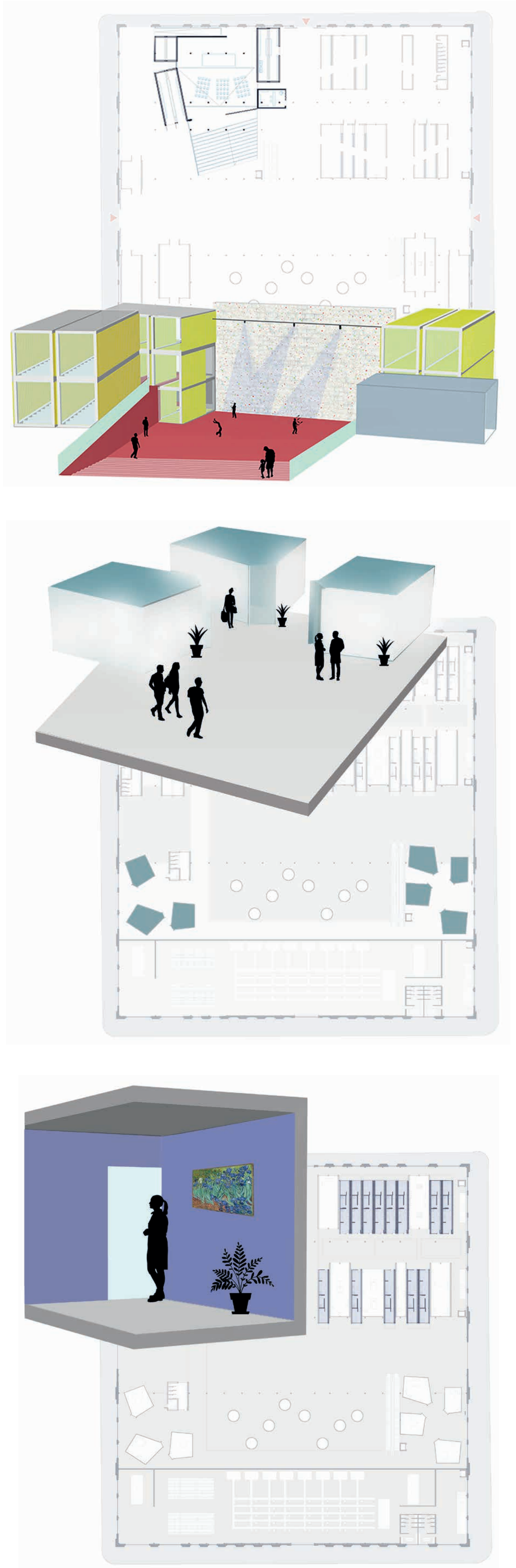


FIGURE 10: In order - 1) View of the fifth stage of the auditorium made by compressed plastic blocks named Replast by the US company ByFusion; 2) View of the walls of the incubators made by transparent and back-lit plastic sheets by the Dixpari project; 3) View of the internal partitions of the residences for students made by structural walls whose thermal insulation is caused by the presence of compacted plastic waste by the Mexican Company Ecodom.

From the difference of total net costs and total net revenues, it was obtained a high and positive Net Present Value (NPV) and an Internal Rate of Return (IRR) equal to 16%. Therefore, the proposed project results sustainable and profitable in the reference period.

The project suggests a series of transformations as a response to social problems detected in the interviews and it has been tried to measure quantitatively indirectly through Equitable and Sustainable Well-being (ESW) indicators related to education and training, employment, economic well-being, environment, security, subjective well-being, landscape and cultural heritage, innovation, research and creativity.

By considering as targets to achieve, the increase of the numbers of enrolled students in training courses, the increase in the employment rate within the neighborhood, the organization of events and recreational activities, the increase in creative companies working in the area the increased of perception of safety thanks to the prolongation of district hours, the project proposal proves to know how to look carefully at the needs that raising from a careful analysis of the territory and how to propose a viable and sustainable alternative to the current condition.

5. CONCLUSIONS

The United Nations' SDGs have highlighted the importance of thinking about global development that promotes human well-being and preserves the environment.

The 17 goals relating to the environment, health, training, innovation, etc., offer a series of indicators able to read the real conditions of a context from which experts adopt and organize adequate intervention strategies.

The same line followed by the United Nations is found in the circular economy concept that defines a new economic system that, in its design, production, consumption, till the end-of-life destination of a product, knows how to seize every opportunity to limit the contribution of matter and energy and to minimize waste, paying attention to the realization of new social and territorial value (Ellen MacArthur Foundation, 2017; 2019).

The practice that best comply with these objectives is the act of re-using, a practice that aims at the conservation and protection of environmental resources such as soil, energy and materials but also at the cultural and social resources where the good, object of study, is made warning.

The proposed strategy identifies the decision-making process most suitable for analysing the study subject and oriented towards the adaptive re-use of the existing, in particular, of the industrial heritage.

The chosen methodological process was structured and composed in such a way that each method lead to the choice of the appropriate subsequent method according to the following general phases:

- Data collection (bibliography, survey, site survey);
- Definition of possible decision-making actors;
- Submit interviews;
- Interview analysis;
- Definition of possible scenarios;
- Comparison between possible scenarios and stakeholder preferences;
- Assessment of scenario multidimensional impacts.

This strategy combines global objectives and local authorities of the study subject and, at the same time, does not disregard the preferences of the community that lives and knows the neighbourhood and builds a process that leads to the definition of the preferable scenario. Therefore, the strong bond between the circular economy and community involved is fundamental for the re-use actions in the abandoned urban spaces.

For enhancing the tangible and intangible resources, in order to generate circular economy, it is necessary to consider the objective conditions of the territory but also the subjective preferences of those who inhabit that territory and the impacts that the project generates.

Based on the methodological process chosen, the evaluation of the consequences that re-use operations can have on the context, is central. Therefore, the final assessments of the impacts are crucial to bring out the ability of a re-use process to respond not only to the territorial issues but also to those promoted to improve sustainability at the global level, thus closing the framework of objectives established in the premise of the project.

This decision-making approach is effective for applying a circular economy perspective on the regeneration of existing assets. The aim of the research is not to present an absolute solution but to highlight the validity of a strategy applicable in cases of re-use of existing assets in a circular economy perspective. The research is proposed as an innovative experiment that, by stressing the importance of environmental and social issues, recognizes the value of those materials and those places of the city considered waste.

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WASTE AND WASTED LANDSCAPES: FOCUS ON ABANDONED INDUSTRIAL AREAS

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Urban metabolism

ABSTRACT
Urban ecosystems, in their complexity, like living organisms, have their own metabolism, whose functioning is linked to the presence of input and output streams. These metabolic flows define the interconnection of different life cycle phases and determine the presence of wasted landscapes, i.e. portion of territory waiting for the activation of regeneration actions. The present paper focuses on the abandoned industrial areas that characterize a portion of the Metropolitan Area of Naples, defining a spatial identification methodology and connecting them to the production of Construction and Demolition Waste, in a multi-scale perspective.

1. INTRODUCTION

An ecosystem "is defined as an area, place or environment where organisms interact with the physical and chemical environment" (Chatzinikolaou et al., 2018, p. 43). In this perspective, cities can be seen as urban ecosystems, i.e. systems formed by the combination of people and nature, where biophysical and social factors regularly interact in a resilient and sustained manner and where different spatial, temporal and organizational scales exist (Redman et al., 2004). There is a variety of definitions of this concept, for example Tansley (1935) defines urban ecosystems as a combination of physical factors forming what we call the "environment", while Threlfall and Kendal (2018, p. 248) express the concept according to which "urban ecosystems contain a myriad of natural, constructed and hybrid spaces, where the combination of each is unique in every city and town".

Like any ecosystem form, cities are also nodes of consumption of energy and material as well as production of residuals (Rees and Wackernagel, 1996) and in order to understand their functioning, it is necessary to focus on the material, energy and information flows that sustain the human population (Rees, 1997). Urban ecosystem are characterized by a heterotrophic nature because of their dependence on external sources of energy and they are also energy-intensive entities (Collins, 2000).

About 72% of the European population is concentrated in cities; therefore, in order to support their functioning, vast amounts of energy, food, water and other kind of goods are used, generating as well huge quantities of waste (Phillis et al., 2017). It is possible to say that urban ecosystems are complex and open systems closely linked with their surroundings through metabolic exchanges of energy and material flows and information circulation (Su et al., 2012) and as a consequence they are entities characterized by their own Urban Metabolism (UM) (Marx, 1909; Wolman, 1965; Kennedy et al., 2007). According to Broto et al. (2012), UM links material flows with social and ecological processes and it is necessary to take into account the possibility to modify the actual patterns of consumption and production towards more sustainable schemes.

Definitely, through an analogy between cities and metabolic processes of organisms, it is possible to understand the functioning and the development of a city by the consideration of the inputs, the outputs and the storage of different resources, mainly represented by energy, water, nutrients, materials, and wastes (Maranghi et al., 2020). According to Mostafavi et al. (2014), through the analysis and quantification of the materials that circulate within a city, it is possible to assess the impacts of urban development and to perform a multidimensional assessment of sustainability (Beloin-Saint-Pierre et al., 2017). Furthermore, the actual prevailing linear UM considers the city as an urban machine, consuming unlimited resources and producing waste to dispose of (Gasparrini, 2013), determining the necessity to rely no longer on this kind of model.

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Three main typologies of metabolic flows can be identified within a city (Minx et al., 2010):

- Direct extractions and releases, that are resources directly extracted and wastes and emissions released;
- iImports and exports, that are different products that can be imported or exported in and out of the urban ecosystem;
- Indirect flows associated with imports and exports, such as resources indirectly extracted and emissions and waste products indirectly released.

Moreover, UM can be examined at different scales: global UM studies analyze the global antroposphere, while there are studies at the national or regional scale as well as at the urban and local dimension (Li and Kwan, 2017). Definitely, UM determines the necessity to adopt a flow perspective on urban ecosystems (Dijst et al., 2018).

Having defined urban ecosystems, the aim of the present paper is to focus on abandoned portions of these ecosystems, i.e. wasted areas produced by the results of UM. In the subsequent sections, the concepts of territorial life cycle and wasted landscapes are introduced, presenting a methodology to spatially identify former industrial areas in a portion of the Metropolitan Area of Naples (MAN). In a multi-scale perspective, abandoned industrial areas are connected to the production of Construction and Demolition Waste (CDW), linking waste landscapes and waste flows.

2. THE CYCLICAL NATURE OF URBAN ECOSYSTEMS

2.1 Renewable cities: the concept of territorial life cycle

The concept of life cycle refers to all the phases that distinguish the life of an element, and in the present case the territorial system is taken into account. Urban ecosystem, being a concentration of environmental, social and economic resources and services, evolve according to the form of governance to which their territory is subjected. A set of interconnected phases strictly linked to a system of resources and performances that characterize the territorial functioning, determine the end of a life cycle and the rise of a new phase. This concept can be referred to a particular temporal scenario in which, it is possible to find three different processes (Torricelli, 2015a):

- Settlement processes;
- Processes of use and consumption of resources, equipment and services;
- Processes of production and consumption of goods destined more or less to the territory.

These processes result in the generation of environmental flows and social relations linked to the territorial activities. In this perspective, a territorial portion does not have the possibility to grow endlessly, but when the system of its resources is exhausted, this area will overcome an involution phase until a new balance is found, i.e. a new life cycle is started (Zucchetti, 2008). An urban ecosystem, like all complex autopoietic systems, tries to keep its identity intact thanks to flows of matter and energy and the end of a territorial life cycle does not mean that the territory interrupts its functioning, because this process is continuous.

Different social, economic and multidimensional factors are responsible for the evolution of the territorial life cycle. However, this concept is not totally new: for example, it is possible to think about the slogan developed by the American architect William MC Donough and the chemist Michael Braungart "Cradle to Cradle"(McDonough and Braungart, 2002), which is based on the application of biological criteria to industrial processes, that, passing from one state to another, can generate new life cycles.

In the present paper, this concept is based on the possibility of generating new life cycles for abandoned portions of the territory, giving rise to recycling strategies for building, urban and environmental resources (Bocchi et al., 2013), determining to the so-called "hyper–cycle, i.e. a reactivation of a certain life cycle. Another interesting concept is that of the so called Cityforming©, proposed by Carta (2016), that is a design protocol capable of reactivating the metabolism of an area starting from its latent regenerative components, activating multiple cycles of increasing intensity to create a new sustainable urban ecosystem over time. The application of this protocol is able to reactivate the inactive cycles, but also to reconnect the interrupted ones or to activate new ones, more suited to the new identity of the places. Carta (2016) identifies three main life cycle phases:

- The colonization phase, in which some new functions are identified or some buildings are recovered; the latter are like stamina cells. This phase can also comprise the removal of some infrastructural or environmental detractors, facilitating the reconstitution of some ecological networks;
- The consolidation phase, that acts on the new ecosystem through the grafting of some more valuable functions, able to generate profits, increasing the attractiveness of the area;
- The development phase, in which the new metabolism of the area is able to generate new urban value.

Definitely, the life cycle phases of the territory can be generated by different causes, spontaneous or induced. The latter generally intervene on those portions of the territory whose life cycles, almost completely exhausted, require the start of strategic regeneration actions capable of giving new life to the territory. If city are like living organisms, through the start of a new life cycle it is possible to proliferate and hybridize the surrounding tissues, transforming a group of undifferentiated cells into new organs and new connective tissues (Carta, 2013). If the concept of life cycle can be associated to that of change, a city is like a body in constant transformation (McDonough and Braungart, 2002) and can be seen as a renewable resource.

In conclusion, the starting point of the present work is the assumption that the city does not follow an unmodifiable biological path, but has the ability to regenerate itself, overcoming a life cycle and decline phase, reinterpreting its components (Gabbianelli, 2013).

2.2 Wasted landscapes

As already specified, "*cities are not static objects, but active arenas marked by continuous energy flows and transformations of which landscapes and buildings and other hard parts are not permanent structures but transitional manifestations*" (Berger, 2006b, p. 203). According to Lynch and Southworth (1990, p.146), waste "*is worthless or unused for human purpose. It is a lessening of something without useful result; it is loss and abandonment, decline, separation and death. It is the spent and valueless material left after some act of production or consumption, but can also refer to any used thing: garbage, trash, litter, junk, impurity and dirt. There are waste things, waste lands, waste time and wasted lives*".

Similarly, Berger (2006, p. 203) states that "*contemporary modes of industrial production driven by economical and consumerist influences contribute to urbanization and the formation of waste landscapes – meaning actual waste (such as municipal solid waste, sewage, scrap metal, etc.), wasted places (such as abandoned and/or contaminated sites) or wasteful places (such as oversized parking lots or duplicate big-box retail venues)*".

Waste in its spatial connotation is the outcome of urban processes that characterize the activities of the supply chain, i.e. the set of activities that feed the life cycle of a product from the phase of extraction of raw materials up to the disposal of waste materials. The supply chain, in other words, represents the distribution chain of a product or service from the supplier to the customer, starting from the raw materials necessary for its realization, then moving on to the realization of the product, and subsequently to the phases of management and distribution to the customer, which carries out the consumption phase. Each single phase determines the production of waste products, and tracing the waste streams starting from the production phase of the products, allows to analyze the consumption patterns and to identify better paths to be taken, facilitating the transition from the linear economy model to the circular one.

In this perspective, urban ecosystems are characterized by the presence of portions of territory at the end of their life cycle, i.e. wasted landscapes or wastescapes (Amenta and Attademo, 2016; Amenta and Van Timmermen, 2018). This concept, has been analysed in the Horizon 2020 Project REPAiR – Resource Management in Peri-urban Areas: Going Beyond Urban Metabolism[1], that proposes an association between waste products and wasted landscapes. The concept of wastescapes derives from that of drosscapes coined by Berger (2006), i.e. wasted landscapes that are an outcome of metabolic processes. Drosscapes "*accumulate in the wake of the socio – and spatio – economic processes of deindustrialization, post-Fordism and technological innovation*" and they "*are located in the declining, neglected and deindustrializing areas of cities*" (Berger, 2006, p. 239). Consequently, there are physical components of the urban structure that lose their function and, at the same time, the economic and social recognition of their usefulness: what occurs is the definitive or temporary suspension of a determined use of a certain space, with its consequent abandonment, the subsequent re-use, and more rarely and more distant in time its full replacement.

Wastescapes are an inevitable result of the processes of economic growth that produce waste and emissions that damage land, water, fields, but also buildings and infrastructures. Therefore, the flows of matter and energy and those of waste that feed or come from the activities of the supply chain, respectively, are also able to shape the territory in its physicality. This generates the development of portions of territory that are no longer able to provide goods and services and, finding themselves at the end of their life cycle, they are like "waiting spaces" or terrain vague. The activation of new urban regeneration processes may be able to give new functions to these portions of territory and to reconnect them to the surrounding urban fabric. This means that the real challenge is to integrate these portions of land into the functioning of urban ecosystems (Berger, 2007), turning useless matter into useful matter, as it happens in the waste recycling system (Erz, 1992; Strasser, 1992), avoiding further land consumption. The disuse can be understood as a "natural" phase of the life cycle of the functions and spaces predisposed to welcome them (Baiocco et al., 2017). This vision determines the consideration of urban ecosystems as endowed with a metabolism capable of digesting, assimilate and feed the succession of cycles of production and where space is always small with respect to the quantity of flows (economic and human) that cross it.

Definitely, waste can be interpreted as a natural and unavoidable component of an evolving and dynamic urban ecosystem and represents an indicator of its healthy growth (Berger, 2007).

REPAiR projects identifies 5+1 categories of wastescapes that are grouped in drosscapes and operational infrastructure of waste, the latter represented by the plants dedicated to Waste Management (WM) (Geldermans et al., 2018):

DROSSCAPES
1. Degraded land (W1)
2. Degraded water and connected areas (W2)
3. Declining fields (W3)
4. Settlements and buildings in crisis (W4)
5. "Dross" of facilities and infrastructures (W5)

\+
6. OPERATIONAL INFRASTRUCTURE OF WASTE (W6)

2.2.1 How to map wastescapes? A spatial methodology for their identification

For the territorial identification of wastescapes, it is necessary to define a precise spatial methodology of analysis that could be systematically replicable. The flows of matters and energy that cross the territory, allowing the carrying out of the activities of the supply chain, cause not only emissions and waste flows, but they also physically shape the territory. There is, indeed, a strict link between territorial processes and wastescapes determination, which can be considered the spatial result of UM together with impacts at micro, meso and macro scale. Therefore, the metabolic activities of extraction, production, distribution and consumption that define the supply chain and the activity of Waste Management (WM), affect resources, but simultaneously are able to generate Land Use Functions (LUF) and to provide environmental, social and economic services as well. In the same time, they alter the territorial performances, generating multidimensional impacts and in addition a particular form of spatial impact known as wastescape (Figure 1).

The general idea for the wastescapes characterization methodology is that of aggregating increasingly complex information up to the definition of performance indicators . The spatial organization of a city, as well as its infrastructural system, affect the resources used to support human activities and therefore its level of environmental pressure on the regional and global environment (Alberti and Susskind, 1996).

The starting point is the concept that these metabolic activities are powered by resources (EEA, 2015) that feed the processes that act on the territory and generate in the meantime environmental, social and economic performances. The European Commission's Thematic Strategy on the Sustainable Use of Natural Resources (European Commission, 2005) states that European Economies depend on natural resources that can be defined as anything that occurs in nature that has the possibility to be used for economic production or consumption (OECD, 2010) or also that can be used for producing something else (UNEP, 2011). Furthermore, spatial planning in general is able to condition the use of resources, influencing as well the consumption pattern of an urban ecosystem, because the spatial form of cities has a long-standing impact on the daily resources needed (Dijst, 2013). Consequently, urban ecosystems are undergoing multiple and often contradictory changes from expansion to de-industrialization and land abandonment (McPhearson et al., 2016).

According to European Commission (2005), natural resources that feed European economies are composed by:

- Raw materials, such as minerals, biomass and biological resources;
- Environmental media such as air, water and soil;
- Flow resources such as wind, geothermal, tidal and solar energy;
- Space (land area).

The life cycle of the supply chain processes and the available resources allow interpreting the territory as a system of use functions (Loiseau et al., 2014; Torricelli and Gargari, 2015).

The system of interpretation for the wastescapes characterization and spatial mapping is formed by four main steps which follow each other cyclically (Figure 2):

- Pattern;
- Process;
- Driver;
- Effect.

As far as the pattern is concerned, this refers to the spatial and territorial organization of the area under analysis and of its characterizing geographies, in terms of combination between land cover, land use and land use func-

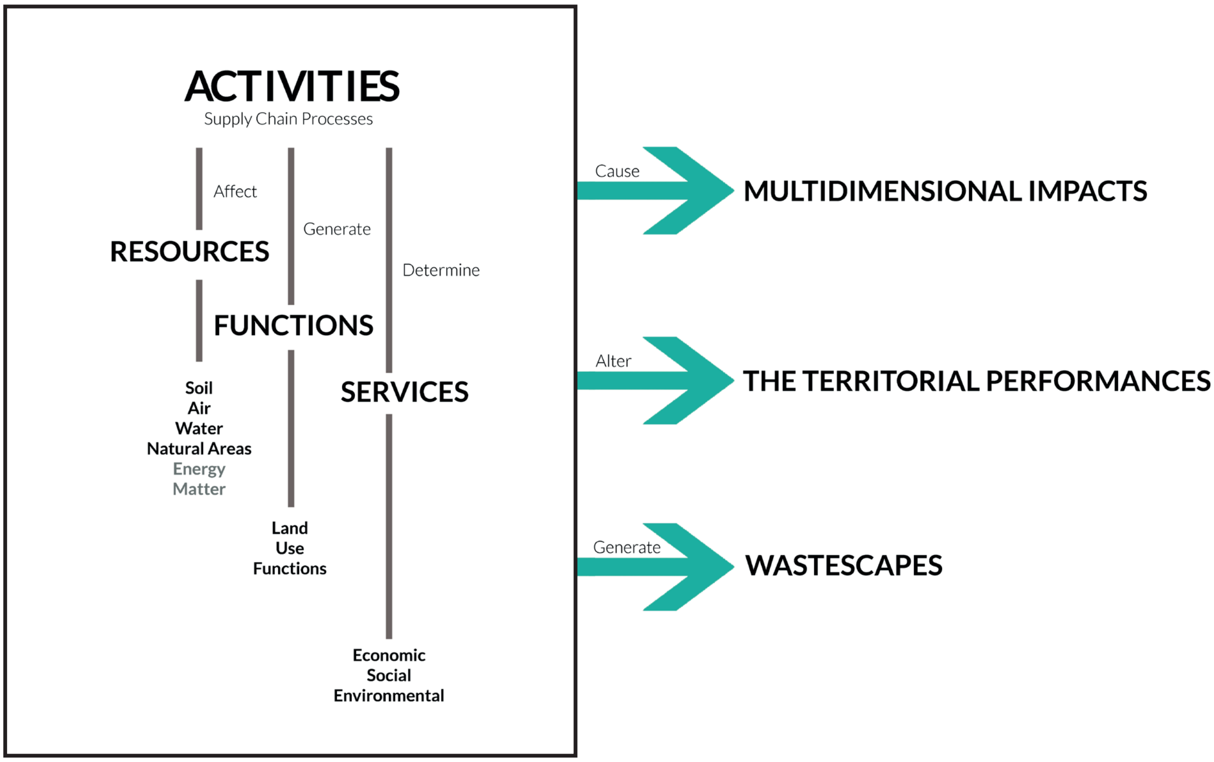

FIGURE 1: Activities in the supply chain processes and their consequences[2].

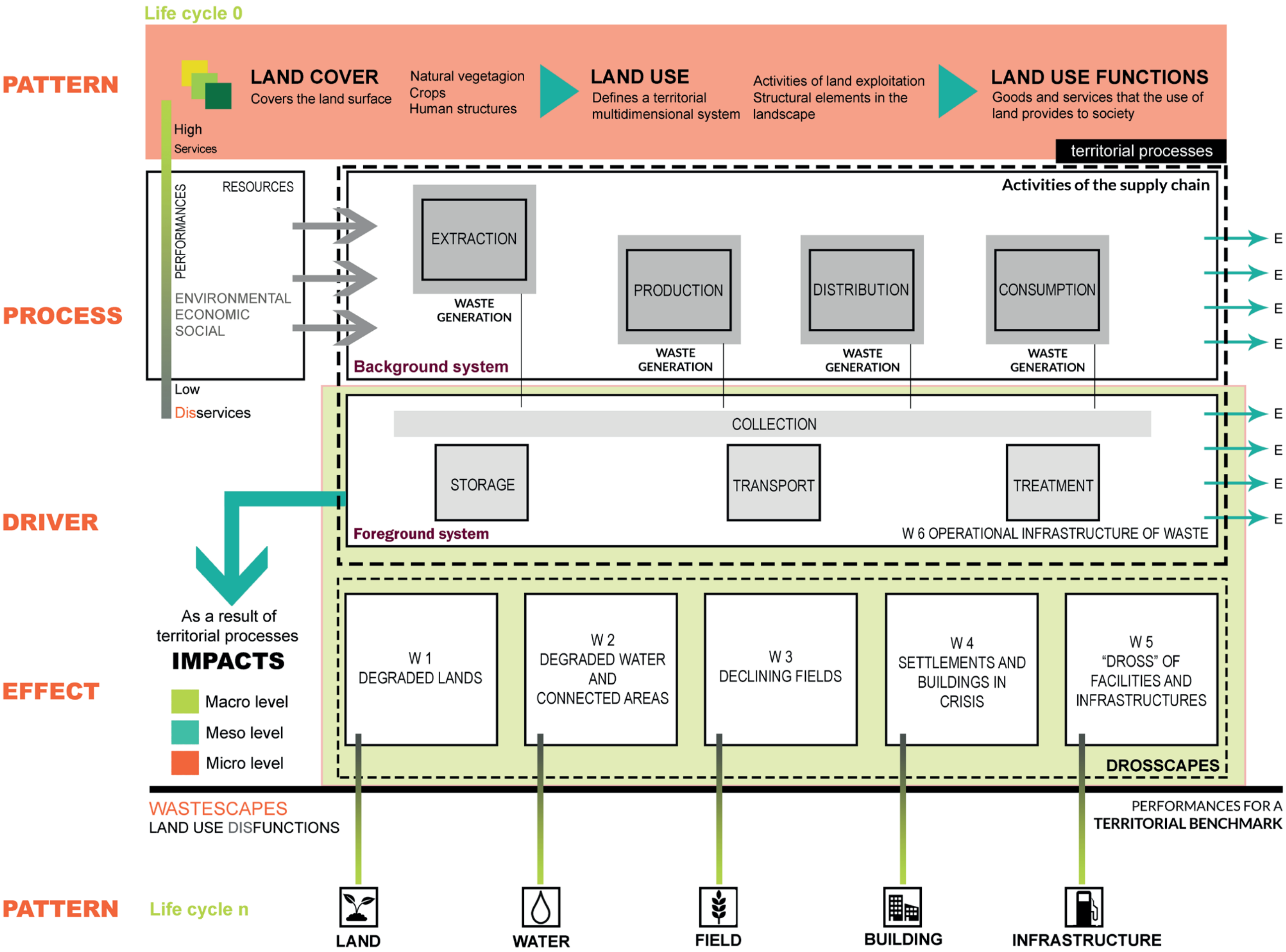

FIGURE 2: Wastescapes characterization model.

tions. The latters allow defining the main features of the area under analysis from a physical and human perspective (Geldermans et al., 2017). As a matter of fact, "*form – the spatial patterns of the built, infrastructural, and embedded biotic components of cities – is a crucial component of urban structure*" and this link between urban structure and *its functioning provides a new way of analyzing urban ecosystems patterns and processes* (McPhearson et al., 2016, p. 206).

Secondly, wastescapes are the results of the territorial processes and therefore they could be analyzed according to each single activity of the supply chain that influences flows and stocks within the urban ecosystem (Dijst et al., 2018).

Once chosen the activity to analyze, it is necessary to define the land cover that hosts this activity and the subsequent land use. On the one hand, the first represents the observed (bio)physical cover of the earth's surface (Di Gregorio, 2005) and it is formed by three main categories: natural vegetation, crops and human structure, each one generating a certain number of sub-categories. The main reference for the land cover is represented by the Corine Land Cover (CLC) elaborated by Copernicus. On the other hand, land use refers to the human activities carried out on a certain land cover from a functional dimension (Torricelli, 2015b) and the reference can be represented by the categories of land use proposed by European Environment Agency through Urban Atlas. Land use is a determining factor that influences the ability of ecosystems to provide services (EEA, 2015).

From a combination of the two informative layer, a system of Land Use Functions (LUF) is developed according to the categories proposed by Pérez-Soba et al. (2008), to which the cycles of the activities of the supply chain and the resources that feed these activities refer. As stated by Verburg et al., (2009), more attention should be given to land use as well as to LUF and to the correlations between the two.

LUF can be defined as the "*goods and services that the use of land provides to human society, which are of economical, ecological and socio-cultural value and are likely to be affected by policy changes*" (ESPON, 2013, p. 12). LUF, representing the social, environmental and economic issues of a territory, are classified by Pérez-Soba et al. (2008) as follows:

- Provision of work;
- Human health and recreation;
- Cultural and aesthetic values;
- Residential and non land-based industry and services;
- Land-based production;

- Infrastructure;
- Provision of abiotic resources;
- Support and provision of biotic resources;
- Maintenance of ecosystem processes.

Each LUF can be analyzed from an environmental, social or economic perspective according to the wastescape to characterize. LUF consideration allows to complete the pattern definition.

The following step is related to the processes that happen in the territorial system, as the activities of the supply chain that define the territorial processes are contained in the LUF categories. In particular, it is possible to identify two systems:

- The background system, that is related to the activities of extraction, production, distribution and consumption, each of them generating a certain amount of waste;
- The foreground system refers to the WM activities that happen in the Focus Area or Region (Taelman et al., 2017). Collection is a transversal activity, followed by storage, transport and treatment of the collected amount.

These territorial processes determine an effect represented in the form of impacts at micro, meso and macro level (Taelman et al., 2017) as well as the above-mentioned wastescapes.

The next step is the drivers identification; drivers refer to causes of alteration of the territorial functioning and represent factors of change with influence on the environment and also on economy and society. According to Dijst et al. (2018, p. 193), "*drivers refer to macro developments which have an impact on needs and constraints experienced at the micro (individual or community) level. We can distinguish various types of drivers: socio-cultural (e.g. values and norms), economic (e.g. growth and decline), political (e.g. power relations and policy aims), demographic (e.g. ageing and population decline), urbanization, climate change and natural resources*".

The final step of this chain is the identification of performance indicators (Loiseau et al., 2014), characterized by thresholds for a territorial benchmark. If these thresholds are exceeded, they act on the pattern through degradation processes and they generate the transition from services to disservices. While at the initial life cycle the performance is high and the pattern is in a healthy condition, able to provide goods and services through LUF, as the territorial processes take place, they generate drivers of change and the life cycle tends to run out, until it flows into the wastescapes at the end of the territorial life cycle.

In the following chapters, it will be proposed a methodology to spatially identify a category of wastescapes represented by abandoned industrial buildings.

3. CASE STUDY

The case study selected for the experimental application coincides with the Focus Area (FA) chosen for the Italian case study in the Horizon 2020 REPAiR Project (Geldermans et al., 2017), formed by a portion of the Metropolitan Area of Naples (MAN), that includes the following municipalities (Figure 3):

- Acerra;
- Afragola;
- Caivano;
- Casalnuovo di Napoli;
- Casoria;
- Cardito;
- Cercola;
- Crispano;
- Frattaminore;
- Naples (with the following areas: Poggioreale, Industrial Zone, Ponticelli, San Giovanni a Teduccio, Barra);
- Volla.

The boundaries of the Neapolitan case study have been selected in REPAiR Project through a reasoning based on the spatial organization of the area. One of the aspect that

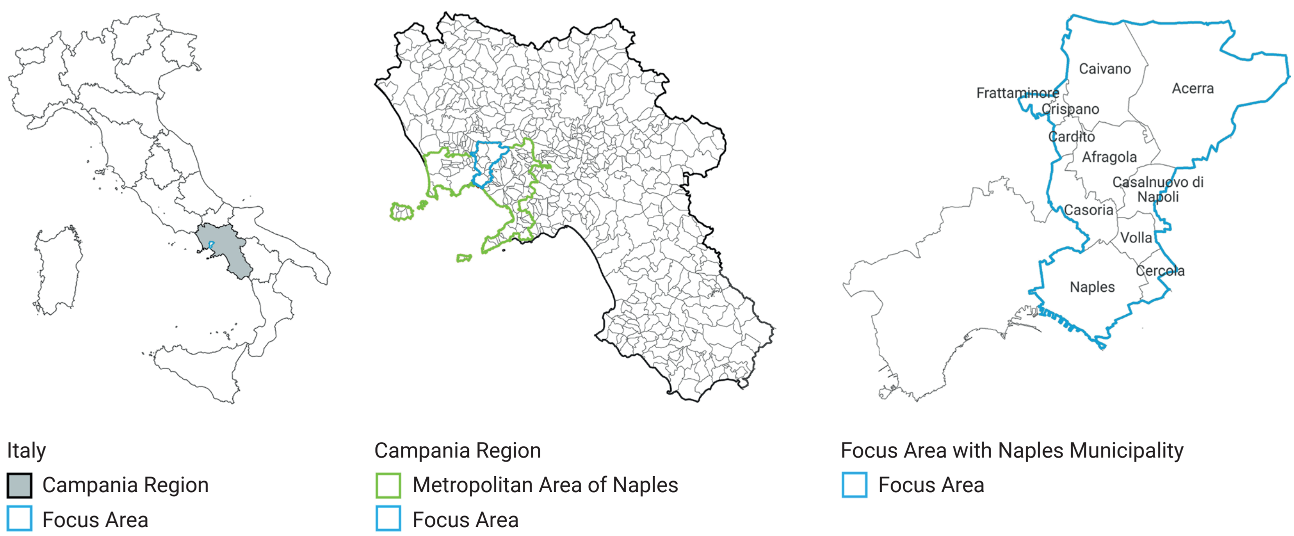

FIGURE 3: Focus Area boundaries.

has been taken into account is the territorial distribution of the transport system together with some ecological aspects. As a matter of fact, the case study is crossed by a plain area and by a network of rectilinear channels, mostly artificial, located in the North-Eastern part of Naples and known as "Regi Lagni", that was worth including.

Metropolitan cities in general are territorial entities of wide area aimed at the care of the strategic development of the metropolitan territory, the promotion and integrated management of services, infrastructures and communication networks and finally the care of institutional relations, including those with European cities and metropolitan areas (law 56/2014, art.1). In addition, metropolitan areas require as well suitable planning instruments because of the presence of environmental conditions that are more critical due to energy consumption and greenhouse gas emissions, generating many negative impacts.

The MAN as a whole can be considered highly affected by territorial aggressions of human matrix (Mazzeo and Russo, 2016) and it is formed by 92 municipalities, representing the third most populated metropolitan area in Italy, with more than 3.5 million inhabitants.

The MAN is also characterized by an unregulated urban development and during the last two decades, the different municipalities have welded together, creating undifferentiated suburbs, with socio-economic and environmental disorder. Moreover, it is marked by an extremely anthropic urban development with a notable population density and the occurrence of both phenomena of density and of dispersion of settlements at the same time (Formato and Russo, 2014), which make the territorial development somewhat chaotic. Furthermore, congestion and urban chaos are the dominant characteristics, especially in the outlying areas. For this reason, the urban conditions of the suburbs of Naples are among the main concerns of the city. In this area, there are numerous environmental and social problems, for which the search for a solution is one of the main challenges that the city has to face (Morelli and Salvati, 2010). Moreover, the MAN has an irregular development due to the lack of an integrated plan of coordination of the entire territory, but a succession of sectorial plans. This led to the presence of a fragmented territory, often caused by the succession of illegal settlements and by a continuous of built up soils, interrupted by poorly connected rural areas.

Facing the specific merit of the selected case study, it is a territory characterized by the combination of valuable elements and at the same time elements characterized by a high degree of fragility together with a considerable concentration of peri-urban areas. The latter are characterized by the symbiotic interaction between rural/natural ecosystems and urban ecosystems (Zhu et al., 2017), habitually seen as residual areas lacking in identity and autonomy and usually located near large urban agglomerations (Gonçalves et al., 2017). As defined in the REPAiR Project, peri-urban areas deal with hybrid portion of territory, sometimes characterized by densely urbanized areas, agricultural land, discontinuous campaigns, as well as abandoned territories, pervaded by degraded ecosystems, with high levels of pollution. In particular, in the South area (Naples, Casoria, Volla, Cercola, Casalnuovo di Napoli) the main feature is the presence of abandoned land linked to the presence of former refineries and oil depots with a consequent intense level of pollution of soils and aquifers. The East area (Caivano, Acerra, Frattaminore, Crispano, Cardito, Afragola) is characterized by an under-utilization of agricultural land and the presence of huge infrastructural systems with many phenomena of disposal. Anyway, despite the problematic context of the present case study, there is also great potential of development, thanks to the territorial variety, the presence of high quality landscapes and many economic, cultural and environmental resources.

Definitely, metropolitan areas require suitable planning instruments because their environmental conditions are more critical and these instruments could be better applied if supported by useful evaluation methodologies. It is necessary to build a solid knowledge base able to support the decision making phase not only at the metropolitan level but also at different and smaller scales, according to the variety of the territory. The aim is to enhance the capabilities that the territory is already able to offer and to act on the weaknesses in order to create environmental, economic and social win-win solutions.

3.1 Wasted landscapes: dismissed industrial areas

According to ISTAT, about 3% of the entire Italian territory is occupied by abandoned industrial areas. In Italy, there is a specific distinction between "dismissed industrial areas", that are areas in need of processes of redevelopment and "contaminated sites", that require processes of reclamation. According to the Environmental Code, dismissed sites in general can be defined as sites were production activities ceased. Dismissed sites can be:

- Contaminated;
- Potentially contaminated;
- Non-contaminated.

In the last decades, because of the economic crisis and the changes in the productive sector (especially in the most advanced countries), there has been a progressive reduction of industrial activities. This process has determined the born of large dismissed areas with the presence of abandoned industrial buildings, very often located in peri-urban areas that are strategic for the urban development. As a consequence, the re-development of these areas constitutes a current problem of considerable interest, characterized by economic, social and environmental repercussions and it represents as well an unavoidable opportunity for activating urban regeneration actions and for the valorization and re-connection of peri-urban areas. For this reason, new operational methods and techniques are required, in compliance with environmental compatibility (Arbizzani and Materazzi, 2012).

It is possible to add that when an industrial activity ceases, it leaves not only a physical vacuum, but it also continues to occupy the territory, polluting it with its residues. Above all, since the mid-1980s, industrial dismissed areas have been recognized as a form of heritage to preserve as a demonstration of the cultural value that it is possible to attribute to productive activities and for this reason, it is worth preserving and promoting this form of heritage.

The disused industrial areas are also generally already served by the main infrastructures and are often located near railway plants or important sections of the road network that can determine a good accessibility, therefore the return of these areas to the city can constitute an important occasion for the redesign of the local urban fabric (Aiello, 2012). The recovery of abandoned industrial areas connected to the location of new important urban and productive functions, can be configured as a unitary intervention of metropolitan level, able to define places and relationships related to a large pool of users and able to renew and increase the points of reference in the vast territory (Miano, 2005).

For the case study elaboration, the selected wastescape category is called "settlement and building in crisis" and it is formed by a series of subcategories represented by: vacant/underused, neglected or obsolescent buildings and settlements, urban settlements suffering from fatigue, informal settlements, urban lots in transformation, unauthorized buildings and settlements, confiscated assets. The application is focused on the subcategory "vacant/underused buildings and settlements", that in REPAiR Project is described as follows (Geldermans et al., 2017, p.17): "*vacancy and underusing phenomena can be the direct consequences of the urban decline, due to several factors in the organization of the territory. Economic changes/crisis could also cause abandonment of settlements, or of some parts of them. In this category, abandoned, vacant, underused, dismissed industrial, commercial, military buildings are also included. Examples are: a) brownfields; b) abandoned historic buildings (farms, houses, mills); c) building blocks with high percentages of apartments and/or offices and/or commercial premises not leased; d) agricultural products (such as greenhouses or shelters)*".

3.2 Methodological application: spatial identification of abandoned industrial areas in the Focus Area

The model of characterization presented in paragraph 2.2.1 is applied in order to characterize and spatially identify the selected wastescape category.

First of all the correspondent land cover and land use that host vacant/underused industrial buildings are represented respectively by artificial land cover, in particular industrial and commercial units and industrial use (known as "industrial, commercial, public, military and private units") (Figures 4-6). Combining land use and land cover, it is possible to select the correspondent LUF, represented by "residential and non land-based industry and services", according to the industrial activity, in particular the activity of production, with reference to the supply chain (Figure 7).

Various typologies of degradation processes can alter the available resources, that in this case are represented by the land that houses the industrial activities and by the building stock itself that is no longer able to perform the economic functions previously carried out. It is not easy to go back to the specific drivers that caused the disposal

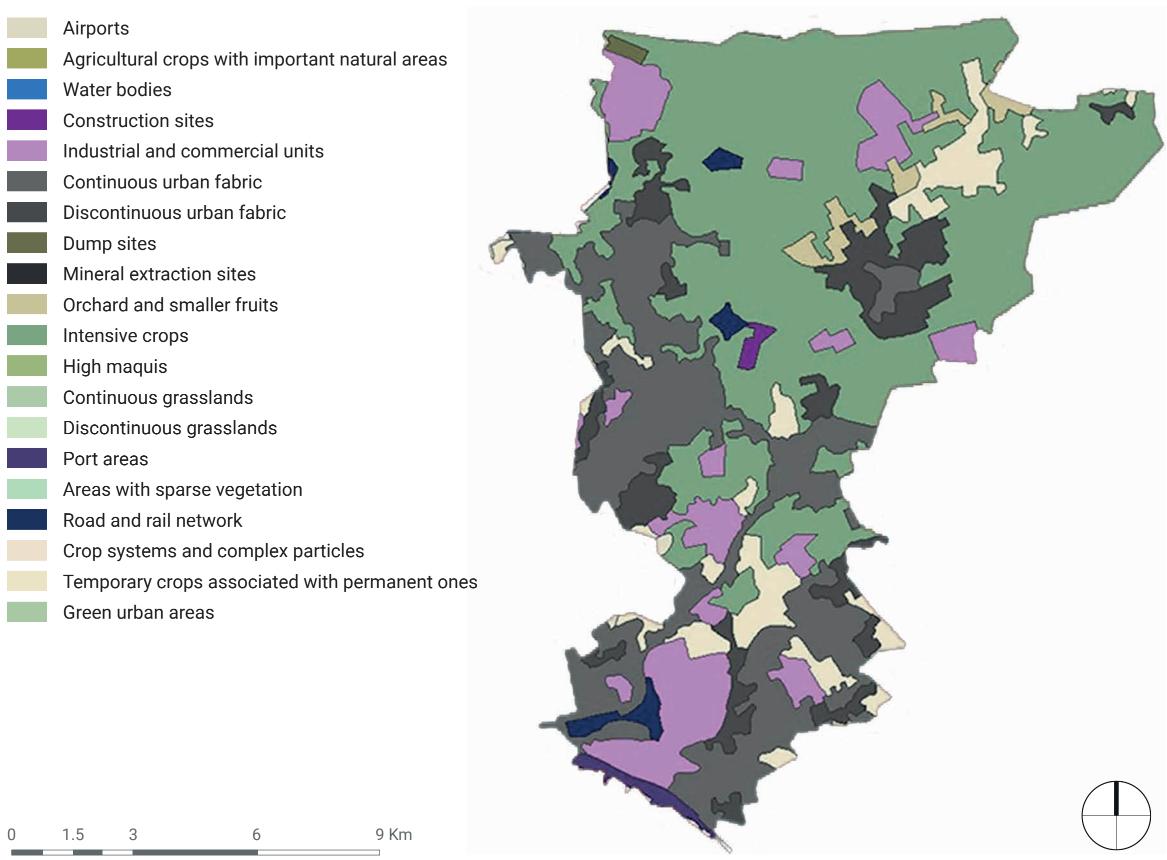

FIGURE 4: Focus Area land cover based on CLC.

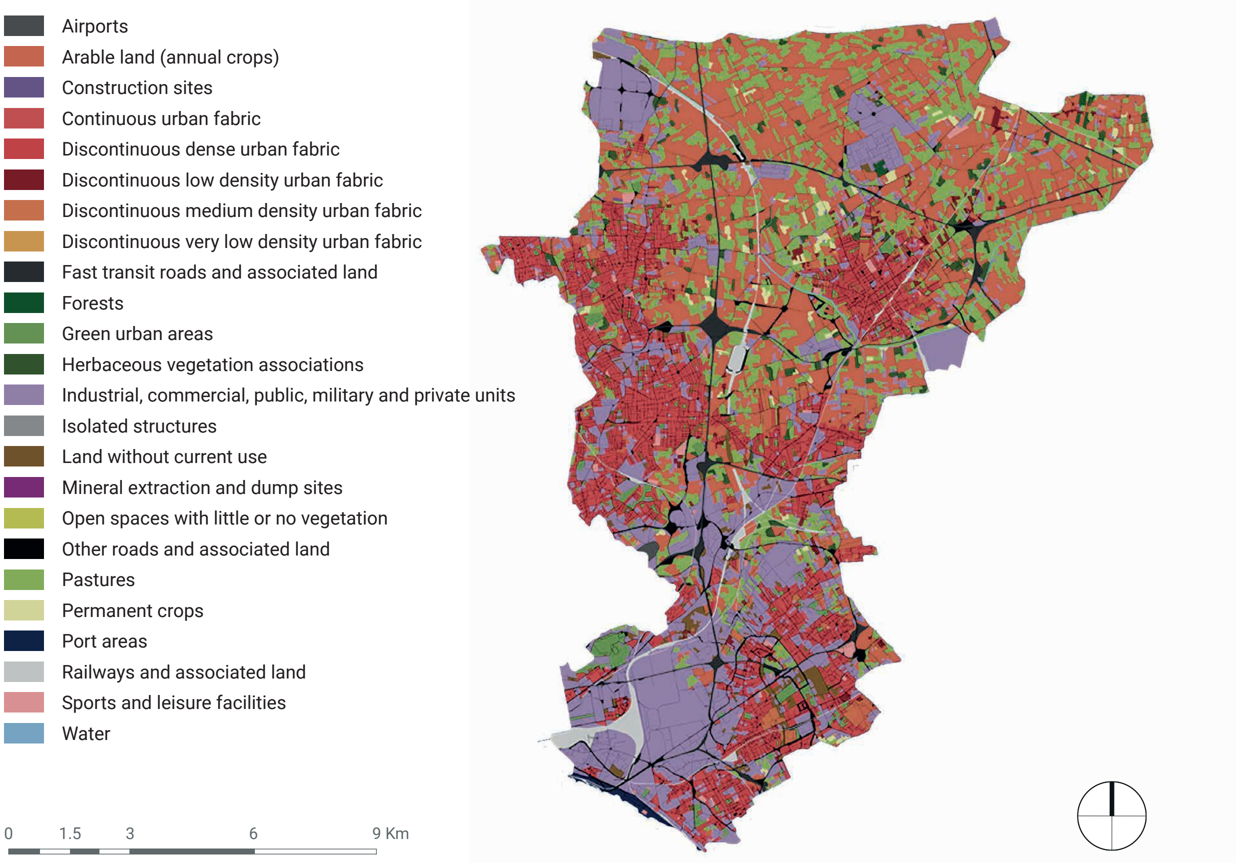

FIGURE 5: Focus Area land use based on Urban Atlas, year 2012.

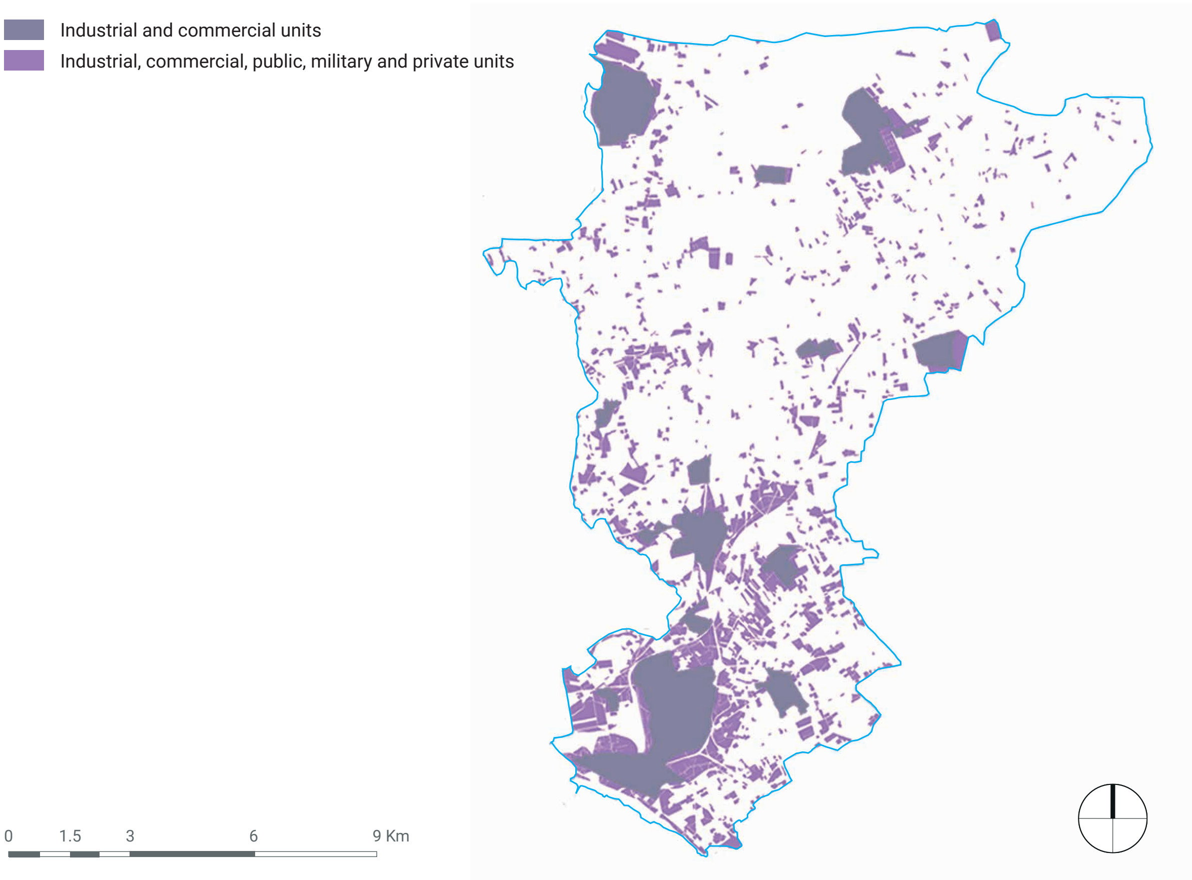

FIGURE 6: Wastescapes characterization model.

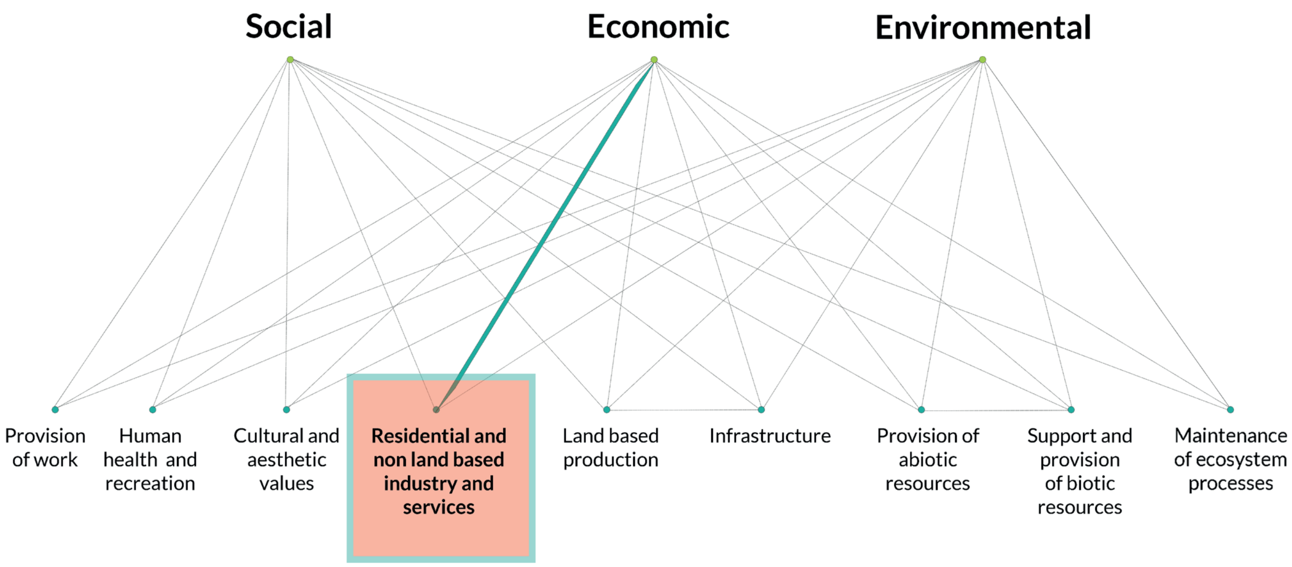

FIGURE 7: LUF identification.

of industrial buildings, but often the closure and the transfer of the plants are due to the contraction of the productive apparatus and the tendency to transfer the productive activities in countries with low labor costs. Therefore, it is possible to assume that drivers are represented especially by economic factors.

The final step of this methodology is represented by the selection of a performance indicator, that in this case is represented by the number of employees. Where the number of employees is equal to 0 (assumed as the previously described threshold), it can be a potential abandoned industrial building, passing from the industrial productive service to the disservice of abandonment. The data considered in this phase have as a source the industry and services census carried out by ISTAT, and indicate for each census section two relevant information for the purposes of the present survey:

- Number of local units;
- Number of employees.

These data were subsequently spatially coupled and represented through Geographic Information System (GIS). The use of reference maps is vey significant for the visualization of those elements of the decision-making problem that are characterized by a spatial dimension and has proved to be very useful in various occasions (De Toro et al., 2016; De Toro and Iodice, 2016; De Toro and Iodice, 2018).

In order to complete the survey and get to the selection of the investigated wastescape, it was necessary to integrate aerial views through the use of Google Maps, making a first selection of all the areas potentially useful for the analysis. To this, it was added a selection criterion that allowed to make a further reduction of the sections, excluding those that meet the following requirements:

- Sections containing Roma settlements;
- Sections containing plants;
- Sections containing greenhouses;
- Sections containing already demolished buildings.

Consequently, the sections containing built structures in terms of large abandoned spaces, with abandoned industrial buildings characterized by lack of activity, or where there are often perimeter control activities have been examined.

4. RESULTS AND DISCUSSION

The first result of the described methodology is represented in Figure 8. As it is possible to observe, the census sections represented in white are those that contain a number of employees between 0 and 5. Some, especially those of larger dimensions located in the northern part of the FA, are constituted by agricultural fields. The final result is represented in Figure 9, where, the wastescapes “vacant/underused, industrial buildings and settlements” can be spatially identified

For the application, by way of example, the attention has been focused on one single wastescape that belongs to this category. The selected wastescape is the former industrial plant known as “Rhodiatoce”, located in the Municipality of Casoria (Figure 9).

Casoria (Figure 10) located in the north-eastern suburban part of the Neapolitan area, is characterized by the presence of a series of dismissed areas that determine the existence of abandoned portion of territory and large urban voids without function that delineate a specific landscape, configuring itself as a real environmental issue.

Because of the crisis of urban production facilities, Casoria is represented by an industrial scenario in transition, with many abandoned factories, as skeletons of monuments, as a fixed and resistant scene, in a territory of transformations. One of the main problems to be addressed in view of a possible recovery of these areas is represented by the presence of polluted soils, which determine the need to carry out extensive reclamation operations before any type of intervention.

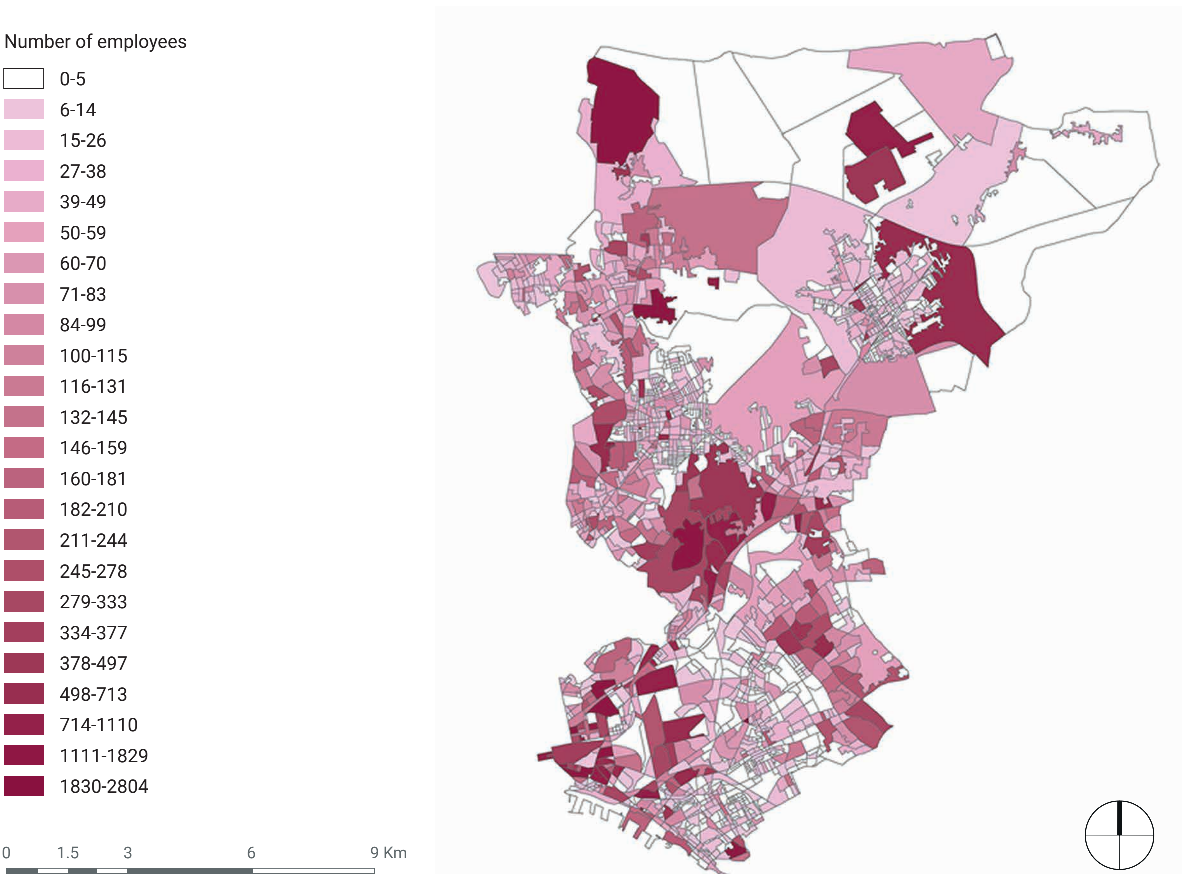

FIGURE 8: Preliminary results.

FIGURE 9: Vacant/underused, industrial buildings and settlements with focus on Rhodiatoce industrial plant.

FIGURE 10: Municipality of Casoria.

This industrial landscape has developed and at the same time died in an urban life cycle of around 30 years (Miano, 2005).

The redevelopment of the abandoned industrial areas can be seen in the context of a territorial reorganization, creating the possibility of establishing links between apparently autonomous elements of the urban fabric (Miano, 2005).

Among the five disused industrial plants that characterize the territory of Casoria, there is the Rhodiatoce industrial plant for nylon production, that rises in 1928 and one of its branches was born in 1953; its organization and distribution is accurately described by Miano (2005).

4.1 The life cycle of a building: how to manage Construction and Demolition Waste

Having previously specified how the territory is characterized by its own life cycle that determines the formation of residual spaces, it is necessary to underline that also the built heritage, in a multi-scale perspective, is endowed with its own life cycle.

The life cycle of a building is based on the analysis of the practices that affect the whole path of life that a building undergoes in the course of some years. The life of a building begins with the design phase, in which the costs and times are the items that most influence the result of the final project. In the next phase, the construction phase, the life cycle of materials, the times, the costs and the building site take on a particular relevance. After the construction, begins the period of use of the artefact in which different functions can be carried out with different subjects who perform maintenance works of the building. A possible next phase is that of abandoning the building.

Some possible scenarios arise subsequently: it is possible a recovery of the building with the part of the disassembly in which the existing conditions are evaluated. It is also possible a complete demolition of the artefact, without a new construction, determining the necessity of the disposal of waste or also its recovery. Finally, the last alternative is the demolition of the building but a subsequent construction of a new building (Baiocco et al., 2017).

As far as the demolition phase is concerned, there are two possible alternative scenarios (Figure 11):

- The first concerns the total demolition of the building, without recovering the waste materials and the construction of a total new building;
- The second alternative is based on the demolition of the existing building and the construction of a new building by reusing part of the demolition materials.

The demolition phase and the way it is carried out depends strictly on the constructive process, underlining the necessity to consider the entire life cycle.

In the demolition phase, it is possible to take two opposite paths:

- The firs concerns the disposal of the materials without any opportunity of recovery;
- The second provides the possible recycling of Construction and Demolition Waste (CDW) and the disposal of the material that it is not possible to recycle.

As a matter of fact, the disposal phase is very relevant and it is necessary to support this phase by accurate economic and environmental evaluation procedures (Baiocco et al., 2017). Furthermore, the application of sustainable development principles can influence and improve the sustainability of urban ecosystems and among this principles there is that of Waste Management (WM) (Dizdaroglu, 2015).

CDW belongs to the category of Special Waste, which in turn is divided into hazardous and non-hazardous one. The CDW flow is produced during the life cycle of a project, that can be summarized in three main phases (Wu et al., 2014):

- Construction;
- Usage/maintenance;
- Demolition.

4.1.1 Life Cycle Assessment as a tool to support the regeneration of abandoned industrial areas: CDW quantification methods

At this point, it is necessary to specify that it is important to collect reliable information on the expected quantities of CDW in order to facilitate the establishment of policies and alternative possible solutions (Ding and Xiao, 2014), also using environmental assessment methods able to improve the decision making phase. One of the most useful tool is represented by Life Cycle Assessment (LCA), that can provide quantitative information, able to facilitate the selection of sustainable choices (Helling, 2017).

Usually LCA takes origin from the production of raw materials until their disposal, i.e. "from cradle to grave",

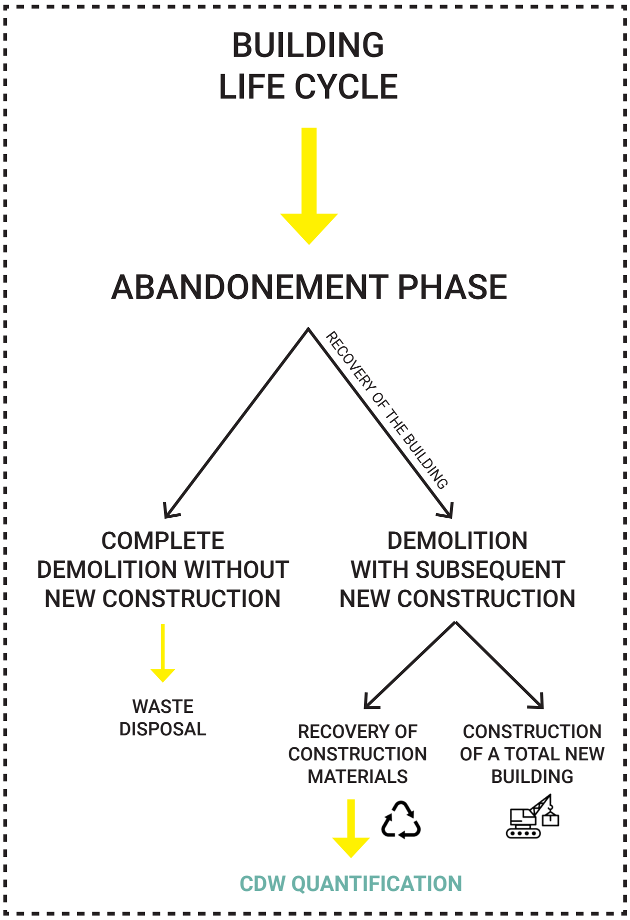

FIGURE 11: Building Life Cycle.

but could be an useful instrument also for specific phases of the life cycle, such as that of WM. The latter comprises everything that happens when the product becomes waste, in order to evaluate the impacts of its disposal (Turconi et al., 2011; Brogaard and Christensen, 2016; Taelman et al., 2019).

Supposing a reuse and requalification of Rhodiatoce industrial plant following the architecture project described in Miano (2005), it is necessary to bear in mind that a clear tendency to rise for the next years for retrofitting and demolition activities is shown and since they have proven to generate more waste than construction activity (Coelho and De Brito, 2011), it is necessary to identify a suitable quantization model and to monitor the environmental impacts.

As stated by Martínez Lage et al. (2010) and Ding and Xiao (2014), CDW is the sum of Construction and Demolition Flow as well as the waste produced by retrofitting or renovation activities.

CDW quantification represents a fundamental prerequisite in order to implement a successful WM. Wu et al. (2014) propose an analytical review of the existing quantification methods, introducing a first distinction between quantification at two different levels:

- At regional level, with the aim of quantifying CDW of all projects in a particular region;
- At project level, that has the aim of forecasting CDW quantities in a single project.

Still Wu et al. (2014) identify six major categories of quantification methodologies:

- Site Visit method (SV), in which it is possible to adopt both direct measurement, through which the waste produced is measured on site and indirect measurements, such as truck load records and on-site interviews as well.
- Generation Rate Calculation (GRC) method, that is based on the waste generation rate for a particular activity unit (for example Kg/m^2) and the amount of total units. This category of methods can comprise per capita multiplier, financial value extrapolation and area-based calculation. The latter can be estimated by multiplying the generation rate and the total area.
- Lifetime Analysis (LA) method that is based on material mass balance and on the principle according to which the amount of demolition waste must equal the mass of the construction. This methodology is divided in building lifetime analysis and material lifetime analysis.
- Classification System Accumulation (CSA) method, that is based on a platform for quantifying different specified materials.
- Variables Modelling (VM) method is based on the principle according to which CDW quantification and generation depend on a series of variables such as economic indicators, construction areas, etc. Very interesting can be the quantification framework based on an "Activity Based Waste Generation" (Wimalasena et al., 2010), according to which the total CDW quantity can derive from the sum of the waste quantities produced in each construction activity.
- Other methodologies, such as method based on chemical characteristics or method based on fix percentages of the purchased materials.

These methodologies can be adopted either individually or in combination, depending on the needs.

As far as site visit is concerned, this method could be the most precise but it is time consuming and costly and it could be characterized by significant barriers (Franklin Associates, 1998).

The first factor to determine for the application of the calculation model is represented by waste characterization. Secondly, the main factor for the estimation of CDW is represented by the Waste Generation Rate (WGR), that depends on the quantity of material developed from different sources (Ghosh et al., 2016). Different quantification formulas have been proposed in the literature; for example Kofoworola and Gheewala (2009) suggest to apply for construction waste the quantification model based on the following formula (1):

$$Qx = A * Gav * Px \quad (1)$$

whereas Qx represent the quantity (tons), A is the area of activity, Gav is the waste generation rate and Px is the percentage of waste material. Martínez Lage et al. (2010) propose a quantification model that estimates a quantity of 80 kg/m^2 of CDW for new construction work, 1350 kg/

m^2 of waste for demolition work and finally 90 Kg/m^2 for renovation work.

According to the data availability, for the present application it is considered appropriate to choose the method indicated by Wu et al. (2014) as "area based calculation" linked to the "generation rate calculation" category.

Therefore adopting the formula proposed by Kooworola and Gheewala, (2009) (1) and the estimations of Martínez Lage et al. (2010)[3], it is expected that (2-3-4):

*Construction Waste = Anc * 80 kg/m² = 25955[4] m² * 80 kg/m² = 2.076.400 kg* (2)

where Anc is the total area of new construction based on the project of renovation described in Miano (2005).

*Renovation Waste = Arc * 90 kg/m² = 1416 m² * 90 kg/m² = 128 Kg of total RW* (3)

where Arc is the total area of the renovated building, as established by Miano (2005).

*Demolition Waste = Adc * 1350 kg/m² = 46000 m² * 1350 kg/m² = 62.100.000 kg* (4)

where Adc = is the total area of the demolished building always according to the demolition proposed by Miano (2005).

Therefore the total CDW flow is:

CW + RW + DV = (2.076.400 + 128 + 62.100.000) Kg = about 62.102.204 Kg.

At this point it is necessary to specify that these are forecast estimates based on broad indicators and which naturally determine plausible but not effective results. To this end, it would be necessary to use the "direct measurement" method during the actual construction and demolition phases linked to the building transformation processes envisaged for the future.

Once quantified the CDW that would arise from a renovation project of Rhodiatoce factory, it could be possible to run a LCA model to assess the environmental impacts linked to the treatment of CDW, in order to identify some sustainable guidelines aimed at reducing environmental impacts.

TABLE 1: Material fractions for Rhodiatoce industrial plant: a hypothesis.

Material Fractions	%
Bituminous mixture	0.5
Clear Glass	1.5
Mixed CDW	45
Insulation materials	1
Ferrous components	5
Concrete	35
Ceramics	0.5
Wood	1.35
Gypsum	0.15
Soil	10

As regards the quantitative information related to the individual flows, REPAiR Projects performs a LCA for the CDW produced in the Focus Area and has officially received from the Campania regional agency for environmental protection (in Italian "Agenzia Regionale per la Protezione Ambientale in Campania" – ARPAC) data related to CDW flow according to the year 2015 (Tonini et al., 2019). For the present application, the percentage considered for the flow produced in the Focus Area is basically maintained and it is considered representative of an average CDW flow. Anyway, some adjustments are necessary according to the specificities of the building.

Therefore, on the basis of these two information, namely on the one hand the flow produced in the Focus Area and in Campania Region, described in Tonini et al. (2019) and the temporal and constructive characteristics of the building that create the necessity to eliminate some fractions and to make a general calibration, a possible hypothesis of the CDW fractions coming from Rhodiatoce renovation could be the ones represented in Table 1[5].

5. CONCLUSIONS: WHAT'S NEXT?

Urban ecosystems are characterized by complex social-ecological interactions where sustainable choices made in one place can create social, economic or environmental problems elsewhere (McPhearson et al., 2016). Urban ecosystems, in their complexity, like living organisms, have also their own metabolism, whose functioning is linked to the presence of input and output streams. Hence the concept of UM has been introduced and described together with the concept of territorial life cycle. This is because the territory, like living organisms, is not only endowed with its own metabolism but is also marked by the succession of life cycles that are shaped by metabolic flows. The portions of territory that are at the end of their life cycle, configure themselves as territorial waste, and a spatial methodology for their identification has been proposed. A multi-scale approach is adopted, as cross-city comparison at multiple scales is a key quality to understand and analyze the complexity of social-ecological interactions (McPhearson et al., 2016) (Figures 12-13).

Focusing on one single category among the wastescapes proposed in the Horizon 2020 Project REPAiR, the attention has been focused on the abandoned industrial areas. Here, the LCA could be a valid instrument to support the decision-making phase of possible renovation actions, providing useful information about the environmental impacts connected to the management of the metabolic flow represented by Construction and Demolition Waste.

This procedure serves also to demonstrate how the LCA tool could prove to be useful in supporting the regeneration of the territory, and in this case to support the demolition and reconstruction of the abandoned buildings, suggesting to the decision makers good practices of demolition and reconstruction, such as that of selective demolition. As a matter of fact, at the scale of city and urban region, LCA is a field of application that has not yet been properly explored (Albertì et al., 2017) (Figure 14).

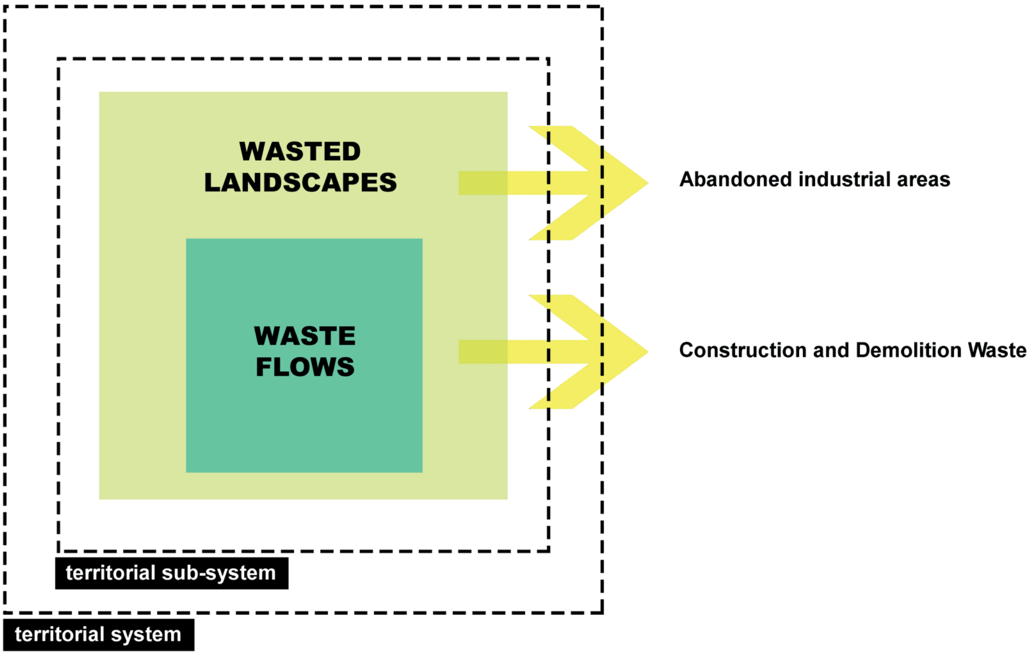

FIGURE 12: From wasted landscapes to waste flows.

This example also shows that the same procedure could be repeated in the same territory or even in different territories to identify and support the redevelopment of the abandoned building heritage.

Definitely, the present paper proposed a first possible association of LCA as a tool to support the regeneration of the territory, but it is also open to future advances. For example, it is possible to take into account all the other wasted landscapes, in order to calculate the total amount of CDW that would come out of the regeneration of abandoned industrial buildings in the Focus Area. The real challenge would also be the reuse of the materials of abandoned artifacts, using LCA to asses the economic and environmental costs of this recovery, that in general could be energy-intensive and thus very demanding for the environment. In this perspective, a very useful approach focusing on the territorial aspects of LCA is that represented by the "Territorial LCA" (Loiseau et al., 2012; Loiseau et al., 2013; Louseau et al., 2014; Loiseau et al., 2018) that focuses on the impacts linked to the territorial activities, comprising also that of WM.

Secondly, it is also possible to focus on other activities that take place on the territory or on other types of metabolic flows, to support the regeneration of other typologies of wastescapes.The real step forward, however, would consist in the geographical mapping of impacts (Gargari, 2015), which is linked to the distribution of pollutants in the air. Indeed, the combination of the results of an LCA evaluation with models of territorial mapping of emissions is an innovative development line in relation to the issue of spatialization of environmental impact indicators.

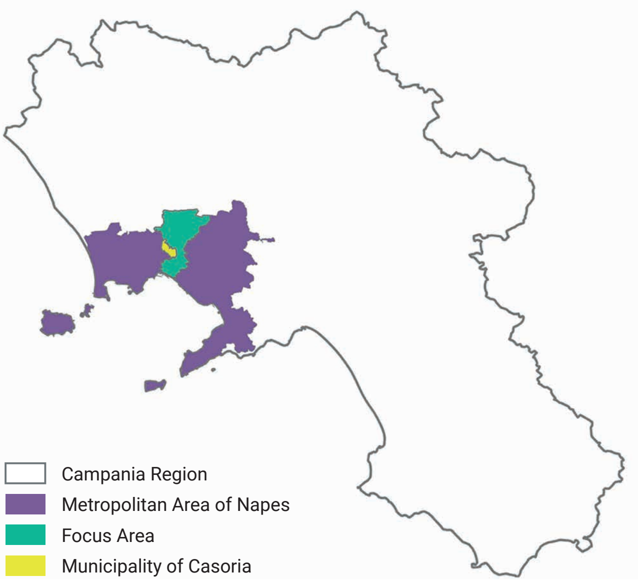

FIGURE 13: Multi-scalarity.

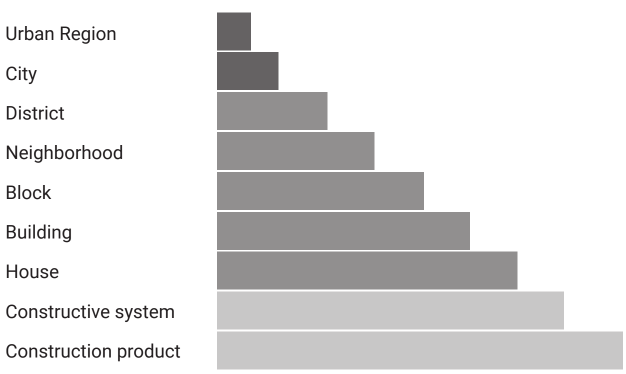

FIGURE 14: Hierarchy of the built environment, adapted from Albertì et al., (2017).

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AUTHORS CONTRIBUTION

Conceptualization: Silvia Iodice and Pasquale De Toro; methodology and data curation: Silvia Iodice and Pasquale De Toro; formal analyses: Silvia Iodice; writing, review and editing, Silvia Iodice. All authors have read and agree to the published version of the manuscript.

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[1] Information about REPAiR Project are available at: http://h2020repair.eu/

[2] Figure elaborated by the authors for the Horizon 2020 REPAiR Deliverable 3.3 (Geldermans et al., 2018).

[3] The choice to adopt these indicators compared to others is due to the similarity of the Spanish context, in which the application is localized, compared to the Italian one.

[4] Dimensional measures about the Rhodiatoce industrial plant have been calculated trough the cartographic material kindly provided by Professor Pasquale Miano from the Department of Architecture of the University of Naples Federico II.

[5] It is necessary to bear in mind that the aim of this section is not that of calculating a precise amount, but that of developing a multi-scale methodology that could serve as an example.

Extra contents

COLUMNS AND SPECIAL CONTENTS

This section comprises columns and special contents not subjected to peer-review

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Architectural report

THE VALUE OF ABANDONMENT: THE GIACOMINI PARK IN ITALY

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INTRODUCTION

An abandoned disposal site for Municipal Solid Waste (Environmental Facility for Separate Collection - EFSC) located in a town of approx.10.000 inhabitants provided an opportunity for requalification of an open space and regeneration of a neglected woodland with restricted use, in accordance with EEC Regulations 2052/88. Both these elements were deemed strategic for different reasons. A juxtaposition of "natural"/artificial both requiring intervention. Two critical elements, two issues subject to ongoing debate by public administrations striving to identify an equilibrium in an attempt to proactively support this type of area. An open space, of value in its own right due to uninterrupted availability, multifunctional and readily organizable but burdened by a need for control and management, and the vegetation and its importance as an environmental vector, a symbol of strategic needs encumbered by maintenance and governance issues.

An obsolete area conveys a double value: it both contains and constitutes the neglected object, two separate conditions featuring an active subject in the first case and in the second the object of the action itself. The "non-use" may be referred either to a container and/or to the context of space, terrain vagues or volume. The term "to abandon" is linked to a negative concept corresponding to synonyms such as to give up or desist from doing something, to leave definitively forever implying a surrendering of control and responsibility, terms and concepts indicating varying degrees of awareness, time frames and modalities. Each is associated with an indisputable innate and deep-rooted hostility towards an interpretative vision according to which mankind is the ordinator architect of all things mundane, a maintenance technician and supervisor aware of all that goes on before his eyes. On losing control (by choice or necessity) and thus leaving something behind, this position however assumes a lesser role, being somehow ill-suited to cover an active role in a routine setting.

Within the context of this mechanism, time, humanly managed, is annulled and loses any form of link with reality, it is left hanging (definition included amongst the diverse meanings of abandon) in a sort of limbo surrounding the fate of the neglected object.

On relating abandon to a space, the mindset focuses on aspects of increasing ambiguity, giving rise to a visual and mental association which, taken together, generate a negative frame of mind. This summation produces an image in which the limits and confines of frequentation, vision, management and socialization have been lost, thus determining a kind of marginalization (situated externally, beyond the confines) in which the dynamics manifested are out of control, unlimited and lacking direction.

Recent research has focused on the ecologic and environmental qualities afforded by an obsolete space, furthering a complex scientific view aimed at examining the potentialities of the in-between and the terrain vagues occupying a less central position amongst the physical and aesthetic requirements of our presence in these locations (through an association once again linking an automatism new/cared for/beautiful).

The literature relating to derelict areas documents through renowned cases, architectural and industrial qualities that acted as a driver for new configurations, producing a determinant impact on the landscape and sociality.

The case illustrated turns its gaze towards a less courtly and in some ways anonymous "lesser place", one of many that punctuate our territories in various capacities (with a series of different former destinations) which may become virtuous in the context of recovery/recycling.

The project is comprised of two basic elements: a former collection centre and a woodland, both left to themselves. Two different entities, with gradients of naturalness and hybrid artificiality to be brought together in order to devise a renewed environmental, ecological and social functions.

THE REQUALIFICATION PROJECT: FROM A FACILITY FOR SEPARATE COLLECTION TO AN URBAN PARK

The area was comprised of a small facility for separate collection, a strictly organized structure with no remaining functionality. It was an anonymous place created according to a pre-established design with a view to performing specifically-identified functions. A situation of widespread anonymity defined by law in terms of size and characteristics (Figure 1).

The Ministry for the Environment, Land and Sea issued a Decree dated April 8 2008 regulating centres for the separate collection of municipal solid wastes, in line with

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FIGURE 1: Orthophoto of the area of intervention.

art.183, comma 1, letter cc) of Legislative Decree n.152 dated April 3 2003, which defined the fields of application in municipal or inter-municipal collection centres for household and non-domestic users. Collection centres are made up of a series of removable containers for the conferment of non-hazardous household wastes featuring internal road networks, impermeable paving in the areas for unloading and deposition of wastes, fencing of a height no less than 2m, and an outer barrier of hedging and/or trees or mobile screens to minimize visibility of the facility. The centre includes an area for conferment and deposition on impermeabilized slabs featuring accessible ramps for the conferment of bulky or heavy materials (Figure 2).

Prior to intervention, the area was characterised by the presence of a series of abandoned undifferentiated wastes such as waste oils, plastic containers, inert and other materials deposited both throughout the paved and the green areas. The paving at ground level was comprised of concrete slabs delimited on all four sides by a runoff point and rainwater disposal system. One of the storm drains was placed inside the area for the disposal of special waste (batteries, exhausted oils, etc. ...), protected by a mobile aluminium cover with a PVC sheet. The fully asphalted raised level used for the unloading of various types of waste was accessible by means of two asphalted ramps. Wooden sheet piling had been embedded immediately prior to the north ramp to contain the soil, and a layer of gravel had been spread in the vicinity of the escarpment delimiting the southern raised area featuring a series of accumulations of inert material. The centre for separate waste collection was delimited along the perimeter by a series of fences of different heights interspersed with steel access doors and by two 6-metre high Leylandii cypress hedges to the sides of the main entrance to the west. In addition, in the vicinity of the latter, a prefabricated construction shed with a drinking water tap at the back had been erected on a concrete slab.

Nearby, the woodland consisted in a relatively young area planted along parallel mulched rows with plants of various sizes, including ash, walnuts, alders, hornbeams, elms and poplars, in addition to a dense undergrowth of mainly privet and hazel. A lack of maintenance had led to a dangerous degradation of the arboreal and shrub vegetation, with fallen plants and forked and chipped branches, making the area unpassable and close to collapse. These two areas are located close to the historic centre of the Municipality of Motta di Livenza (Italy), in an enclosed area lacking any road network devoted to a series of public uses: municipal swimming pools, sports field, care centre for the elderly, all frequented by different groups and remaining operational throughout the day.

Taken together, the waste area and the woodland portray a landscape of abandonment featuring a strong potential for regeneration based on the intrinsic qualities and po-

FIGURE 2: General layout of the area of intervention featuring the EFSC area and the section of woodland to the east.

sitional value, nestled amongst the numerous surrounding activities that constitute a dynamic context (Figure 3).

The project, initially intended to completely demolish the collection centre structure, has evolved with the aim of promoting a proactive link between the structures present on site, financial availability and the functional requests of the community.

The main works envisaged include (Figure 4):

- Realization of a road network and access system;
- Treatment and erection of masonry and flooring in the area dedicated to games and leisure activities (ex-ESFC);
- Potentiation of vegetation and realization of the woodland .

The first operation undertaken was to develop the road network to afford a simple, seamless system of access to the area: a series of intersecting continuous tracks providing access to the entire area distinguished in three separate zones:

- The woodland area to the east
- A fully equipped central plaza
- A polyfunctional grassed area to the west

As highlighted above, the waste conferment areas are codified spaces made up of a few functional elements: a concrete area housing the containers for storage of the various materials and a high altitude perimetric road providing easy user access to specific waste containers.

Thus, from the basic elements comprised in the equipped area, a park was born. A park in a few easy steps. Taking advantage of its barycentric position and elementary structure of concrete floors and walls, a series of simple operations of removal, salvaging, excavation, and cutting were undertaken to restore the area to an operational function. A restoration not linked merely to use of the space, but also featuring a regeneration of environmental principles.

Initial operations focused on the cleaning and remediation of surface materials in the area of the plaza, the grassed area and the fringes, with removal of the asphalted surface to facilitate access to the drain partially compensating the area concerned; the material removed was crushed and re-used by the contractor.

Cleaning was carried out on the long oil storage tank comprised of a curb raised above the height of the ecological area. The containers and plastic cover protecting the drums deposited during the operational phase of the EFSC area were removed This concrete paved space was then reconnected with the underlying soil by breaking the paving to allow resurfacing of the soil required to convert this box into a new organic container.

The paving slabs featured a series of diversified irregularities and abrasions, although the superficial characteristics of the latter did not hinder a routine presence of the

FIGURE 3: Obsolete EFSC.

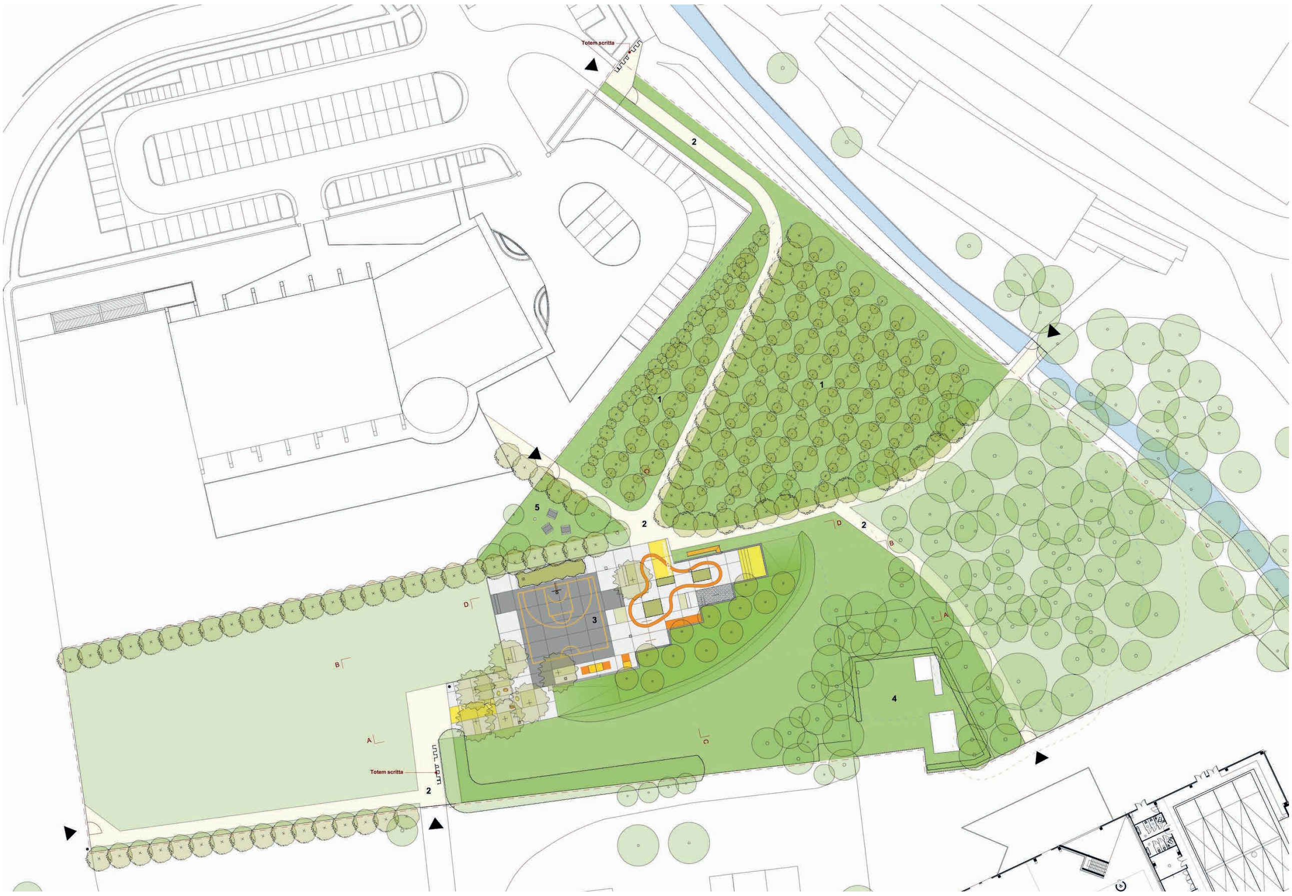

FIGURE 4: General project layout showing the extension of the woodland area, redesign of the road network linking the various areas, and the new function of the EFSC area.

public and were maintained. Each cut and each removal required a detailed operation aimed at adhering to the original lines / joints traced on the ground and promote the development of a geometric pattern deriving from the original form of the area and thus generate 'discarded' sections indicated for outplacing. The sections thus obtained proved to be of a particular qualitative and formal interest attesting to the granularity of their composition.

The elements present were ludically interpreted based on their capacity, their consistency, and presence of vertical walls and horizontal surfaces, and a series of diverse patterns hypothesized.

By manipulating the existing area, sections of concrete were removed to restore permeability to the soil to yield ground on which to plant new trees needed to mitigate the heat, provide shaded spots and constitute areas of collective appeal, design spaces in which to linger, whilst bearing in mind how the soil "is a vital organ to all effects" (Figures 5,6 and 7).

Basic, "circular" actions devised to avoid production of scraps or waste: digging, removing, operating through coring to deform the area, to build the playground, each concrete element cut with precision or deriving from diversified diameter coring was reallocated in the same area to form the basis for a new application - hard paving on which to locate picnic tables or route a brief itinerary.

The concrete blocks obtained from cutting of the paving and particularly from coring of the inclined wall, were positioned at varying heights perpendicular to the wall at a point where, due to the presence of surface water, a depression needed reinforcing to ensure stability of the intervention had formed. This particular arrangement was devised to guarantee leaching of surface waters into the concrete slab drainage.

Vertical concrete surfaces of an identical height featuring an original coarse finish maintained to act as a bond for the chromatic colours used to define the playrooms were used. A variety of tones of yellow were applied as the main colour, and the existing north-south facing walls were decorated using pictograms to portray the range of activities, whilst the remaining east-west facing walls depicted the range of games available.

A succession of rooms decorated with scenes of shooting, climbing, and street workouts constituted the play area; different colours were applied to mark out space for the specific activities. The floor paving was dyed to create a games itinerary for wheeled vehicles and/or skates, and a basketball court delineated (Figures 8, 9).

A room to the north was designed for use in the event of shows by creating between the existing walls a smooth concrete staircase comprising four steps created using painted disposable formwork similar to the existing walls.

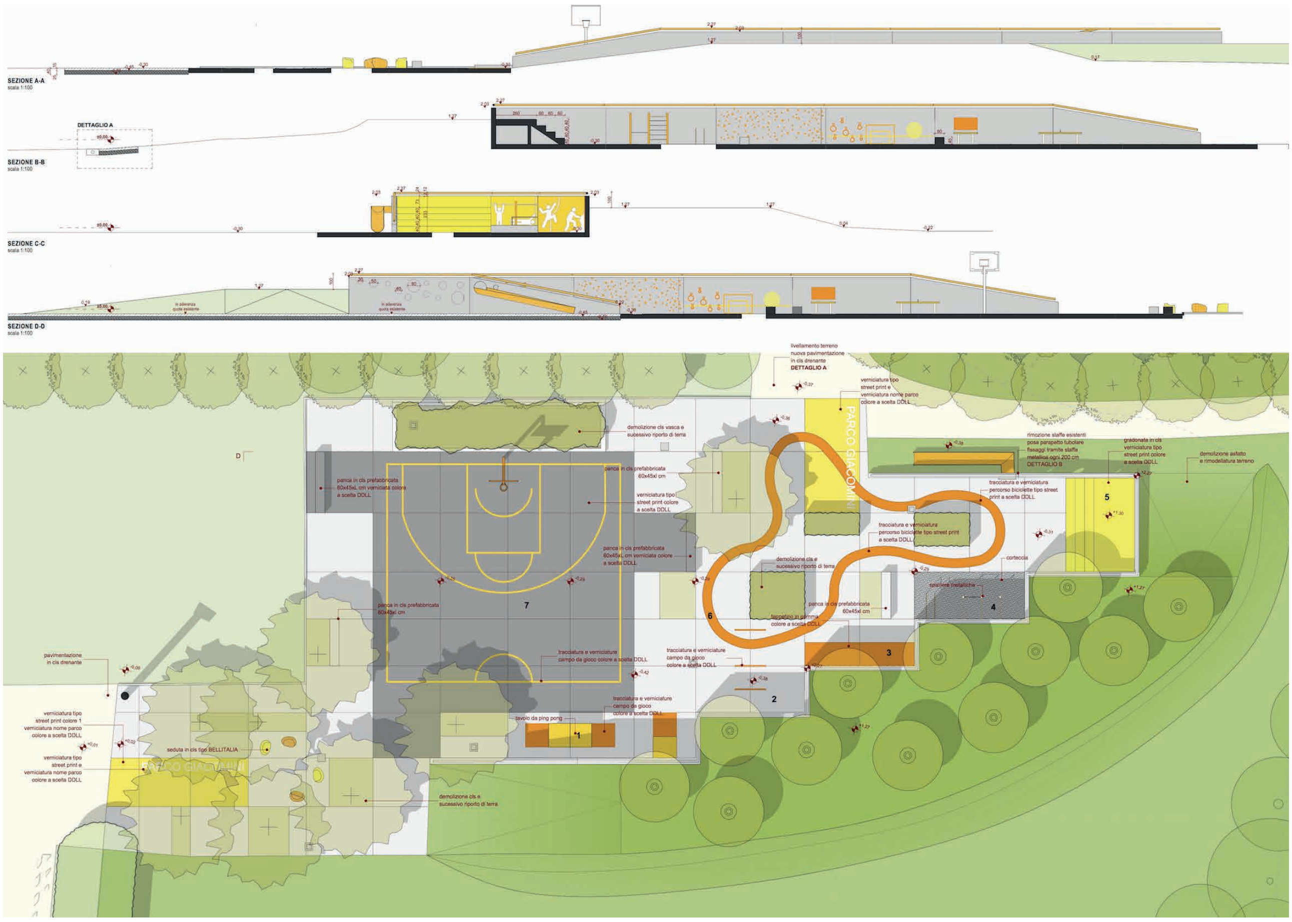

FIGURE 5: Detail of the project in the EFSC area indicating the range of activities.

FIGURE 6: Diversified core drilling on the vertical wall.

FIGURE 7: Incisions to the ground during recovery of permeable areas.

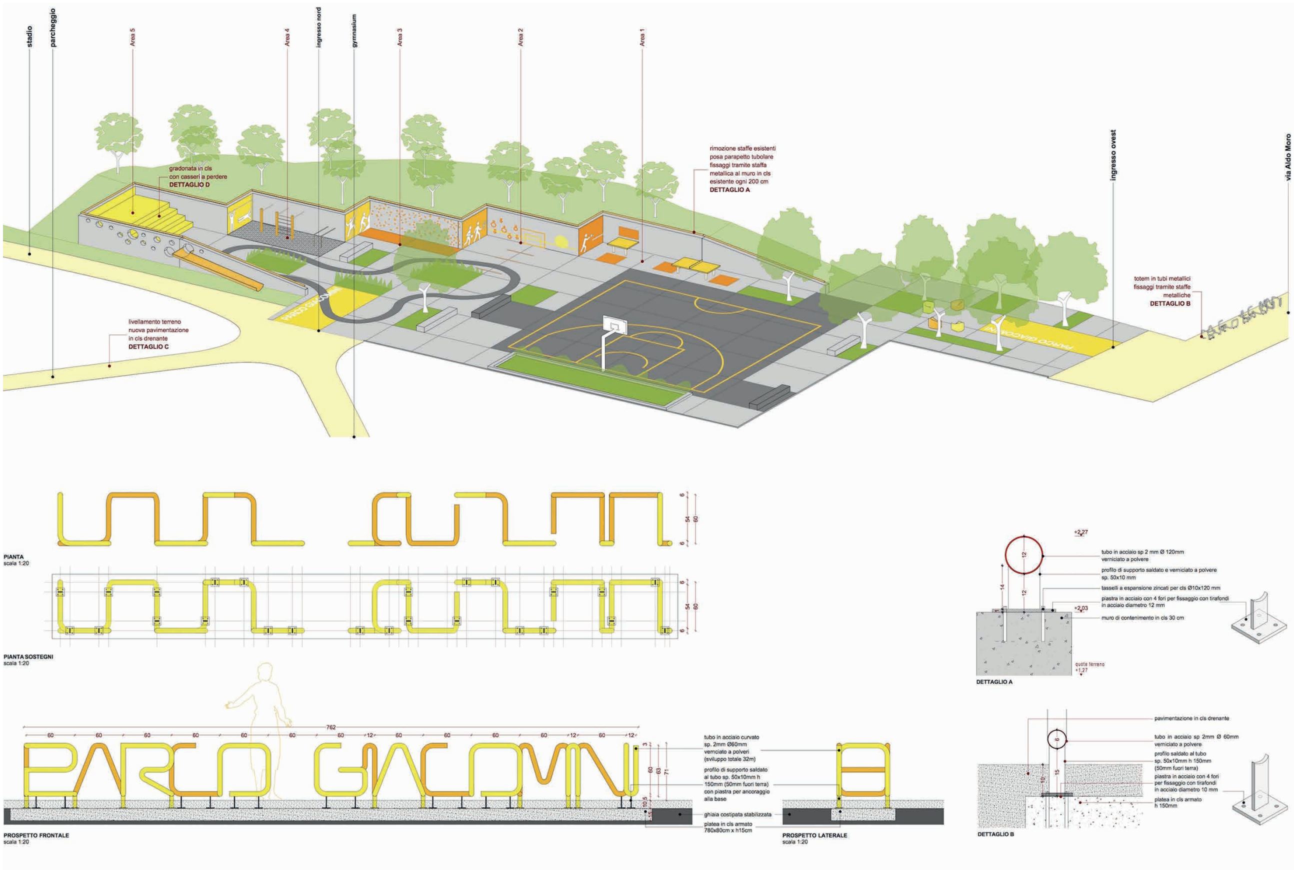

FIGURE 8: Axonometric detail of the area, tubular signage used at entrances to the park.

FIGURE 9: View of the intervention in the play area.

In the upper part previously occupied by the asphalt, a de-paving operation was carried out and a flowering meadow sown with no use of fertilizers and requiring very little water; Malus New York trees were planted to create a shaded area in this leisure space, a raised observation point providing a wide view over the new spatial structure (Figures 10, 11).

In this part of the embankment, a deviation with respect to expected footfall was found to lack compliance with safety regulations. Accordingly, a continuous tubular metallic handrail was superimposed on the walled edge with a zigzag pattern and the underlying concrete part left rough and uneven, thus designating the metal edging as a protective measure.

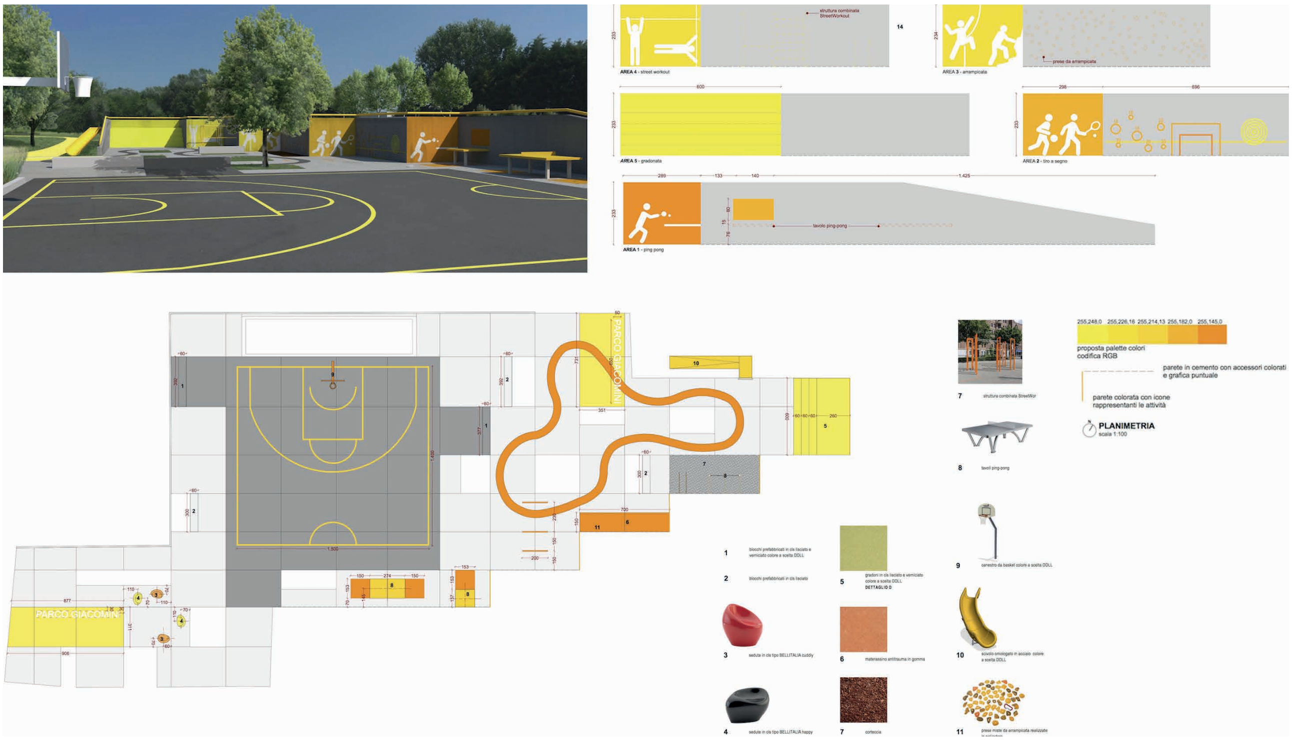

FIGURE 10: Detail of the décor and pictograms.

FIGURE 11: Children's climbing wall.

Not all spaces from which cement was removed have been re-vegetated, with sections of permeable soil being deliberately left devoid of formal planting to promote the spontaneous arrival of new seeds and establishment of free-growing vegetation. The ultimate composition of the flora will forge a self-imposed equilibrium.

A park in continual movement and evolution, free to flourish thanks to the additions freely provided over time by the visitors, a site capable of accommodating other activities and other potential uses - by all accounts a flexible and exploitable space.

Each plant was chosen based on its capacity of resistance in a harsh urban context and its ability of regeneration.

In the cemented plaza, the trees planted were mainly of the *Celtis australis* species, selected for their ability to establish in hard, difficult soils and survive in conditions of scarce water availability; likewise, flowerbeds were planted with gramineous plants including: *Gaura lindheimeri, Pennisetum orientale, Agastache Summer Glow, Agastache Firebird*.

Once freed from the concrete surface as described previously, the large tank that contained the oil drums was covered with cultivated soil and planted with a variety of very low maintenance grasses, including the purple coloured *Perovskia atriplicifolia, Verbena bonariensis, Echinacea purpurea Rubinglow*, and *Eryngium giganteum*, all highly attractive to butterflies and pollinating insects (Figure 12).

The surrounding existing woodland, planted more than twenty years ago, is populated by *Fraxinus excelsior, Juglans regia, Alnus glutinosa, Carpinus betulus, Ulmus minor* and *Populus alba* with a dense undergrowth, creating an impenetrable area suffocated by the remains of previous works. The operation of valorisation and enhancement has restored the woods to its role as an irreplaceable repository of environmental values, of benefit to the physical and mental wellbeing of mankind. Accordingly, in line with consolidated indications provided by EEC Reg. 2080/92 and former Measure of the Rural Development Programme of the Veneto Region, the arboreal shrub area has been extended through addition of new closely planted rows intended to guide visitors throughout the new itineraries created in the park using draining concrete.

The woodland plants were arranged in rows using a prevalently sinusoidal pattern with a combination of *Quercus robur, Fraxinus angustifolia, Acer campestre, Morus alba, Carpinus betulus* and interspersed shrubs such as *Cornus mas, Cornus sanguinea, Cercis siliquastrum, Crataegus oxyacantha, Viburnum opulus*, and *Prunus spinosa*. It should however be pointed out that the woodland will take time to flourish and slowly grow, providing a fundamental contribution to the development of an urban reforestation landscape destined to merge increasingly with the construction features in the public park.

CONCLUSIONS

The landscape illustrates the diverse capacity for regeneration of territories in their autonomous and unceasing adaptation to natural and human tension. Adhering to frequently remarkable times and methods, their free transformation re-naturalizes spaces and areas, constituting vital new resources to be employed in future amendments. Recovery, reuse, and regeneration represent key parameters in an urban context with a view to maintaining control over management of resources, avoiding waste, and particularly in exploiting the potential of what may at first sight appear to be of scarce utility or unserviceable (Figure 13).

FIGURE 12: View from the top of the embankment towards the regenerated woodlands.

FIGURE 13: Itinerary accessing the sports area.

In achieving valorisation of the commonplace for the purpose of reclamation and restoration of numerous "mundane" spaces by attempting to combine resource availability with the management and maintenance of open spaces, the Giacomini Park represents a conscious expression of the value of uncomplicated actions accomplished by carefully exploiting the potential for regeneration and interpretation potential that the area silently concealed.

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WHILE WE WAIT - NUCLEAR WASTE FACILITY RISØ, DENMARK

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Schools of Architecture, Design and Conservation, The Royal Danish Academy of Fine Arts, Denmark

This project addresses issues associated with the disposal of Danish nuclear waste generated during the operations and decommissioning of the Risø Research Centre. The issue is highly relevant in view of the alarm created by current storage of the waste at Risø. Due to the poor condition of the concrete canisters containing the radioactive waste, a decision as to how best to manage the waste is a priority matter. The most appropriate solution would be represented by use of a depot: a building complex developed to house and encase the radioactive waste for several future generations. The depot would represent a unique structure, the distinctive and mysterious function of which would undoubtedly generate a great deal of debate. The project is a concrete idea of how disposal can be incorporated into an extended societal context. Storage of radioactive substances is a global problem frequently associated with strong feelings. By addressing the issue from an architectural point of view, hopefully a humane dimension can be conveyed to a highly inhumane subject, and potentially result in the erection of a monument that gives something back to its surroundings rather than acting as an unpleasant burden.

Realisation of the project would be intended to transform a social taboo into an attraction, a monument that represents a Danish model for an intermediate storage facility. A model achieved as a result of skilful interaction between mankind and nature. Denmark has never deployed nuclear energy as part of its energy supply, thus, the quantity of waste involved is relatively small. This situation consequently represents an ideal starting point from which to initiate a debate relating to a modern view of disposal. The problem is a global issue; indeed, although on a different scale, the project concept will be of global relevance. Architects should be bold enough to face and take on tasks such as this! Although indeed the task at hand comprises a considerable number of practical, structural and engineering challenges, it likewise represents an issue that conveys a substantial poetic dimension.

Landscape room

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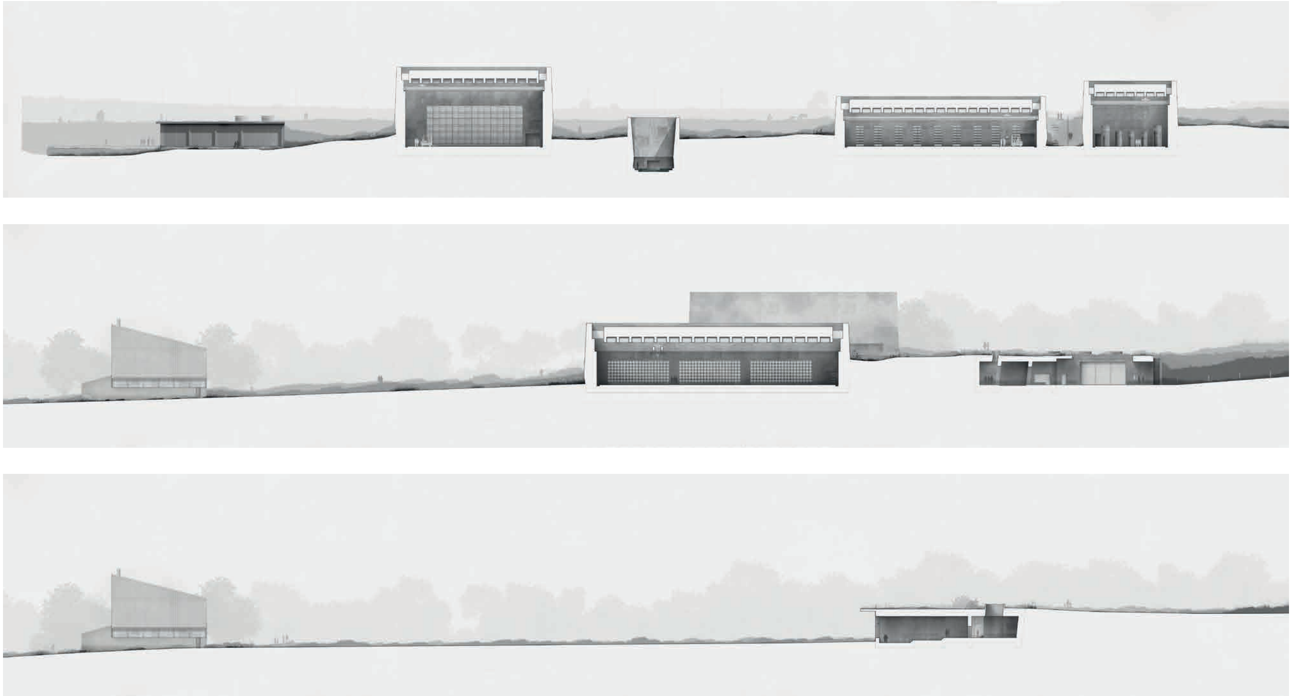
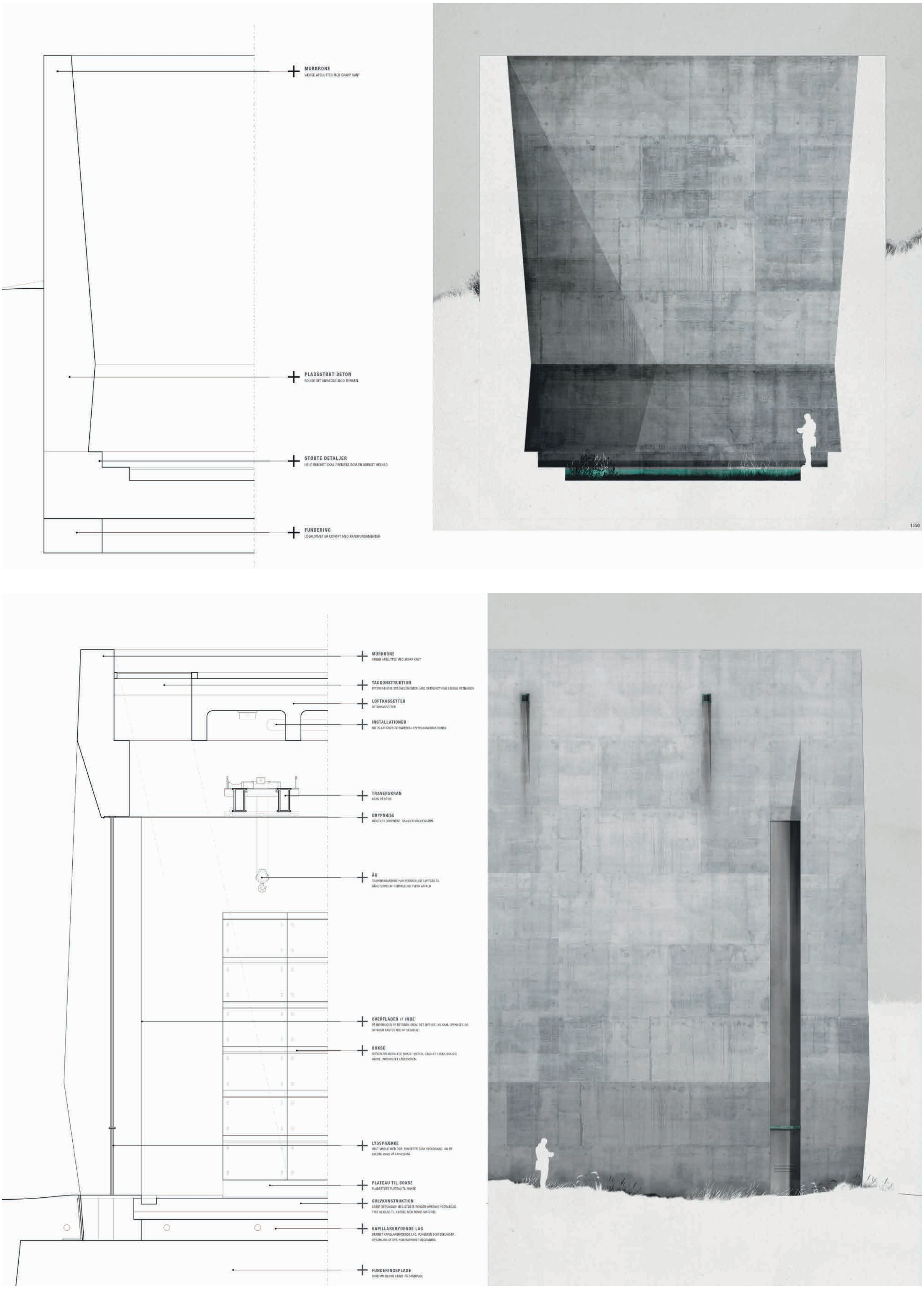
Site plan

Depots in the landscape



Sections

The depot - boxes



Construction details

The depot - canisters

Walk towards the light / Visualisation of the small subterranean outdoor space

Peter Ravnborg
Peter Ravnborg graduated from The Royal Danish Academy of Architecture in early 2016. Following his graduation he worked as an Architect at Lundgaard & Tranberg I Copenhagen, designing large scale buildings. In 2019 he set up his own studio, Hald & Ravnborg to focus primarily on the small scale creation of high-quality designs with a subtle, yet significant, character.

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REHABILITATION OF LANDFILLS: DESIGN LAB AT THE INTERNATIONAL WORKSHOP ON WASTE ARCHITECTURE 2019

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[2] Department of Civil, Environmental and Architectural Engineering (ICEA), University of Padova, via Marzolo 9, 35131 Padova, Italy

In 2019 Arcoplan Associates organised the third edition of the International Workshop on Waste Architecture / Waste Management in Landscape and Urban Areas conceived as a parallel event of Sardinia 2019, 17th International Waste Management and landfill Symposium.

The first day of the event was devoted entirely to oral presentations, whilst the second was taken up by a practical design and planning workshop. The design lab was coordinated by Studio Arcoplan with the collaboration of Stefanos Antoniadis, research fellow at the University of Padova.

During the lab participants had the opportunity to apply theoretical notions learnt during the oral sessions to an actual case study promoted by a company, and to exchange views and opinions with colleagues and experts as part of a working team.

The most important concept that emerged during the workshop focused on how landfill redevelopment is much more likely to be successful if the project is undertaken by a multidisciplinary team (architects, environmental engineers, planners, etc.) developed during the active phase of the landfill. Indeed, the possibility of using new wastes as a plastic material to mould the shape of the mass will extend the range of potential functions to be assigned to the project and provide greater freedom in reorganising the final configuration of the area. With a view to designing the area not as a landfill, but rather in line with the final use envisaged by the project, wastes may be used immediately to forge the final morphology of the landscape. By implementing a strategic land planning, landfills may thus be transformed from environmental eyesores into an integral part of the urban landscape, instruments intended to provide a new intended use.

During the workshop a series of redevelopment projects focussed not on the mere conversion of areas into urban parks or playing fields, but which devised a series of innovative intended uses, were elaborated. The first case envisaged an extensive archaeologic-industrial park featuring terraced lakes, whilst the second a system of themed itineraries that crossed the area and intersected throughout the landfill.

The results of the workshop are presented below.

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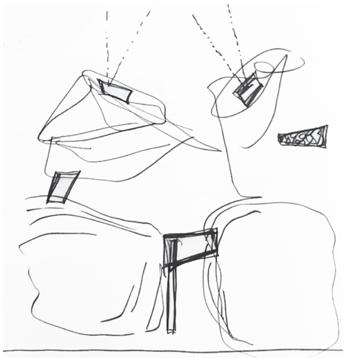
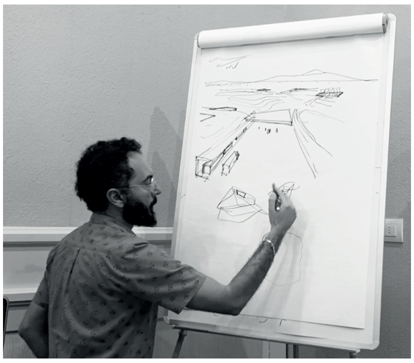
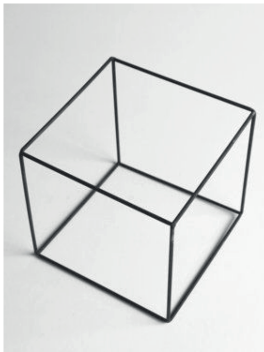
LANDFILL ARCHITECTURE:
NEW SHAPES
Biological N removal
Older leachates
Emerging contaminants
Metals
Clogging








WASTE ARCHITECTURE
LANDSCAPE
Landfills
BUILDINGS
WM plants
URBAN AREAS
Collection systems

CASE STUDY 1: LANDFILL FOR HAZARDOUS AND NON-HAZARDOUS SPECIAL WASTES / ECOFER AMBIENTE SRL

Proposer: Ecofer Ambiente Srl
Location: Rome, Italy
Area: approx. 25 hectares
Type of plant: landfill for hazardous and non-hazardous special wastes
Tutors: Anna Artuso (Arcoplan Associates), Stefanos Antoniadis (University of Padova, Italy)
Working group: Giulia Bassi, Giacomo Bellussi, Emilia Rutkowski, Stefano Sardu, Giovanni Sommariva

Ecofer Ambiente Srl manages a sanitary landfill authorised for conferment of hazardous and non-hazardous special wastes. The landfill was designed at the start of the year 2003 in accordance with criteria established by Legislative Decree 36/2003 relating to hazardous waste landfills, subsequently enhanced by the regulations contained in the authorization permits. The landfill accepts solely non-hazardous wastes originating from the metal recovery sector (end-of-life vehicles and other metallic wastes).

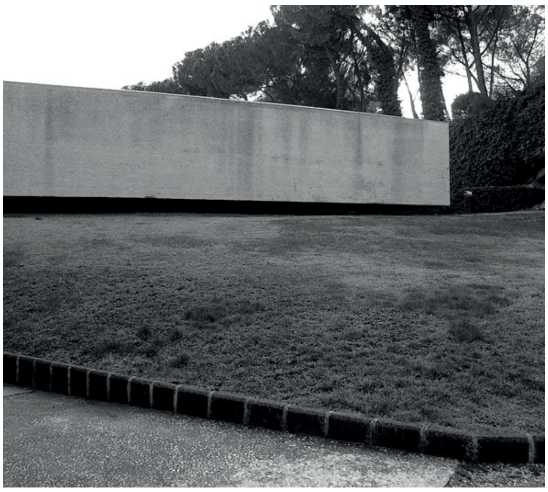
Partially following the division of the former quarry, the area on which the landfill is sited is divided into three operative lots: Lot 1 has been in the aftercare phase since 2013, Lot 2 is currently operational and Lot 3 will be opened in September. Post-operational management envisages, to complete the authorized volume, reconstruction of the hilly landscape of the zone to the profile featured prior to extraction, compatibly with the existing structures and management of rain water. The areas located to the north and north-west of the storage tanks, are used as a temporary deposit for fertile soil and clay and a green area with vineyards. To the west lie via Ardeatina and the regional railway. The service area is situated approximately 15 metres below road level; the slope decreases on moving north, reaching a flat plain close to the border of the area.

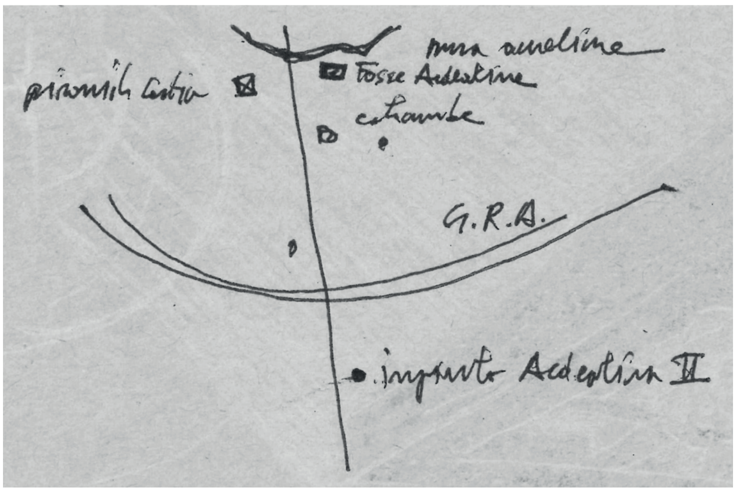
View of the existing landfill

1 / THE PROPOSED CONCEPT

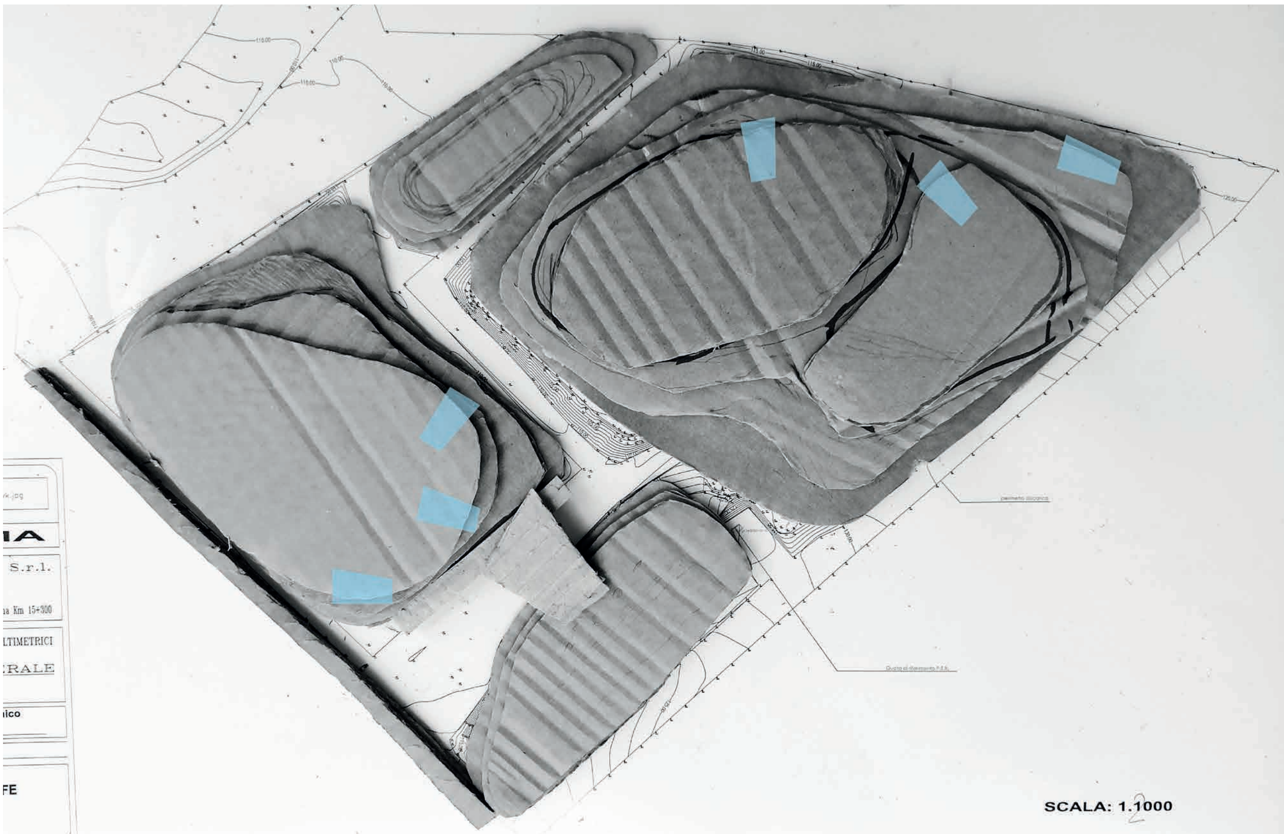
Le Corbusier, with his famous drawing called La leçon de Rome (1925), showed how the ancient Roman architectures, through the abstraction skill, can be read as a series of main geometric solids. Rome is dotted with large cylinders, pyramids, cubes, parallelepipeds and spheres. But even in less urbanized contexts, such as the countryside, the strong presence of classical and medieval ruins, pieces of bridges and infrastructures of the past scattered everywhere has for centuries influenced the representation of the Roman countryside studded with large recognizable artificial forms. The architectural design for the transformation of the Ecofer Ambiente case study, located in this same territory, not so far from a series of evident landscape-scale signs (the Aurelian Walls, the GRA ring road, the important sings of the ancient Roman roads) and large forms of the landscape (the Pyramid of Caio Cestio, the cylinder of the Mausoleum of Cecilia Metella, the plate of the Mausoleum of the Fosse Ardeatine). Therefore, beyond a functional program that will evaluate the strategic location for palatability activities in order guarantee a desirable and continuous post-management use as a place open to the community, the regenerative hypothesis draws strength from this big scale objects' poetics. The new Ecofer Ambiente site must not be continually remembered merely as a former landfill, but it can become a new element that contributes to the construction of a landscape vocabulary as much as the other forms of the territory. A large ribbed concrete slab identifies the access to the area, shades a vast open space, and suspends wrecks of cars – the type of waste stored there – to keep the memory of the place alive but also archaeological fragments and Roman finds – which could be displaced there under concession by the cultural institutions – to underline once again the need for contemporary urban stuff. Other slab are inserted and suspend among the embankments of the landfill – especially for those still to be designed and filled, therefore authorizing some structural predispositions – to house swimming pools, sports courts, and hanging gardens.

Map of the area

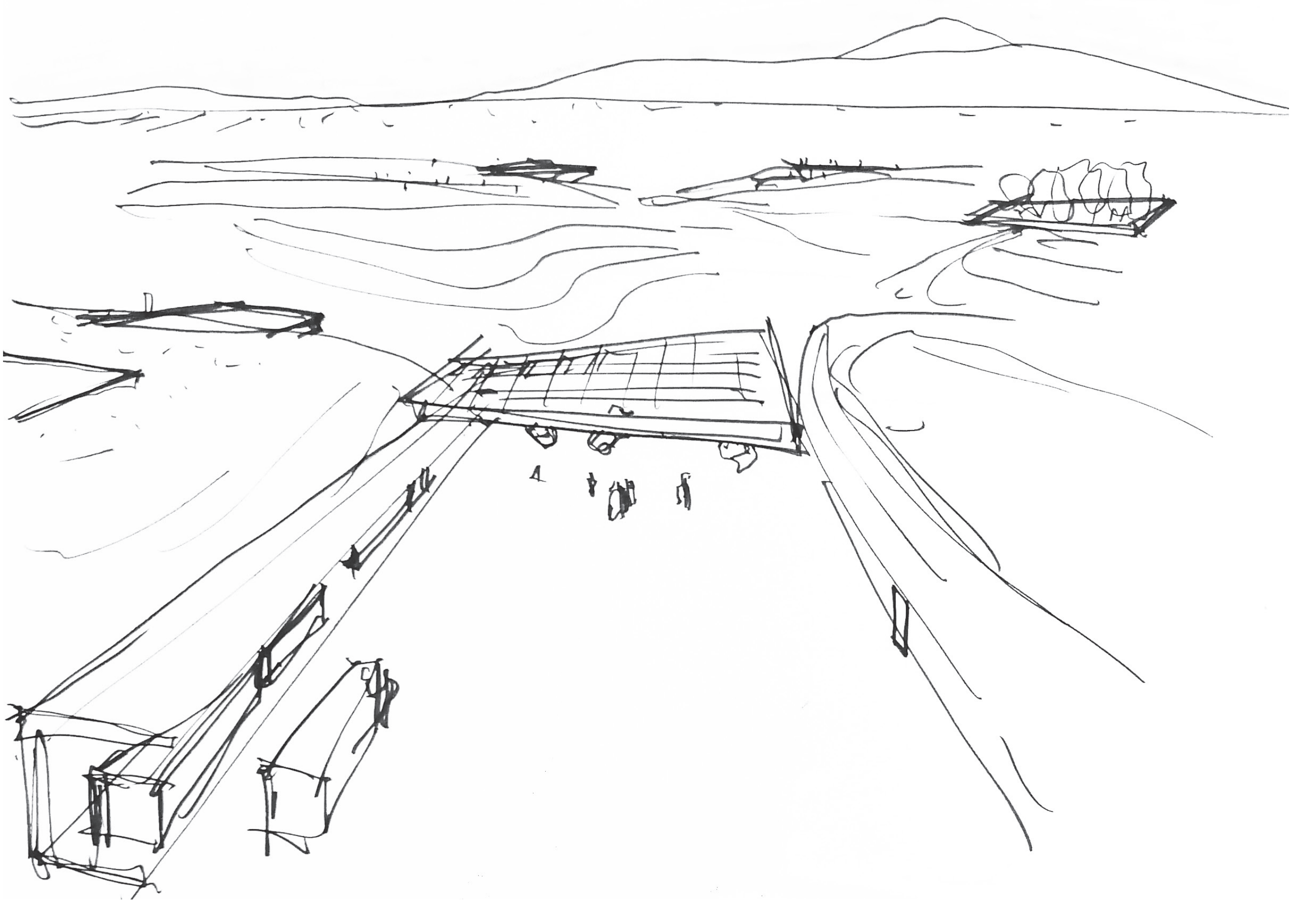




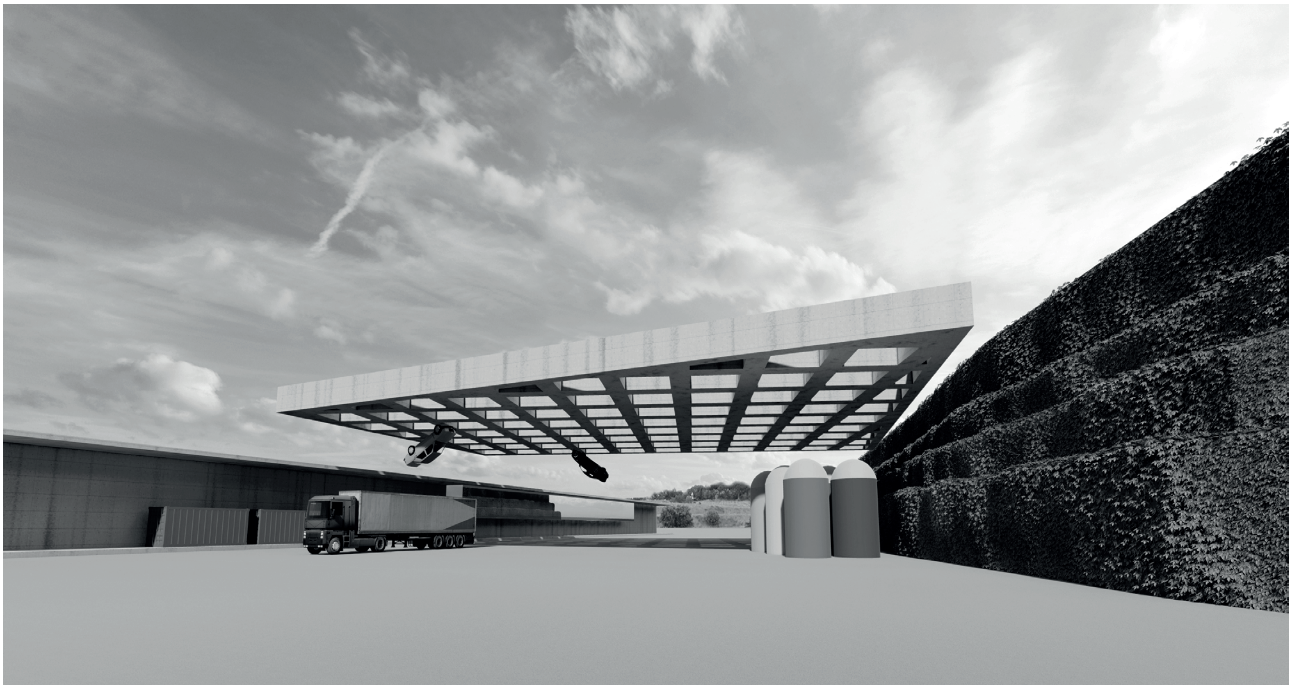
On the left: The Mausoleum of the Fosse Ardeatine (1945-1949), by N. Aprile, C. Calcaprina, A. Cardelli, M. Fiorentino, F. Coccia, G. Perugini and M. Basaldella. On the right: Constellation of big scale objects in the south part of Rome (sketch by S. Antoniadis, 2019)



Architectural model


View of the landscape (sketch by S. Antoniadis, 2019)

View of the access area and the ribbed concrete slab (sketch by S. Antoniadis, 2019)



Architectural rendering (figure by G. Bellussi, 2019)

CASE STUDY 2: THE SERDIANA LANDFILL / ECOSERDIANA SPA

Proposer: Ecoserdiana Spa
Location: Serdiana, Cagliari, Italy
Area: approx. 10 hectares
Type of plant: Non-hazardous special waste landfill
Tutor: Elena Cossu (Arcoplan Associates)
Working group: Salvatore Colombo, Alessandro Forte, Andrea Giacomin, Danai Ilyadu, Antonio B. Montero, Luca Pia

The Serdiana landfill, managed by Ecoserdiana Spa, is a non-hazardous special waste landfill located in the Municipality of Cagliari, Italy. The area features an undulating morphology due to the alternating presence of flat areas and hills. The physical location of the landfill was identified by the Municipal Authorities in Serdiana due to the presence on site of a sandstone quarry.

The landfill is comprised of 6 modules that have developed over time, only one of which is currently operational, and occupies a total surface area of approx. 10 hectares. The operative module has a raised banking and leans against two decommissioned landfill modules for non-hazardous special wastes and Municipal solid wastes. Some modules are currently in the post-operational phase.

The proposing body has shown interest in undertaking environmental requalification and landscaping of the area not limited to greening of the site, but also providing for re-use of the same.

View of the existing landfill

2 / THE PROPOSED CONCEPT

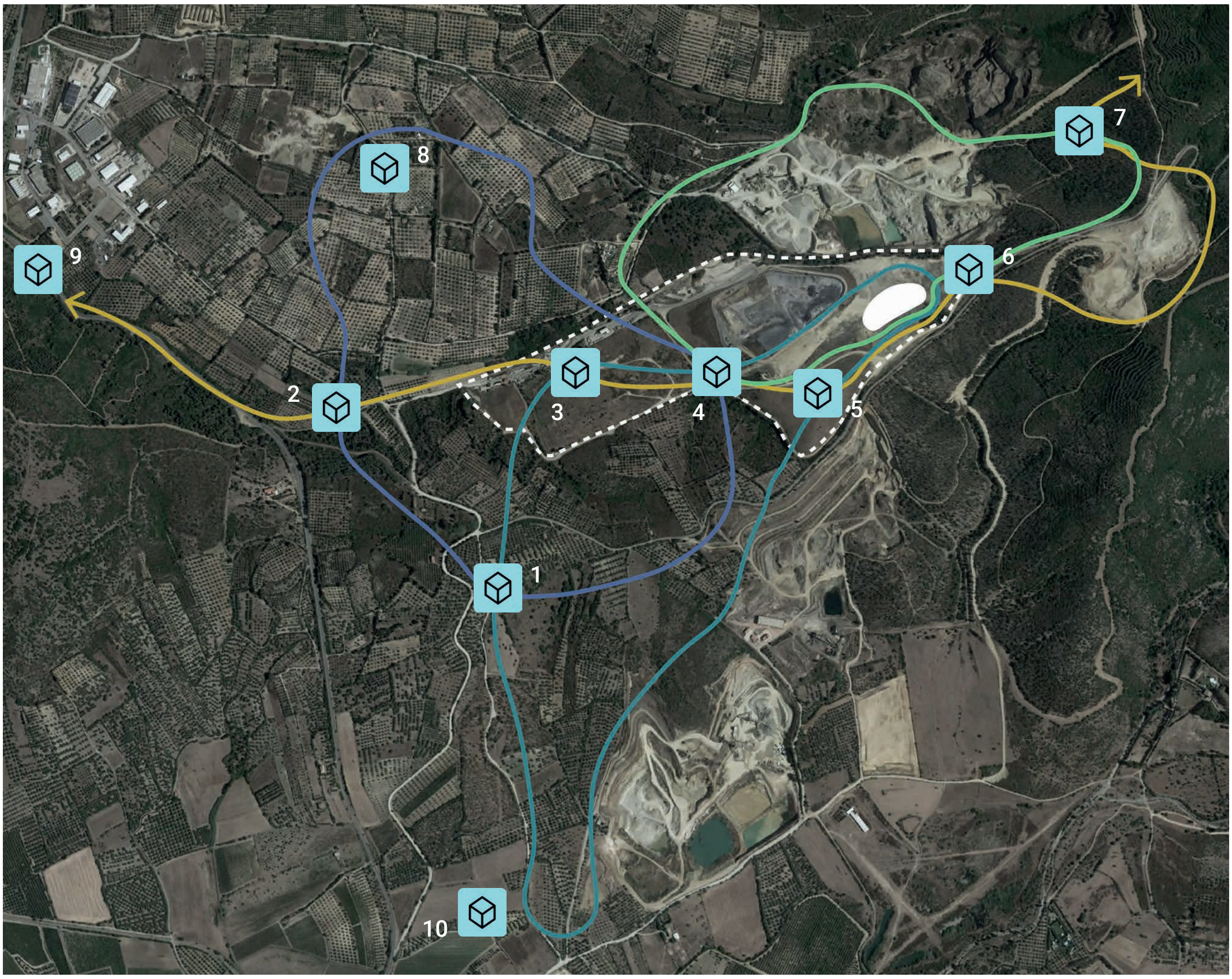
The proposal originated from a preliminary analysis of elements relating to a territorial, social and landscape context, as well as to the cultural vocations of the territory, whilst taking into account valorisation of the site with regard to its potential scientific value as a landfill and to the possibility of positively exploiting several of its features.

The proposal, consisting in a network of thematic itineraries that intersect both within and external to the site, was conceived for the purpose of rendering the site the barycentre of an extensive multifunctional system. The landfill therefore is seen as an opportunity to experience and benefit from an apparently scarcely characterised area.

A series of potential thematic itineraries have been identified based on the pinpointing of singular features present throughout the territory indicated for a potential interconnection with the landfill system (see map).

Each itinerary has been defined as a series of milestones to be reached focused on recreational, socio-cultural and educational aims and on fostering environmental awareness. The intersecting points will act as a link for the multi-itinerary system, i.e. strategic stages along the itinerary to be marked with an architectural feature. The presence of these links has been physically marked by means of a very simple construction, which is however clearly recognisable on the landscape, even from a distance: a cube. Indeed, these constructions feature a regular, modular and interlocking (both vertically and horizontally) form that may be adapted for diverse uses according to the functional requirements. Subsequently, a specific use of the cube as a multifunctional container at all intersecting points was envisaged: managed as a system of facets, of filled and empty spaces, the cube is declined in all its possible configurations. As a greenhouse, a charging point for e-bikes, a birdwatching tower, and a wine-tasting area, the cube becomes the lynchpin of the system, heralding the presence on the landscape of a “diffuse project”. The use of materials and colours will need to conform to a degree of homogeneity to allow the “cube stations” distributed throughout the territory to be interpreted as elements of the same system, both when located within the landfill site and when located externally. Use of transparent materials, wood surfaces, green surfaces and recovered materials may be envisaged. The possibility of turning a few of these “cube stations” into interactive totems all linked up by smart applications, and illuminating them during the hours of darkness, charging and heating them using diverse forms of energy (solar panels, wind power, waste heat recovery from biogas engines,

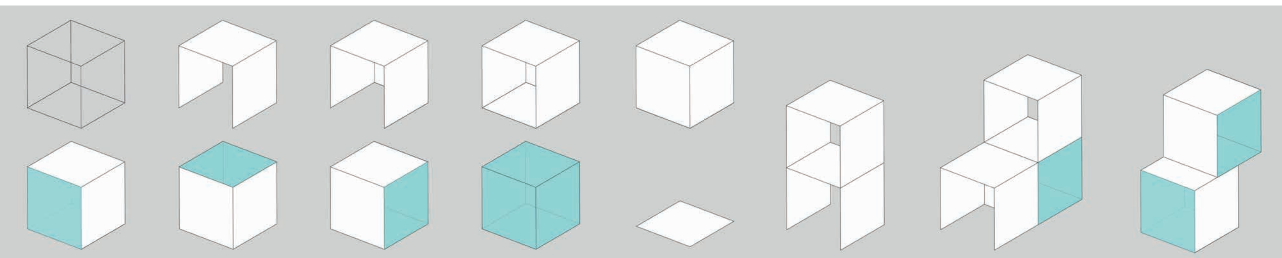
etc...) will add to the appeal of the potential applications of this concept.
A project of this nature will foster the development of important synergies on multiple levels, embarking the entrepreneurial entities present on the territory on a course aimed at raising competition territorially from a point of view of the economy, society and the environment. Particular emphasis will be placed on the elaboration of a model that can be replicated and adapted to fit into any type of context.



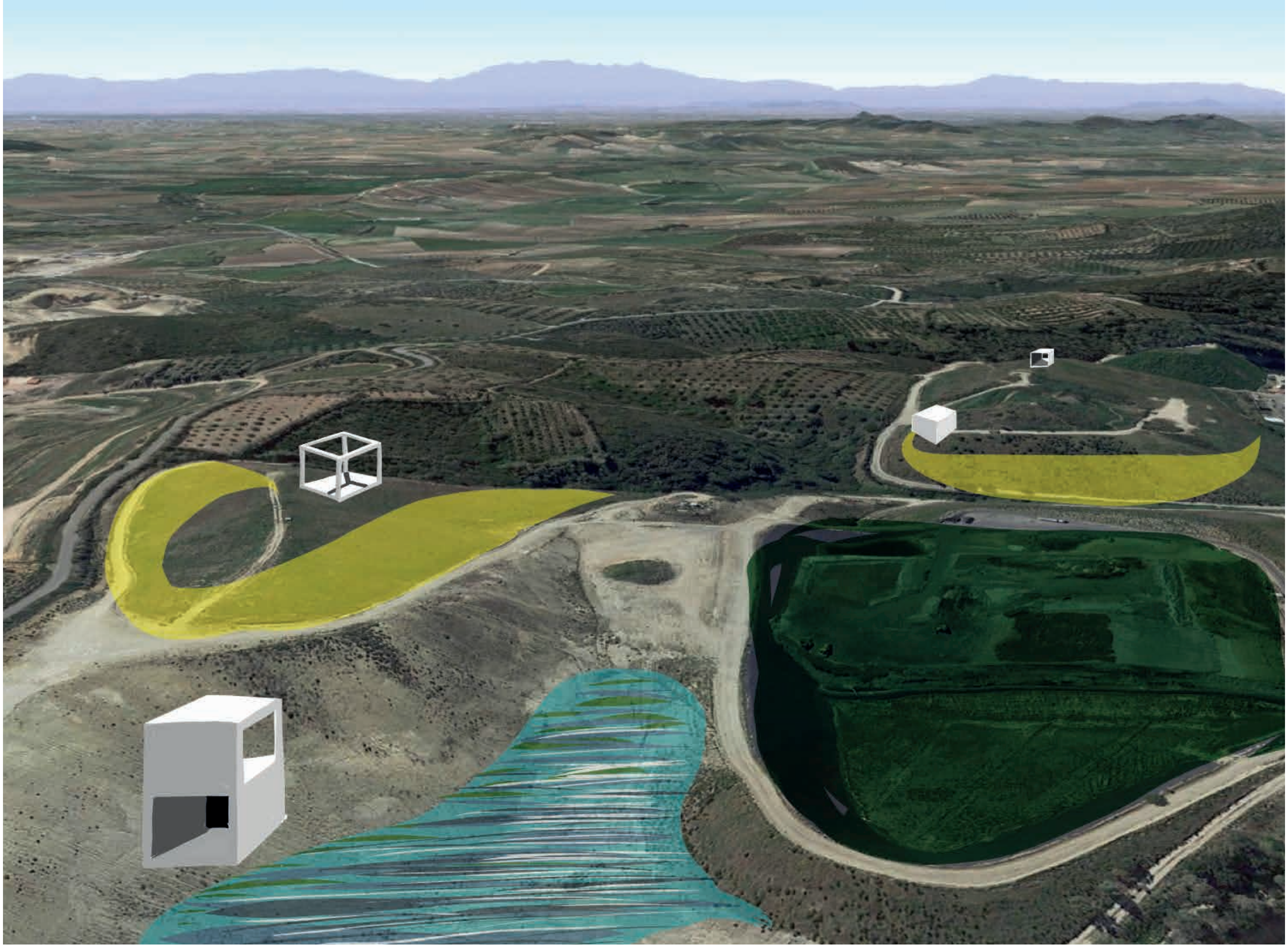
cube stations
landfill site
biodiversity itinerary
green energies itinerary
wine itinerary
hiking / e bike / sport itinerary

1 greenhouse
2 food education
3 bike station
4 greenhouse
5 segway station
6 bird watching tower
7 refreshment area
8 taste area
9 sport station
10 gravel crushing

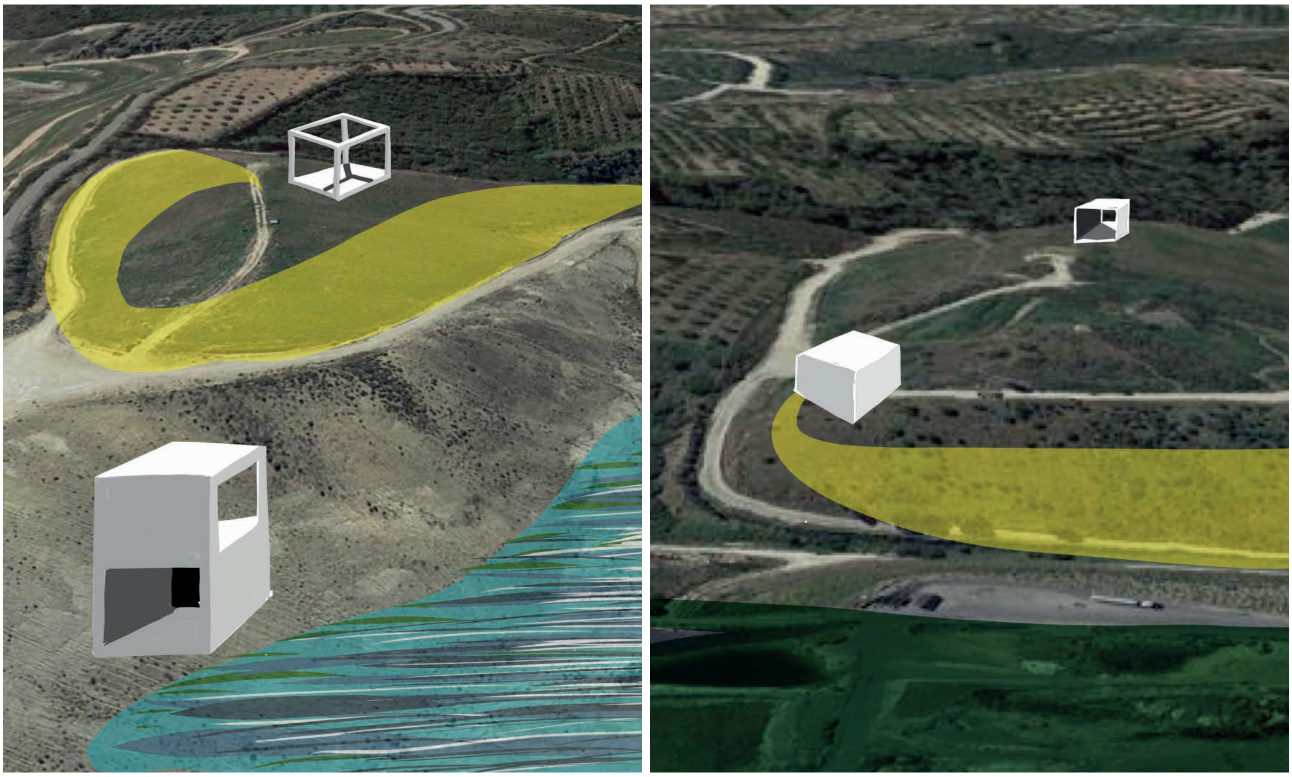
Map of the area: itineraries and cube stations (figure by E. Cossu)



Possible configurations of the cube stations (figure by A. Artuso).



View of the landscape (figure by A.B. Montero, 2019)



Details (figure by A.B. Montero, 2019)

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A PHOTO, A FACT, AN EMOTION

"An unusual urban glimpse of an ordinary drosscape reveals the controversial nature-artifice dyad: two rising elements, a lattice tower – the emblem of progress – and a bud – the resilience of nature – stand out equally. Are the contemporary scattered landscapes potentially much more capable of supporting life, or even generating new lives, than we are led to believe? Are we ready to face the "from dross-scape to spore-scape" challenge?".

"THE BLACK AND WHITE"

Padova, Italy

Rolando Ghirardi, Italy

ABOUT THE AUTHOR

Rolando Ghirardi obtained his Master degree in Civil Engineering from the University of Padova in 2017. Having collaborated with several engineering companies, he is currently a freelance structural engineer. With a passion for photography from the age of 13, his images have been published in a series of books and magazines on architecture, design and technology.

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