RETROFITTING [INDUSTRIAL] ECOLOGIES

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Abstract
This paper delves into a design proposal for the Naga' Hammadi Sugar Cane Factory in Upper Egypt, strategically positioned on the western bank of the river Nile. Contrary to challenging the factory's ongoing production and economic legitimacy, the design proposal addresses the adverse effects associated with its current operational model, specifically targeting issues related to air pollution and the occupation of agriculturally suitable land.

The envisioned redevelopment along the riverbank goes beyond mere mitigation, actively embracing and amplifying the productive essence inherent to the site. Through a thoughtful adaptation of the existing system, the outcome is the establishment of an eco-industrial and technological park. Functioning as a transformative tool, the park is conceived with the overarching goal of evolving the industrial site into a dynamic and vibrant urban environment, fostering sustainable development.

The park, designed as an open and adaptable system, exhibits a strategic foresight by incorporating components that can be easily retrofitted to seamlessly accommodate the ever-evolving demands of production and environmental standards. This foresightedness not only enhances the park's functionality but also positions it as a resilient and dynamic entity capable of withstanding changing needs over time.

The generic nature of the intervention further contributes to the versatility of the proposal, promoting a myriad of possibilities for adaptations to organically emerge and function effectively in diverse contexts. This multifaceted approach ensures that the proposed eco-industrial and technological park is not only a localized solution but also a scalable and replicable model with the potential to positively impact various industrial landscapes. Overall, this paper provides a nuanced exploration of the design proposal, elucidating its intricacies

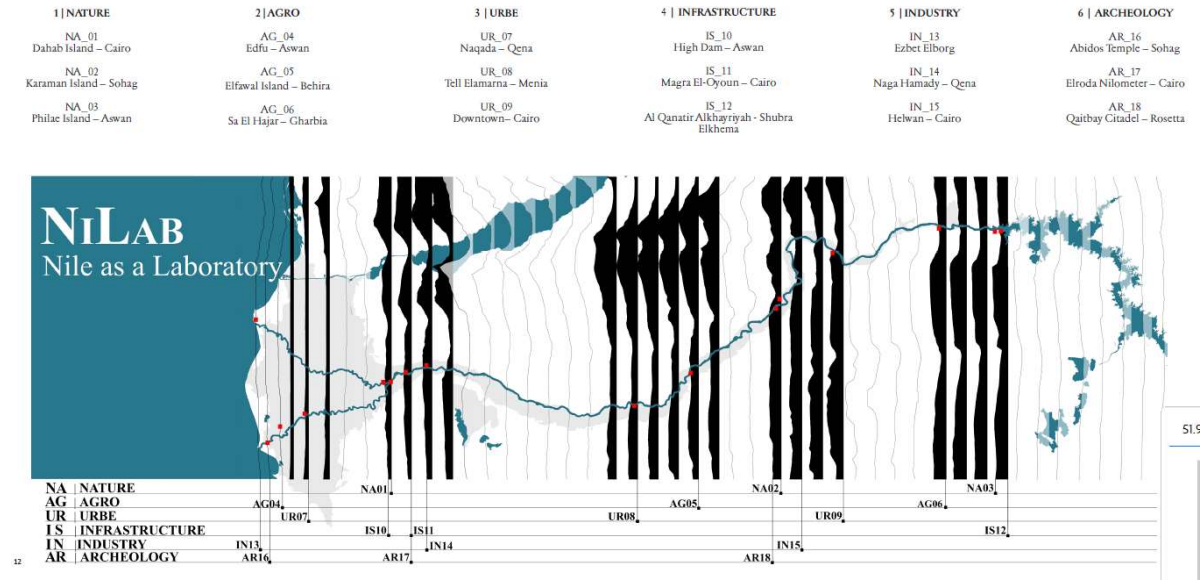
and emphasizing its potential to act as a catalyst for sustainable urban development in the broader regional and global context.

Keywords: *Egypt, Industry, Retrofitting, Landmark, Eco-Industrial Park, Sustainable Urban Development*

Introduction

The project Retrofitting (Industrial) Ecologies is part of the project NiLab (Abd Elrahman, Tornatora, Amaro, Samir & Hassan, 2023), the proposal for the Egyptian pavilion presented at the 2023 Venice Biennale. The aim of NiLab was to become a space for participation, knowledge, research, and international discussion between Egypt and the world on topics of climate change, water resources, and sustainable development. It was structured as a laboratory for the development of ideas and projects on the Nile River, a space for reflection on the Nile as an infrastructural axis and an important resource for Egypt. The themes, corresponding to six landscape sections – Nature, Agro, Urbe, Infrastructure, Industry, and Archaeology – were developed through eighteen design intervention areas, intended for international discussion between Egypt, Africans, and the world.

Figure 1: NiLab, six landscape sections – Nature, Agro, Urbe, Infrastructure, Industry, Archaeology – developed through eighteen design intervention areas



Therefore, this paper delves into one of the investigated areas and the design proposal for the Naga' Hammadi Sugar Cane Factory in Upper Egypt, strategically positioned on the western bank of the river Nile. In lieu to challenging the factory's ongoing production and economic legitimacy, the design proposal addresses the adverse effects associated with its current operational model, specifically targeting issues related to air pollution and the occupation of agriculturally suitable land.

The main research question that this project tries to answer is: what is the adequate approach towards heavy industries, like sugar cane production, in the struggle for sustainability and search for lower environmental impact? Further on, in this process of transformation, we ask what happens with infrastructures that play an important role as a

figurative and operational landmark for the nearby communities, whole regions, or even states, like the case of Naga' Hammadi Sugar Cane Factory. And lastly, this project tests the concept of retrofitting as a possible intervention into such an important infrastructure chain, recreating its operational status within future sustainable infrastructure networks.

The envisioned redevelopment along the riverbank goes beyond mere mitigation, actively embracing and amplifying the productive essence inherent to the site. Through a thoughtful adaptation of the existing system, the outcome is the establishment of an eco-industrial and technological park. Functioning as a transformative tool, the park is conceived with the overarching goal of evolving the industrial site into a dynamic and vibrant urban environment, fostering sustainable development.

Sugarcane production in Egypt

The sugar industry in Egypt started back in the year 710. Egyptians are considered to be the pioneers in the refined sugar industry since the ninth and tenth centuries. (Hassan and Nasr, 2008). According to Bodenstein (Bodenstein, 2014), the cultivation and production of sugar cane in Egypt underwent a significant revival and transformation during the nineteenth century. Muhammad ʿAli Pasha, an ambitious Ottoman governor from 1805 to 1848, spearheaded efforts to expand cane cultivation in the Nile Valley and modernize processing facilities. Chélu and other sources agree that the first truly modern sugar factories were established during Muhammad ʿAli Pasha's rule in the early nineteenth century.

Nearly all of the important production sites in Egypt are located in Upper Egypt along the biggest infrastructure axis, the river Nile, creating an easily accessed operational line. There are five governorates in which the eight biggest factories, that process the sugarcane as raw material or already processed material, are situated: El Menia, Sohag, Qena, Luxor, and Aswan. There are also three sugar refineries located in Lower Egypt (Nakhla, El Haggar, 2014).

Sugarcane is cultivated in 136 million hectares, which produces 1,075,184 metric tons of sugar (Hassan and Nasr, 2008). Historically, sugar production relied heavily on sugarcane until 1981, when sugar beet was introduced to meet rising local demand. This change transpired because of limitations in expanding sugarcane plantations, renowned for their substantial water usage, aligning with the National water policy's focus on water conservation. (Hamada, 2011). Sugarcane farming is predominantly focused on Upper Egypt, specifically in regions such as Menia, Sohag, Qena, Luxor, and Aswan, where an estimated annual cultivation of around 16 million tons occurs. (Hamada, 2011). Egypt stands at the forefront among Arab nations in sugarcane production, yielding the highest volume, with Sudan following closely behind at an annual output of 7.5 million tons (ESCWA, 2009).

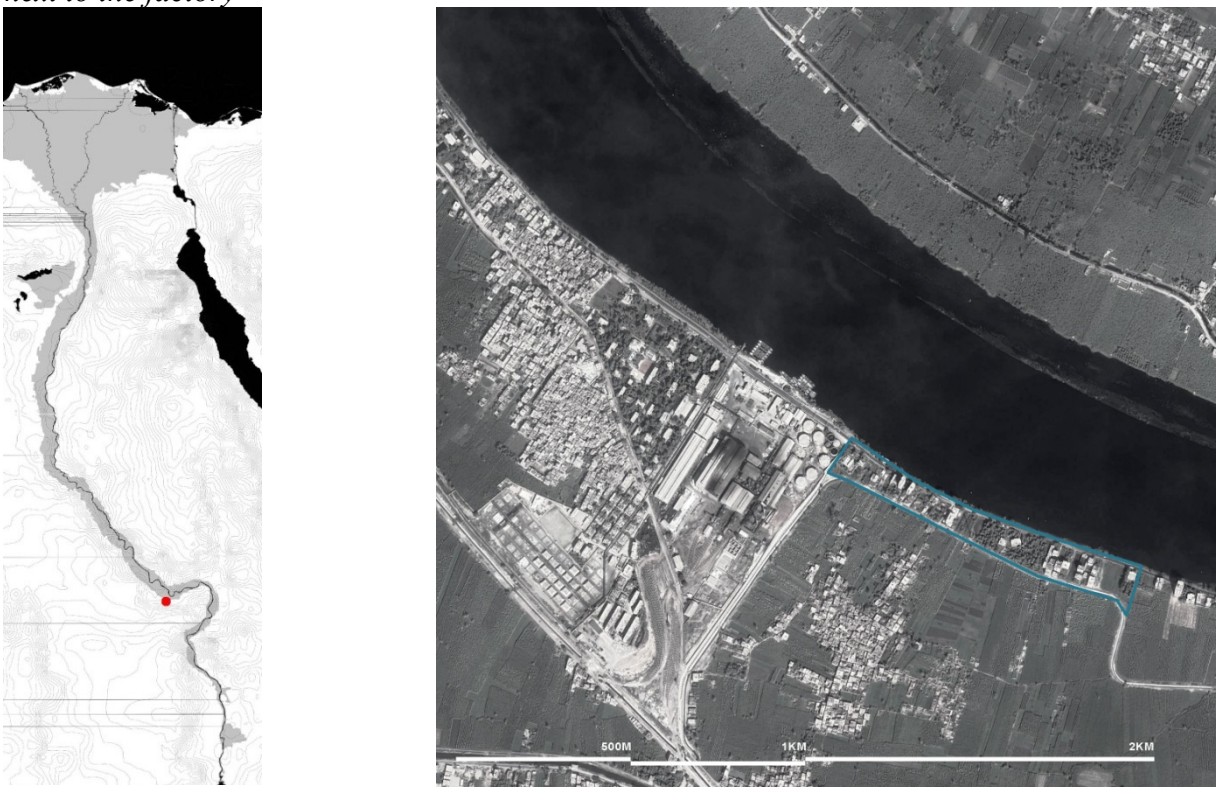
Contextual Analysis

The intervention is located in the governorate of Qena, on the fringes of the city of Naga' Hammadi, to the south of Cairo, on the right side of the Nile's riverbank, near the city of Luxor. What marks the location landscape is the presence of the Naga' Hammadi Sugar Cane Factory, a site of paramount importance that has shaped the area's identity. As we can see, this factory sits between two vastly different residential areas. On the western side, a residential zone that embodies modernist principles is situated, with self-standing buildings adorned with lush green spaces dominating the landscape and on the opposite side, a spontaneously developed vernacular residential area.

Naga' Hammadi Sugar Cane Factory holds immense significance, not only dominating its location but also playing a vital role in Egypt's economy as the second-largest sugar cane

factory in the country. As mentioned before, along the Nile axis other seven sugar production factories are situated forming an operational chain in the resource provision and distribution of final products. This productive infrastructure develops further to the land, in the nearby settlements and sugarcane fields, but also along the Nile in a seamless network of water distribution traffic.

Figure 2,3: Naga' Hammadi Sugarcane factory's position on the river Nile and the design site next to the factory



Aside from the widespread positive effect that the sugarcane industry has on the country's economy, there are several challenges concerning the environmental impact it has on the surrounding space and further. In this direction, the Naga' Hammadi Sugarcane factory's current operational mode relies heavily on bagasse as a fuel source. What is reasonably a rightful act of reusing a byproduct, bagasse (sugar cane pulp), as fuel turns into the utmost hazard due to the CO2 emissions in the burning process leading to detrimental environmental consequences. Additionally, the extensive storage of bagasse, estimated to be around 6000 m², occupies valuable agricultural land, limiting its productive use.

This raises the question: What if the existing factory shifted to natural gas, and bagasse was used for other environmentally friendly purposes instead? Despite these challenges, the factory remains economically viable, underscoring the need for a nuanced approach to its retrofitting.

Conceptual Framework

The concepts of retrofitting industrial ecologies and repurposing industrial buildings as landmarks are at the gist of this research by design process. The proposed conceptual narrative directs a holistic approach that integrates sustainability and design innovation. It further seeks to revitalize industrial sites while addressing the production adverse effects, preserving their economic, historical, and cultural significance, and transforming them into

vibrant, sustainable spaces that contribute to the fabric of the city. Thus, this paper explores the potential of retrofitting the Naga' Hammadi Sugarcane factory site on the river Nile, focusing on managing by-products and establishing landmark structures that would symbolize the site's transformation.

The retrofitting of industrial ecologies involves mitigating the negative externalities associated with industrial byproducts. According to El Haggar and El Gowini (2005), sugarcane (Saccharum officinarum) bagasse is considered the main by-product and represents nearly 30% of the sugar cane industry. It is available in large quantities in the factories but is still largely under-utilized or mainly utilized as a fuel and thus makes the main air pollution source. This research explores the operational possibilities of its further consumption for different products, adding different operations to the industrial complex. In general, the retrofitting strategies aim to transition the factory's operations to more sustainable practices, such as shifting from bagasse-fueled production to natural gas and repurposing bagasse for eco-friendly products. By addressing these externalities, the intervention seeks to create a healthier environment for surrounding communities and minimize the factory's impact on the landscape.

Retrofitting industrial ecologies involves applying measures commonly seen in the manufacturing industry, where new or updated parts are fitted to old or outdated assemblies. This concept extends beyond machinery and buildings to encompass the broader context of industrial sites, where existing infrastructure and processes are modified to meet contemporary needs and standards.

Principally, retrofitting is essential for climate change mitigation and adaptation, particularly in built environments like industrial sites. As society has invested in infrastructure and systems before fully understanding the implications of climate change, retrofits become crucial for reducing emissions and adapting to changing environmental conditions. For instance, retrofitting industrial buildings to improve energy efficiency not only reduces emissions but also enhances resilience during extreme weather events. This aligns with the principles of the circular economy, as retrofitting reduces the need for newly manufactured goods, thereby minimizing lifecycle emissions and environmental impacts.

Retrofitting the Naga' Hammadi Sugarcane factory site involves implementing a combination of technological upgrades and systemic changes to address externalities such as air pollution and land occupation. Transitioning from bagasse-fueled production to natural gas represents a technological retrofit aimed at reducing emissions and improving air quality. Additionally, repurposing bagasse for eco-friendly products aligns with the principles of the circular economy, minimizing waste and reducing environmental impacts. Beyond technological retrofits, systemic changes are also necessary to address externalities and enhance sustainability, which may include redesigning production processes to minimize resource consumption and waste generation.

In addition to the concept of retrofitting the industrial site, recognizing the existing and designing new iconic structures that serve as landmarks within the urban landscape is introduced. The industrial heritage structures dotting the Nile River, such as the Naga' Hammadi Sugarcane factory site, are repositories of profound architectural, historical, technological, and social significance. Embedded within Egypt's urban fabric, these edifices serve as prominent landmarks that shape the collective identity of Egyptian society. Cherchi (2015) underscores the potential of such monumental buildings to rejuvenate city areas, fostering social revitalization and urban renewal. Situated along the Nile River, the Naga' Hammadi Sugarcane factory site holds a distinct position in Egypt's industrial narrative. Beyond its functional role, the site emerges as a potent symbol of the nation's industrial heritage, contributing to its cultural and historical legacy. As part of a larger network of industrial infrastructure dotting the Nile, including dams and bridges, the factory site enriches

Egypt's identity as a state. Xie (2015) emphasizes how these industrial assets imbue local communities with pride, shaping the character of erstwhile industrial hubs.

The process of retrofitting the Naga' Hammadi Sugarcane factory site heralds an opportunity to elevate its status as a landmark, infusing it with sustainable development and innovation. Through a comprehensive retrofitting approach, the site can retain its historic value while embracing modern efficiency and sustainability standards. By adhering to the principles of retrofitting, the site can adapt to contemporary needs while preserving its cultural legacy.

Retrofitting the Naga' Hammadi Sugarcane factory site transcends mere transformation; it enhances its role as a symbol of sustainable progress within the urban landscape. Boschmann and Gabriel (2013) underscore how buildings like the factory site serve as repositories of cultural symbolism, narrating tales of local history. Through meticulous retrofitting endeavors, these structures can embody Egypt's commitment to sustainable urban development, resonating with its industrial heritage.

Figure 4: Conceptual map for the design interventions

Finally, to the conceptual framework, we add the concept of eco-industrial park (EIP). Eco-industrial parks are rooted in sustainability-oriented sciences, primarily influenced by industrial ecology (Conticelli, Tondelli, 2013). They claim that this discipline emphasizes principles such as energy efficiency, focusing on the optimal utilization of natural resources to fulfill human requirements. Additionally, it emphasizes closed materials loops, aiming to balance input and output by minimizing the total industrial material discarded or lost in intermediate processes through re-use. Most importantly, industrial ecology emphasizes industrial symbiosis, viewing processes and industries as interconnected systems within a framework of material, energy, and information flows rather than isolated components.

One of the most important goals of industrial ecology is making one industry waste another's raw materials (Frosch, 1994). These are industrial facilities clustered to minimize both energy and material wastes through the internal bartering and external sales of wastes (El

Haggar, 2007). El Haggar claims that EIP aims to achieve economic, environmental, social, and governmental benefits. Economically, it aims to reduce costs related to raw materials, energy, waste management, treatment, and regulatory burdens, thereby enhancing companies' competitiveness globally and improving their image. Environmentally, it seeks to decrease demand for finite resources, promote resource renewal, reduce waste and emissions to meet environmental regulations and foster sustainability in both environmental preservation and economic development.

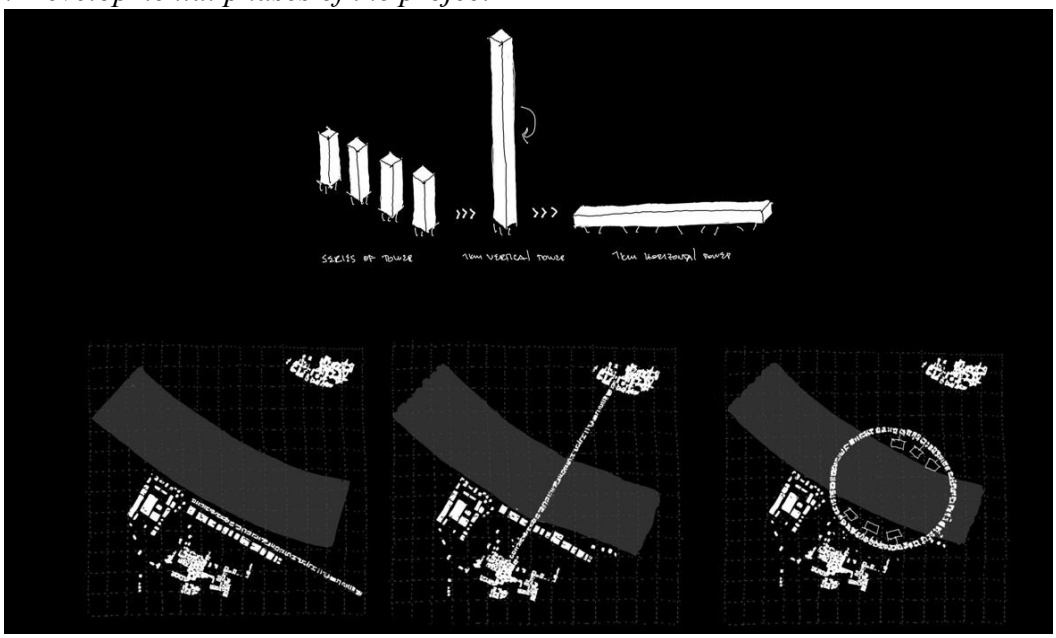
The objective of industrial ecology, according to El Haggar (El Haggar, 2007), is to emulate natural ecosystems within industries, where every material or energy source is utilized by some organism. The managerial aspect of industrial ecology entails examining the relationship between industry and the environment. Conversely, the technical aspect involves adopting innovative process and product design strategies such as cleaner production and eco-industrial parks. The integration of cleaner production, eco-industrial parks, and life cycle analysis ultimately culminates in the concept of industrial ecology.

Naga' Hammadi eco-industrial park

In continuation to the conceptual framework, the outline of the proposal does not question the Naga' Hammadi Sugarcane factory's production continuum and economic legitimacy but looks at the possibilities of surpassing the negative impact that the current operational mode brings to the surroundings. In that sense, the design directs the transformation of the site towards an eco-industrial park, a greenfield complex (Lambert and Boons, 2002), developed according to well-defined concepts of reduction of environmental impacts.

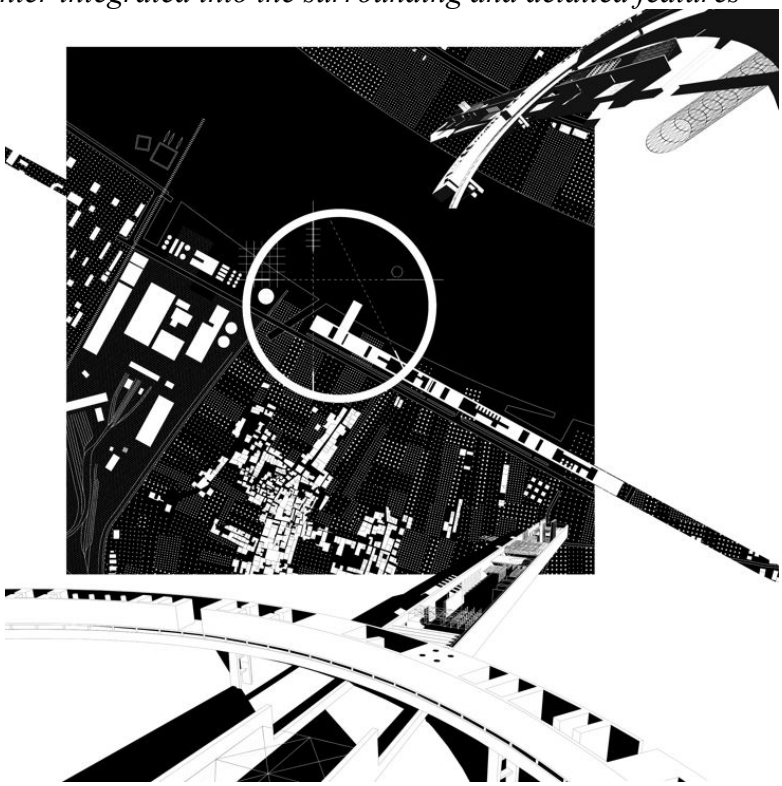
The given program necessitated the provision of high-rise structures within the designated area to serve as directional and commercial apparatus, supporting the local production system. In response to this requirement and consideration of the site's specific characteristics and the prevailing built environment, the design proposal diverged from traditional approaches. Rather than adhering to a conventional arrangement of individual high-rise buildings along the riverbank, the project proposition entailed the consolidation of these structures into a single horizontal skyscraper spanning 1.5 kilometers, emblematic of an eco-industrial and technological park.

Figure 5: Developmental phases of the project



Throughout the developmental phase, the investigation delved into the optimal positioning of the horizontal skyscraper and its potential interfacing with the surrounding milieu. In the initial phase, emphasis was placed on the enhancement of the existing infrastructural axis. This strategy was formulated with the intent of capitalizing on the extant infrastructure to augment the impact of the horizontal skyscraper within the landscape. Subsequently, the second phase elucidated the concept of the horizontal skyscraper serving as a bridge, thereby fostering connectivity with the opposing bank of the river. This innovative design approach aimed to establish a physical and symbolic link between the two shores, promoting cohesion and integration across disparate areas. In the final phase, a variant of the preceding concept has been explored, wherein the bridge not only facilitated inter-bank connectivity but also assumed the role of a prominent landmark. This multifaceted function of the structure sought to draw attention to the adjacent factory premises, highlighting its significance within the industrial landscape and underscoring its latent potential for further development.

Figure 6: Two landmark structures: an eco-industrial park as a stripe and a levitating circular trade center integrated into the surrounding and detailed features

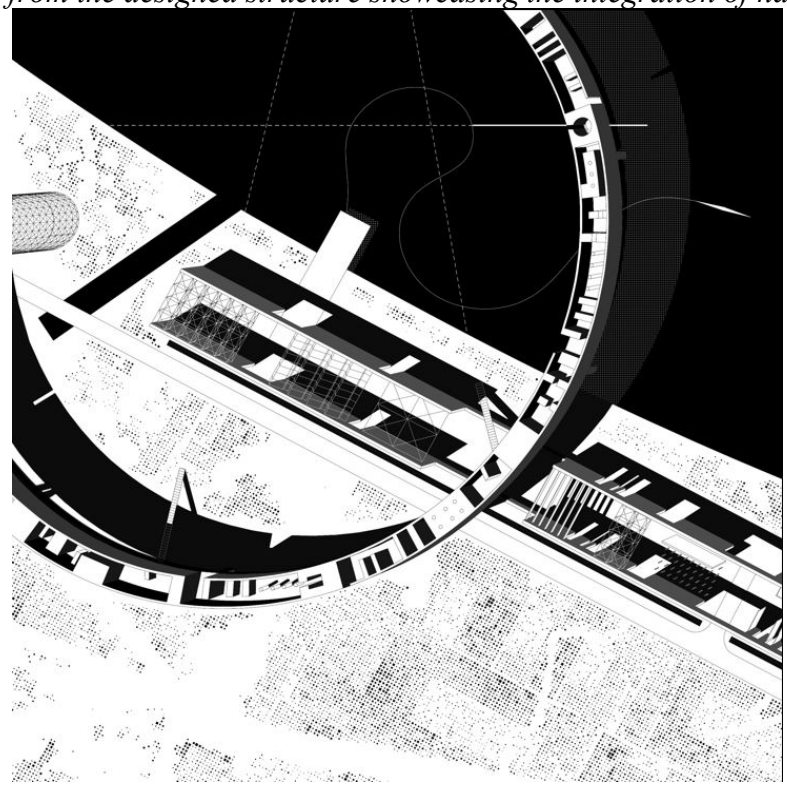


Finally, the idea is eloquently conveyed through the autonomous forms of a stripe and a circle, representing a clear departure from traditional industry and trade. The proposed intervention includes the design of two landmark structures: an eco-industrial park and a circular trade center. The stripe embodies linear production operations, functioning as a riverfront that seamlessly integrates the existing factory on the west and harmoniously penetrates the settlement on the east. Defined by two parallel longitudinal walls, the spatial organization remains porous and open to the public, fostering a sense of inclusion and community. Its distinctive architecture and innovative design features make it a focal point for visitors and a symbol of the site's commitment to sustainability. In contrast, the trade center takes the shape of a levitating circular ring, physically detached from the ground, yet bridging the multifaceted aspects of this productive site—the agricultural fields, the new industrial park,

and the Nile River. The ring structure of the trade center extends the riverfront – above the water and the land, while its abstract form stands out in the surroundings and becomes a landmark. It serves as a hub for commerce and business activities, and its iconic design enhances the site's visibility and contributes to its identity as a vibrant economic and cultural center.

Delving into the two distinctive structures one can recognize a 1.5km eco-industrial and technological park, complete with laboratories for research and design, producing compostable food packages, fiberboards, furniture, and housing units; and a 1.5km circular trade center, hosting offices, commerce, and a covered pedestrian street. This design embodies the spirit of innovation and adaptability, making this eco-industrial and technological park an open and adjustable system, ready to meet future production and environmental requirements.

Figure 7: Detail from the designed structure showcasing the integration of natural elements



By aiming at retrofitting the found industrial ecology, it should be underlined that the project also contributes to fostering resilient communities achieving three main and equally important aspects related to ecological and social values:

1. Ensuring citizens' connection with nature: This objective is achieved through the renaturation of wastelands and eliminating bagasse storing and burning. The transformation of the industrial site to an eco-industrial park results in afforestation and the initiation of natural processes to develop plant communities and restore biodiversity. A key decision in the master plan was to designate part of the region as a park, aiming to reclaim lost natural spaces.

2. Natural components are integrated as a green structure throughout the industrial region, forming continuous green fields and open spaces. This green system acts as a corridor within the Eco-Industrial Park, connecting local industrial areas with urban spaces. New green public areas address the historical deficiency of recreational spaces in industrial cities and villages, offering opportunities for various forms of leisure in the industrial landscape. The program emphasizes diverse activities, making the region popular for family outings and recreational

pursuits such as walking and cycling routes. The development of Naga' Hammadi Park reflects the concept of a public park accessible to all, revitalizing previously neglected areas.

3. Preservation and promotion of historical and cultural values: The project aims to conserve the industrial infrastructure's historical and cultural significance, including landscape features, architecture, and transport elements. The development of Naga' Hammadi Park involves redefining and reinterpreting existing industrial elements, transforming old structures into new uses. The site serves as a repository of memories, leveraging the urban landscape's distinctive structures in the planning process. Many existing spatial elements, recognized as industrial relics, are preserved to maintain their uniqueness and original functions. The industrial landscape contributes to the site's "genius loci," with footpaths and cycle routes following former transport networks.

Conclusions

By taking a holistic approach to retrofitting, industrial sites, like the Naga' Hammadi Sugarcane factory, can not only mitigate its environmental impact but also contribute to the transition towards a more sustainable and resilient industrial ecosystem. Designing eco-industrial parks, by means of retrofitting, should include both technological upgrades and systemic changes aimed at reducing emissions, minimizing waste, and improving overall environmental performance. By embracing retrofitting as a strategy, a designer opens a site to further development concepts and, transformative opportunity to uphold the site's historical essence while ushering in a new era of sustainable urban development. It creates solid ground for a cultural continuum by preserving and creating new landscapes of landmark featured networks, and cultural dynamics by integrating the concept of eco-industrial parks within urban areas.

The retrofitting endeavor redefines industrial ecology, emphasizing ecological and social values. It entails renaturing wastelands, halting bagasse burning, and establishing green spaces to reconnect citizens with nature. Integrating natural components creates cohesive green fields, serving as corridors within the Eco-Industrial Park and addressing historical deficits in recreational areas. Additionally, the project conserves and promotes historical and cultural values by preserving industrial infrastructure, repurposing old structures, and leveraging the site's unique spatial elements. The development of Naga' Hammadi eco-industrial park rejuvenates neglected zones while upholding the distinctive character and original functions of industrial relics, enriching the site's architectural and cultural identity through repurposed footpaths and cycle routes tracing former transport networks.

The park, designed as an open and adaptable system, exhibits a strategic foresight by incorporating components that can be easily retrofitted to seamlessly accommodate the ever-evolving demands of urban production in general following the dynamics of the environmental standards. This foresightedness not only enhances the park's functionality but also positions it as a resilient and dynamic entity capable of withstanding changing needs over time.

The generic nature of the intervention further contributes to the versatility of the proposal, promoting a myriad of possibilities for adaptations to organically emerge and function effectively in diverse contexts. This multifaceted approach ensures that the proposed eco-industrial and technological park is not only a localized solution but also a scalable and replicable model with the potential to positively impact various industrial landscapes. Overall, this paper provides a nuanced exploration of the design proposal, elucidating its intricacies and emphasizing its potential to act as a catalyst for sustainable urban development in the broader regional and global context.

In conclusion, our intervention advocates for a future that unites industry and trade with the values of sustainability and ecological responsibility. By embracing the potential of this visionary transformation, we not only enhance the prosperity of Naga' Hammadi Sugar Cane Factory but also set a new standard for industry and trade across different contexts.

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