Landscape as a Networked Ecological System: The Role of Data and Emerging Technologies in Rethinking Site Remediation

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Abstract: In a world ever-more mediated by data, many aspects of our environment are integrated through information systems. Much of our new understanding is the result of emergent data-generating and visualization technologies that map and make visible information that otherwise would remain dormant and ineffective. This paper examines the use of data-driven and parametric processes in designing adaptive networked ecological systems. Specifically, it will inquire into the degree to which data can prevent or at least mitigate the degradation of future crises. Two case studies will be presented and illustrated. The first will target the San Francisco bay area brownfields, the other mining sites in Latrobe, Australia, both derelict lands that have been laid to waste in the wake of earlier eras of industrialization. By showcasing two projects, this paper presents an overview of several areas in which landscape design can be successfully supplemented by contemporary data systems. Embedding data can allow for project conceptualization, design specification, and an objective design process that achieve environments tailored to their specific geographic context while providing rapid, simulation-based feedback and impact analyses.

Keywords: Data-driven design, parametric design, waste landscape remediation, networked ecologies

1 Introduction

Up until recently, our perception of the environment was largely the product of direct and visible access to information, such as physical context- site boundary, streets, and buildings. Today, data (environmental, economical, and social), new technologies (Data-driven and computational design software), and their applications (analytical systems, simulations, and real-time feedback) are paired with parametric and algorithmic approaches in design. With the capability of adapting a design process according to input parameters to generate different design outputs accordingly, they allow us to see a site not simply as bounded by visible boundaries and visible objects but as a synthesis of multiple invisible ecological, economic, and social factors, among others. These new technologies and processes when correlated, yield information and ultimately decisions that otherwise would be impossible to make. Much of this would not happen without the revolution in digital mapping, not simply as a research tool but as one through whose visual clarity we are able to make faster and more objective decisions (DE MONCHAUX 2016, 9 ff.).

Waste landscapes such as brownfields, landfills, contaminated sites are significant contemporary ecological and social issues. Twentieth-century expansion evolved at the expense of perfectly good and productive land. As industry and infrastructure intersected, a good part of the landscape was frequently marginalized, treated as residue on the leading, peripheral edges of urbanization (BERGER 2002). However, we have come to the realization that we need to "resurface and reprogram the waste for adaptive reuse". Alan Berger, writes about drosscape, as a concept, implying that dross, or waste, may be "scaped". Berger explains that this emerges

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from rapid urbanization and horizontal growth urban sprawl in the wake of the socio-and spatio-economic processes of deindustrialization, post-Fordism, and technological innovation. Drosscape leads a shift in thinking from explicit knowledge (entitled to designer) towards complex responsive processing (designer as collaborator and negotiator) (BERGER 2006, 197 ff.). Building upon such premise, this paper will examine the role of data and data-driven processes in turning "wastelands" and the products of "Urban sprawl"[1] into the social, ecological, and economic positive contributions. How might the nexus of emerging technologies as centered on data, algorithmic analysis and parametric distribution help restore derelict land to urban function?

To answer this question, we need to consider the following 3 factors:

First, today we register nature and landscape differently – in cultural, social, and ecological ways, less as an object to be broken down into the material end and more as a process that has neither beginning nor end[2]. Second, the urban fabric built in the last forty years rivals all the previous ten thousand years of human history combined[3]. Third, nowadays we collect and store information at a rapidly accelerating rate; the stored information, just in the last decade, is more than the total amount of information captured from the start of recorded history. It is important to acknowledge that the information is increasingly spatial and, more than ever, urban (HILBERT 2012; DE MONCHAUX 2016, 9).

Mapping is one the oldest ways of collecting and distributing data. Mapping technique and technology has long been driven by the military's need to understand the lay of the land (THROWER 1996, 97). In 1931 the Polish-American scholar Alfred Korzybski brought to the attention the inevitable semantic and structural gap between the description of a landscape and its representation. Since then, digital mapping has made the gap wider than ever. While cartography functions as a singular reading of and visual reference to the landscape, contemporary data visualization mapping method reveals aspects of design that are overlooked and unimagined in a rather theoretical, polyvocal, and translocational way. It is more about deconstructing the relationships between mapper, resources, and landscape (BERGER 2002, 118).

Since 1970, Geographic Information System (GIS) has further developed our understanding of our environment. Building upon the map-overlay method developed by the landscape architect Ian McHarg, GIS offers analytical capabilities to calculate different social, health, and ecological factors which are essential in making informed design decisions (MCELVANEY 2012). In recent decades, GIS has effectively been used in a set of techniques known as Geodesign to achieve a better integration of design and geography through using advanced

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1 Sprawl has been defined by some as "uncoordinated growth: the expansion of community without concern for its consequences, in short, unplanned, incremental urban growth which is often regarded unsustainable" (BATTY et al. 2003).

2 Baudrillard states that "The modern discovery of nature consists in its liberation as energy and in a mechanical transformation of the world. After having been first matter, and then energy, nature is today becoming an interactive subject. It is ceasing to be an object, but this is bringing it all the more surely into the circuit of subjection (BAUDRILLARD 1994, 78 ff.).

3 United Nations, Department of Economic and Social Affairs, Population Division. (2014), World Urbanization Prospects: The 2014 Revision, Highlights. Retrieved from: https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.pdf.

computational methods. It promotes evidence-based design and a systematic method for spatial planning and decision making. Michael Flaxman describes it as a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts, systems thinking, and digital technology" (STEINITZ 2012, 12). The emphasis in Geodesign is to shape our surroundings to our desired uses with the premise of ensuring an outcome where nothing is wasted but spoken for.

This paper targets specific waste landscapes such as landfill, contaminant sites, brownfields, that also known as enclaves, off worlds, and ladders, located in the ecotone, a region of transition between two biological communities, in the intersection of residential, industrial and ecologies, surrounded by infrastructures, highways, railroads in proximity to wetlands with the potential of having a network between them (Figure 1). Such "In-between spaces" lack definition and stability and dwell between occupancies and uses, continual phases and (dis)investment cycles. Thus, they resist new stability and reincorporation (BERGER 2006). To reverse their downward spiral, this paper adopts Geodesign as an approach, addressing site not as an independent island with a well-hemmed in boundary lines and setbacks, but as an entity at the center of a network of urban forces and ecologies, some having to do with economic factors, others transportation, and still others with health and wellbeing.

Fig. 1: Examples of targeted waste landscape, landfills, contaminant sites, and brown fields around the Bay area

Following the concept of Drosscapes, in this paper, the adaptive reuse of waste landscape within urbanized regions happens through identifying the existing environmental and social issues by digital data mapping and visualization and implementing perceptual, and physical attributes through data-driven and computational algorithmic design. This makes it possible to go well beyond remediation but include prevention in their scope, ensuring that whatever happens does not do so without taking into consideration likely changes in the future.

2 Data and Methods

Data and informational–physical interconnectivity have fundamentally changed our understanding of the environment. How we use it will determine the quality of the environment in which we live next. Achieving ideal infrastructure is more than ever dependent on using data productively through systems that analyze, synthesize, and strategically react to those data (BATTY et al. 2012). If architecture, landscape, and urban design are driven by ongoing data collection, the future could be defined by a world endlessly able to recalibrate itself to meet our needs and changes in the landscapes, much in the same way that a biological organism adapts to its local environment.

The projects discussed in this paper rely on digital data mapping and algorithmic design. Such approach allows for the iterative feedback loop of concept generation, performance evaluation, and design refinement (LEE 2015). The algorithmic thinking behind computational design allows for inferring new knowledge and extend certain limits (MENGES 2011). The discussed method will rely on the integration of GIS software (ARC GIS), coding language (Python), and algorithmic design tools (Grasshopper) to design adaptive landscapes that can better serve their inhabitants. Grasshopper creates complex 3D geometry through algorithms that use numeric, textual, and audio-visual data input. It is capable of incorporating data as input to use its algorithmic logic to perform predefined operations, calculate the results, and subsequently to generate an optimized design output that is parametric which allows for further changes and adaptation during and after design. This paper explores this approach in two case studies. The first targets the San Francisco bay area brownfields, the other mining sites in Latrobe, Australia, both derelict lands that have been laid to waste in the wake of earlier eras of industrialization.

The specific technique for data mapping used in the projects in is “Local Code” which is a data-driven technique that seeks to identify and engage legally and socially abandoned urban sites, transforming undocumented, and marginal conditions through an emergent, digitally mediated method into a social, and ecological resource (DE MONCHAUX 2016). The local code uses geospatial analysis to identify thousands of publicly owned uninhibited sites and proposes that vacant landscape should be a part of a new urban system. It tends to turn scattered resources of unused public land and city-owned yet non-maintained parcels, to a common ecological infrastructure. Digital mapping and GIS software are used to overlay, compile, and diagnose the sites. Conjoining GIS analysis with parametric design software, a landscape proposal for each site is customized to fit the local conditions. The proposals seek to optimize social, economic, environmental, and hydrological performance which would result in enhancement of overall local performance and the whole city’s ecology (DE MONCHAUX 2010).

Local Code, as a digitally mediated, dispersed system, presents a digitally prolific, open-ended approach to social and environmental justice and offers opportunities for urban sustenance and transformation. In a case study of San Francisco, the effects of the projects on the level of energy usage and stormwater remediation was measured only to find out that it would lower the need for costly, centralized sewer, and electrical upgrades by 88-96 %. Digital citizen participation is also suggested as an important final step to achieving new and extended public infrastructure (DE MONCHAUX 2010) (Figure 2). Following the more substantial proposal of the Local Code technique, the two case studies presented in this paper understood and engaged the existing nature of the cities and their underlying networks and offered design solutions for their current issues while imagining a better socially, economically, ecologically future for them. The used method helped to recognize a great potential to look at the landscape on a larger scale and create a networked ecology among hundreds of so-called in-between spaces. To achieve this, the collected data and information are mapped, correlated, and illustrated in Arc GIS. Then, they are introduced to Grasshopper, the generative design software, to arrive at parametrically designed spaces, landscapes, and infrastructures. Facilitated with Python scripting, the parametric design allows us to use the power of algorithms in “furnishing the information” and when combined with data analysis, it provides an opportunity to embed possible flexibility for changes in our design for the possible future environmental and social issue (MENGES 2011).

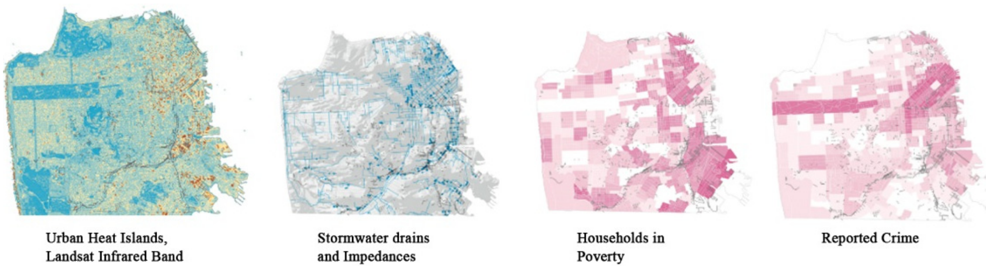

Fig. 2: This figure illustrates the process of recognizing problematic sites in San Francisco by using Local code technique and overlapping data (such as Respiratory Hazard, and reported crime, Stormwater drains, water flow, sun and wind movement) to parametrically govern the dispersal on each site, mediating air quality, drainage and energy loads, and enhancing both site and city. Credit: DE MONCHAUX, NICHOLAS, Local Code the San Francisco case Study, 2009-2011. DE MONCHAUX, NICHOLAS, (2016), Nicholas de Monchaux. http://demonchaux.com/Local-Code-San-Francisco (December 27, 2016).

The first study focuses on two hundred sites found around the Bay area, San Francisco. Here data in conjunction with parametric design processes are nested and functionally integrated to generate solutions at both the local and global scales. With the mining sites in Latrobe, Australia, the situation is such that while active still, they are at risk of falling prey to obsolescence given the likely eventual disappearance of existing coal within the next 20 years. Explored here is the role that data can play in preventing such condition by reconfiguring the potential of the sites and creating new possibilities based on changes in user and environmental needs.

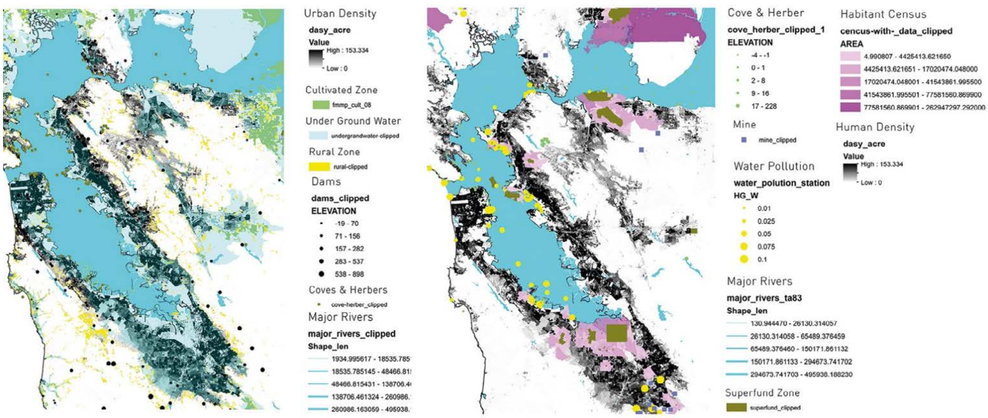

Fig. 3: The projection of invisible data (social, urban, ecological, economical) and overlapping them helped us diagnose the sites in the first project. These sites suffer from ecological and environmental problems and are located in the ecotone zones. Above maps illustrate the overlay of data such as: habitat intersection, inundation, water pollution, water flood potential, census superfund sites, density, zoning, etc.

In the studies, problematic sites were diagnosed by overlapping data from geographical, geological, ecological, environmental, urban, social, economic, and public health sources, helping recognize those sites that suffer from the same issues. Then, the design solutions to existing or upcoming issue are sought through comprehensive algorithmic and parametric design process that can recognize the data, analyze it, and evaluate various design solutions, and finally, suggest the most productive and sustainable solution which is flexible and can alternate and survive in different conditions. What's more, landscape proposals designed through parametric software can offer comprehensive optimized suggestions that fit both local and global conditions and, in turn, relieve burdens on existing infrastructure (Figure 3).

3 Projects and Results

3.1 Project 1

The first case study discussed in this paper is a data analysis, data-driven processes and parametric design of 200 brownfields, abandoned or marginalized around the San Francisco Bay area. This project introduces a network of a system that spreads around and is superimposed to the larger existing system of the bay area (Figure 4).

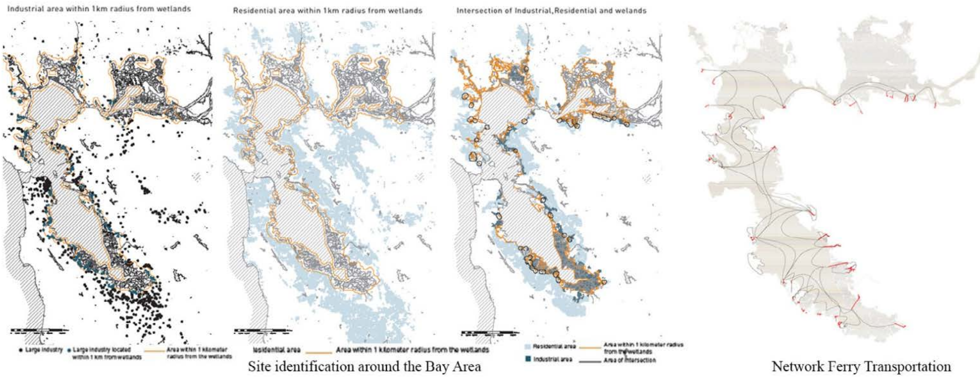

Fig. 4: (Left) diagnosing the problematic sites around the Bay by overlapping and mapping residential, industrial, wetlands, and inhabitant intersection data. (Right) considering those sites in a greater networked ecology and suggesting the network ferry transportation for site remediation through interaction within the system.

This project shows the role of data to cure the existing issue associated with the sites. San Francisco bay area serves as an ideal area for such project as it is a hub of global data flow streamed by tech companies and data centers. Also, ever since colonization San Francisco bay area has been conceived as an ensemble of islands, bridges, missions, for-tresses and other military and defensive facilities, and a constantly changing waterfront; however, what defined its current state were largely the combined effects of the bay fill in the 20th, and the de-industrialization of the brownfields in the early 21st century. The con-temporary image of the edge of the bay looks like a collage of suburban housing, industrial facilities, wetlands, and left-over land, poorly connected to their own context – making their coexistence look almost coincidental. The use of the Local Code technique was pivotal to this project, helping to find the sites obscured by a thicket of suburban gated communities, industrial facilities and wetlands, not to mention the bay itself. Focusing on ecology and wetlands around the bay, this project offers solutions to fold them back into society and make them part of a functioning urban life once again (Figure 5).

Fig. 5: By mapping the wetlands, residential and industrial areas within 1 km radius from the wetland 200, sites were found at the intersection of these areas that mostly are segregated residential islands, having a singular point of access, strictly internal circulation and no relationship with the local ecology. There are no commercial or recreational facilities within walking distance and they are surrounded by a series of elements that function as borders impeding the access to them (highways, railroads, and industrial facilities) and the characteristic horizontality of these areas that forbids visual connections, they eventually constitute suburban islands around the bay.

The design approach is based on a method that superimposes one map on top of another, studies and developed network of systems over an existing one. This project took advantage of data visualization techniques, using Arc GIS, to map the unseen issues. Afterward, through Grasshopper and Python, these information-inspired solutions were given a chance to use a set of established parameters to resolve the current impaired image of the Bay (Figure 6).

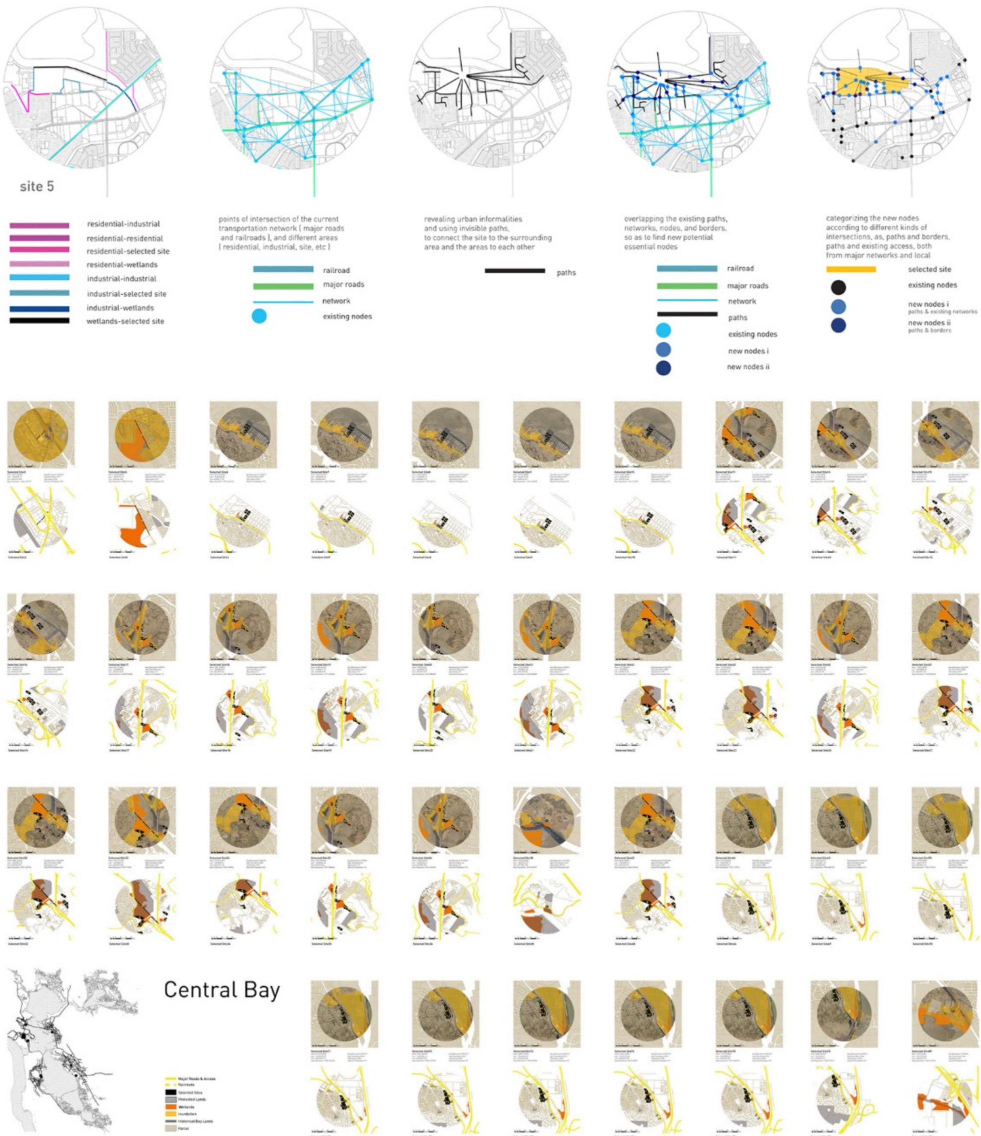

Fig. 6: The problematic sites were recognized by analysing data using infrared GIS, over lapping and visualizing data. Data such as infrastructures, highways, railroad, sea level rising, inundation, zoning, demographic, health, recreation, etc. is used to diagnose the existing issues. Then, a suggested system through parametric design processes are formed in response to existing issues that were found in data analysis. Although merely architectural, the solution was a synthesis of ecological, sociological, and economic considerations.

The proposal deals with two scales. At the larger scale of the bay, the detachment of the filled land from the mainland is proposed, leading to the creation of a network of islands attached to the mainland that are connected through a transportation network of ferries that runs along the whole bay and is connected with existing transportation networks as freeways, highways, BART and bus stations; at the smaller scale of each island, the creation of a "fortress" that carries vital functions for the regeneration of the residential area is proposed, one that eliminates the border by amplifying it -providing a new horizontal multi-level formation landmark for those areas and introducing moments of verticality necessary for the understanding of the reach and complex system of the bay area. Together, at the micro and macro scale, the intervention bridges land with water, facilitate the terminals for the ferry transportation network, provide new access points from the city to the site and offer different levels of transition as well. Since particular areas are characterized by high density and lack of voids, these landmarks work as a network of public spaces (Figure 7).

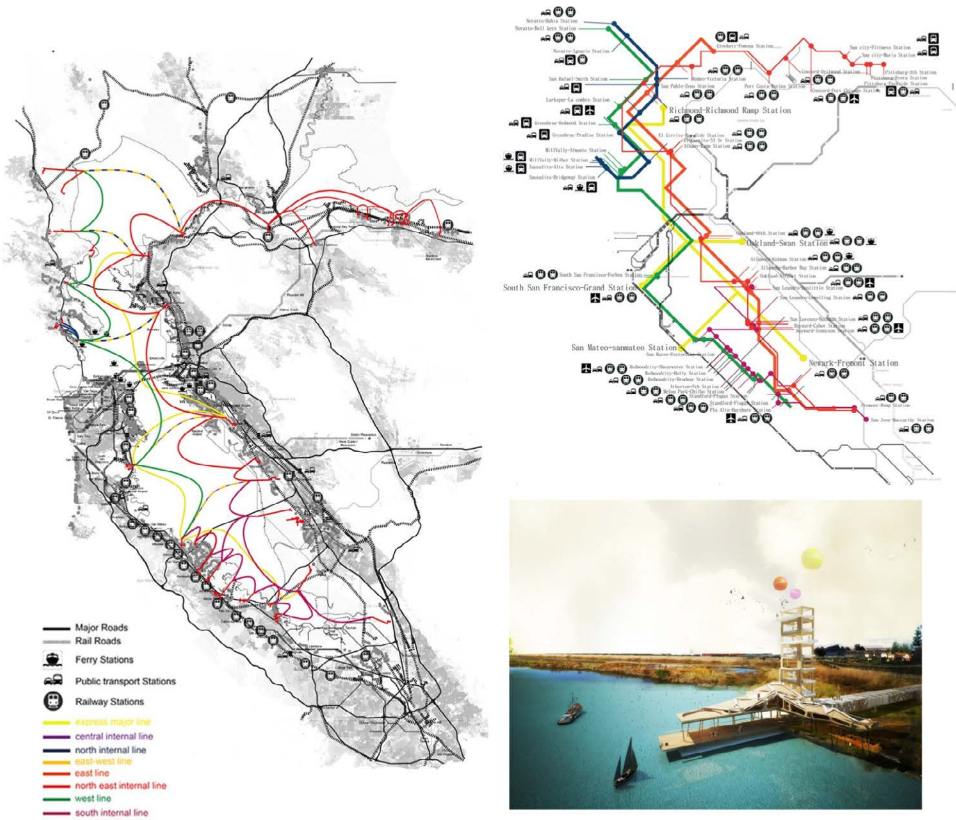

Fig. 7: Network of ferry transportation in a macro scale and ferry terminals and landmark in a micro scale

Fig. 8: Final configuration of each site is shaped by Data and needs of the inhabitants in each site. Parameters such as paths, landscape, programmatic elements, density, population size, habitant intersection, and water pollution are used in parametric design process of these sites.

Fig. 9: Different configurations of each site based on different parameters in the parametric design process

3.2 Project 2

The inevitable shifts in global climate and economic conditions have made us question and rethink the ability of the cities to resist and adapt to these changes. The second case study, which investigates the role of data in the prevention of the future issues, focused on ecological urbanism and the role of architecture as an adaptive infrastructure for landscape remediation. A city like Latrobe, whose landscape, economy and social conditions is based primarily on coal-based energy production, is particularly vulnerable to the global and local changes. With the coal reserves and production reducing, the social and ecological conditions in Latrobe have already started to decline. This project harmonizes relations between city, landscape, ecology and existing coal mines in the area. By mapping the area, analyzing and overlapping data (such as demographic, population, zoning, local economy, agroforestry, agriculture, infrastructures, energy resources, power stations, water body) several sites that are currently underutilized or to become vacant with the mining decline were found. Networked Ecologies rethinks these sites as urban and ecological connectors and as spaces that will yield social and economic dividends to the landscape (FURUTO 2013) (Figure 10).

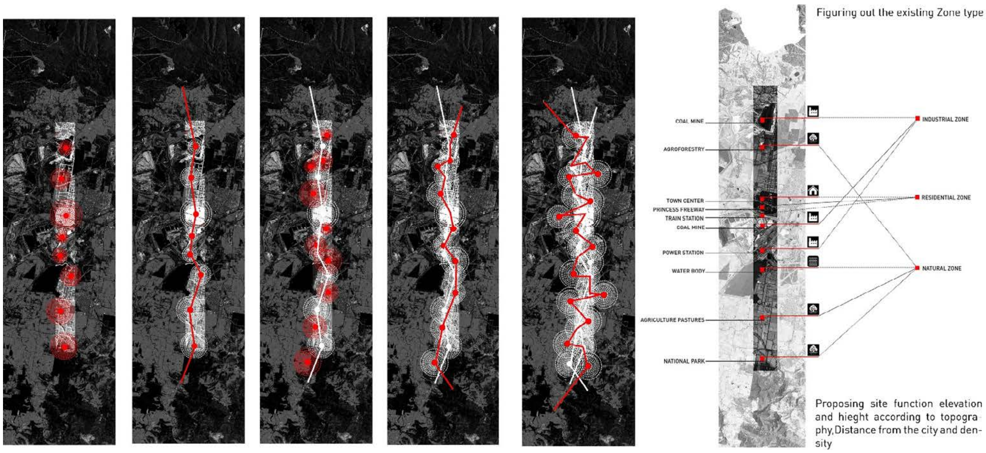

Fig. 10: Overlapping data to find underutilized or soon to become vacant sites and rethinking them as urban and ecological connectors

Depending on the site location and conditions, these data-driven solutions span the gamut of options, from those that tackle energy production (coal and green energies, wind energy, building's tectonic), to landscape remediation (forestry, agriculture, creating built wetlands that will also regenerate the species of the area, creating habitat for birds, animals, etc.), alteration to existing infrastructure (changing them to shared workspaces, residential or commercial or as a green energy production centre), urban agriculture, and in-between spaces that foster new social and economic activities (Figure 11).

The Local Code tequnique, parametric design, and coding are used to overlap those important factores mentioned above to define the location of these inbetween spaces and their possible growth. These "in-between" sites will grow and develop based on the specific conditions and uses, eventually creating a network of infrastructure that will provide robustness to the city. By overlapping data and using parametric design, we can anticipate the location of the soon to be vacant sites and new hubs and we can predict the changes due to data analysis and their growth pattern using information-inspired parametric design. Thus, we can prevent encountering with such issue in future by embedding those considerations in our current design solutions (Figure 12).

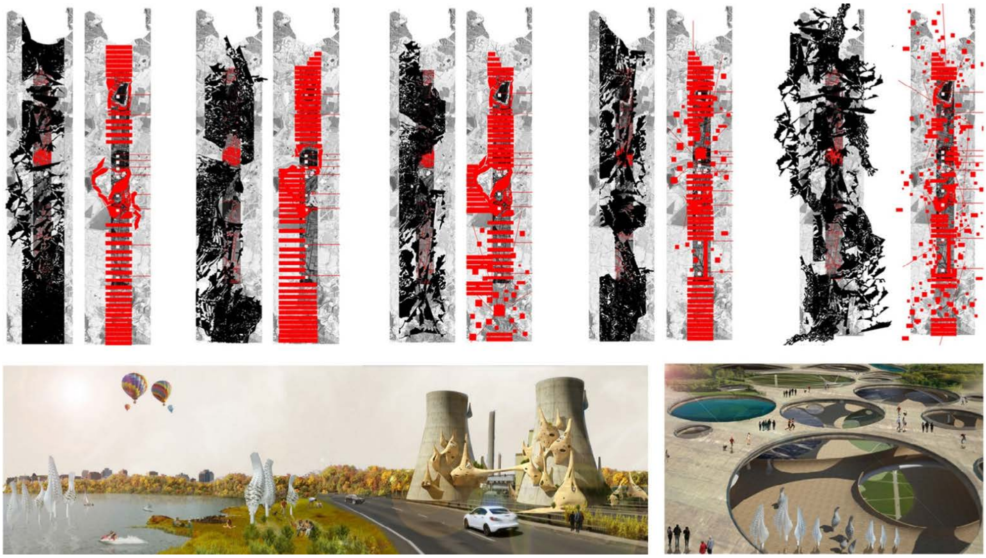

Fig. 11: Different design strategies evaluation. Using GIS and Parametric design to suggest alternation in the energy production and existing infrastructure, landscape remediation, and new in-between spaces as social and economic hubs.

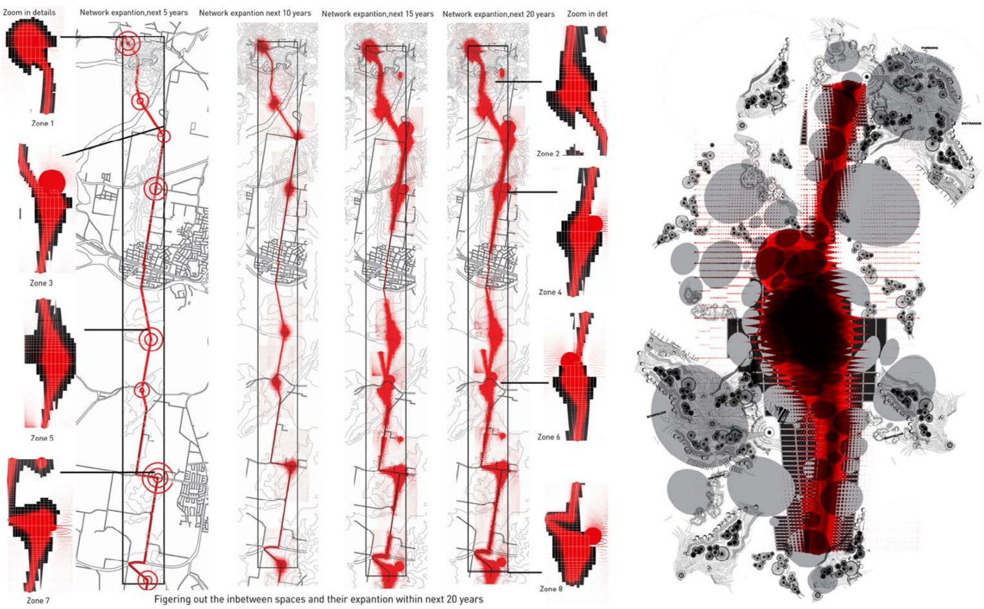

Fig. 12: Using GIS and Parametric design to anticipate and map the growth pattern andexpansion of in-between spaces within 20 years

Of all the virtues of adaptive cities, those whose generation is the product of network analysis, self-reliance is the greatest. Having built themselves on a nervous system constantly in communication with its end zones and generally the regions in which they sit, they create, among other things, self-reciprocating economies, economies independent of central financial and municipal hubs. As the networked ecologies expand, the existing functions of the city are intensified and complemented (FURUTO 2013). These data-driven approach integrated with parametric and algorithmic design provide the tools to explore the different growth and decay cycles of the environmental system, the creation of new ecological networks of new in-between spaces, and their potential spatial transformation across time. This new network is continually growing and adapting to the existing conditions. By pro-cessing data, it develops an adaptive network of self-sufficient landscape, and architectural and infrastructural interventions, which result from a system analysis of the multiple elements that constitute the urban condition (Figure 13).

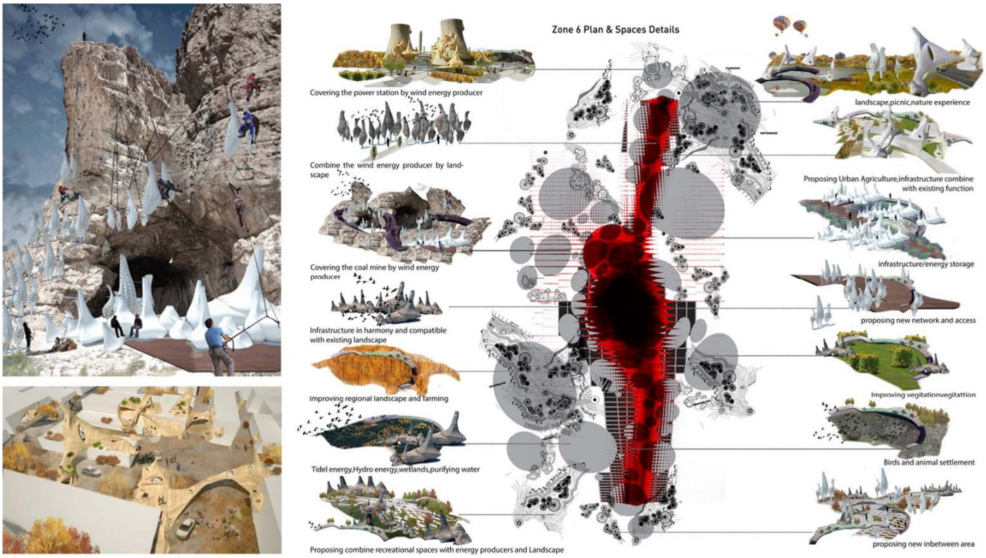

Fig. 13: Different configurations of each site based on different parameters in the parametric design process

3.3 Results

Utilizing contemporary data-driven and parametric design, this paper elaborates on the role of data-driven analysis in testing the legal boundaries of a site, revealing invisible factors that direct us to critical conditions, arguing for a greater inclusiveness of factors, and seeking the design as the product of a much larger ecosystem already underway (Figure 4).

This parametric design thinking enables us to monitor the interaction among the sites as a greater networked ecology itself by applying the same comprehensive design solution for different sites in the network, as a moderator of the bigger system, and yet with different unique local solution suiting each individual site. Since this is an information-inspired system, each unique input data can result in a unique output (Figure 5). Therefore, suggested design solutions expect possible cures for the existing ecological, social, and economical issues and preventing the future issue in the area.

4 Discussion

The initial purpose for using data, parametric design software, and coding languages described in the paper were to simply allow us to recognize the “In-between” sites in a greater network with common social and ecological problems and to arrive at information-inspired proposals to resolve the image of the wastelands. However, the applications of the method were extended to also provide preventative solutions through creating landscape designed based on the information including real-time data. The key points of the discussion are:

1) Integration of real-time data collection and feedback system to retrieve relevant data to be used as input for design solutions.
2) Specifying the priorities and incorporating data-driven parametric design into the planning process at multiple scales to address the priorities.

The limitation is the delay between updating the data with the changes occurring in those sites in a daily manner. One key needed area for improvement is to investigate the integration of real-time data collection and utilization into design and decision-making process since one of the main objectives of such research is prevention rather than only cure. Moreover, data generated today has sheer volume, velocity and variety, and the recurring issues within the sites are multifaceted by nature. Thus, it might prove challenging to prioritize some problems over the other. This challenge calls for further research on more hybrid solutions for flexible and responsive environments that can simultaneously address every dimension of the issues.

5 Conclusion

Where in the past form and functionality had been applied to the landscape as a studied and pre-packaged ideology, this paper claims that through using the data-driven approaches, the landscape can rather be the result of outward communication with the world around. By showcasing two projects, this paper presents an overview of several areas in which landscape design can be successfully supplemented by contemporary data systems and parametric and algorithmic design to revitalize wasteland through networked ecologies. Embedding data can allow for project conceptualization, design specification, and an objective design process that achieves environments tailored to their specific geographic context while providing rapid, simulation-based feedback and impact analyses; the goal is an effective and considerate integration of scientific knowledge into designing our built environment. This method reveals and develops new complex relationships and feedback systems that draw from various contexts and frames of reference only to achieve deeper unity and coherency. Consequently, the built environment becomes an active participant in our cities, drawing on data to respond to the needs of the user. Seeking wide-range design strategies with the focus on energy and infrastructure, this paper provides examples of introducing large-scale comprehensive territorial analysis to parametric design processes to free the “in-between” spaces of their oblivion, as Berger might argue. In the end, our environments can function more effectively by linking all the segregated programs and user needs together and generating a series of preventive actions using data.

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