ARTIFICIAL NATURE: SYMBIOTIC RELATIONS OF BUILT-FORM AND NATURE IN THE POST-ANTHROPOCENE ARCHITECTURE

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ABSTRACT

This study aims to demonstrate a design transformation that demonstrates symbiotic relationship between built-form and nature with the overarching objective of fostering ecological sustainability in the emerging post-Anthropocene epoch. This study can be considered as a direct response to current architectural paradigms that predominantly prioritize human needs and requirements, often at the expense of environmental well-being. Most of our built environment stands on the modes of resource extraction and consumption, frequently relying on finite, non-renewable materials, generating substantial pollutants that disrupt delicate ecological equilibrium. This study begins by exploring the idea of symbiotic between architecture and nature in current design discourse. The exploratory design study follows by establishing potential natural elements that can be accommodated within built-form as living systems. The study identifies three specific roles in the environment as part of the symbiotic programming, which are to feed, to fuel, and to heal. This speculative study further develops architecture proposition as a form of artificial nature through connections of these different programs. By exploring mutually beneficial symbiotic relationships between built-form and natural elements, the study found that artificial nature can create interdependent outputs, where outcomes from feeding can be used for either healing or fueling, and vice versa. This study highlights the need to create architecture that transforms and unfolds as open and collaborative systems. Such discussion informs a systemic form of architecture, where its spatiality enables growth of biological organisms that metabolize the spatial process and its surroundings.

Keywords: *Symbiotic Architecture, Artificial Nature, Post-Anthropocene Architecture, Architecture and Ecology*

INTRODUCTION

This article proposes the biological concept of symbiotic relationship as the basis of designing architecture as artificial nature. The symbiotic relationship is a form of biological association between two or more different species of organisms that are mutually beneficial (Paracer and Ahmajian, 2000). This study explores how such an idea can be expanded, not only to exchange resources between species, but to enable architectural form to be transformatively altered and immersed with nature, generating an artificial nature. Symbiotic relationship of architecture in relation to nature has been discussed within the context of post-Anthropocene discourse as a way to ensure a sustainable distribution of environmental resources particularly (Karpouzou and Zampaki, 2023).

As contemporary architecture relies extensively on natural resources for materials, understanding an alternative way of managing environmental resources become important. The rapid expansion of mankind for the past three centuries creates exploitation to an unprecedented degree which has been causing an effect on the global environment (Crutzen, 2016; Flynn, 2016; Syafriny and Sangkertadi, 2019). Cities are responsible for the global greenhouse gas emissions from burning fossil fuels (United Nations, 2019; Aliyah and Dewi, 2024), while based on data collected by the (International Energy Agency, 2025), buildings are accountable for 75% of global energy consumption, 64,4% of global energy, 77% global carbon emissions and 87% of global clean energy investment. These figures give a picture of how buildings consume resources to be built and to operate.

Facing future challenges such as resource depletion, a fundamental change in architectural design is essential. Nevertheless, despite their impact on the environment as a result of building and architectural presence, architecture has not offered much in return to the environment. 'This situation somehow represents the image of architecture as discipline in a state that is almost imaginably bad and created a form of architecture which is against life, insane, image-ridden and hollow' (Alexander, 2005, p.6). Finding an alternative relationship between the built environment and nature becomes important. Such relationships must support various forms of adaptation to and mitigation of climate change, be it through sustainable land management, adoption of conservation agricultural practices that can support biodiversity and nutrient cycling, provide good-quality water, and so on (United Nations, 2019).

This article develops a speculative design study to understand how architecture can promote symbiotic relations between built-form and nature. This relation expands the design paradigm of the built-form not as stand-alone form that single-handedly extract material from the environment, but instead creates resources for other species within the built-form to grow together, thus offering back to nature. The study starts with investigating how the system of nature works collaboratively in a resource-efficient way to diverse urban areas (Zhong, Schröder and Bekkering, 2022; Rahman, Paramita and Atmodiwirjo, 2023). The study follows by exploring the idea of artificial nature as an approach to promote symbiotic transformation by integrating nature with the built-form and its corresponding processes. The study explores how symbiotic relationships allow natural elements to inform systemic arrangements of resources between building, nature, and its inhabitants. This scenario allows further exploration of architecture's role in developing space that supports not only humans but also the wider ecology.

THEORY / RESEARCH METHODS

Symbiotic Relationship of Architecture and Nature

Intersection between biology and design opens a new terrain of architectural systems (Pasquero and Poletto, 2020; Collet, 2021). Discussion of symbiotic relationships in the field of biology has evolved with the discovery of how physiology of some animal can only be completed by its symbionts, challenging individuality of the animal (Gilbert, Sapp and Tauber, 2012). In such discussion, the physical existence of both species is considered integrated as one. The study is interested in adapting such biological phenomenon as the basis of design in architecture. Exploration of built-forms as part of the natural system require understanding symbiosis as part of the use of biological knowledge in the discipline of architecture (Šijaković and Perić, 2018). The existence of such knowledge should reflect how some biological mechanism plays a central role that goes beyond being a simple environmental regulator, model or inspiration. Biology is in itself the medium of a multi-layered design approach that is materially and socially integrated, creating better resilience (Cruz and Parker, 2022; De Caro, 2022).

The limited biological discussion in architectural practice reflects the disputed understanding of nature in architecture, where architecture often solely strives to imitate and use nature as reference, or instead considered to be in confrontation with nature (Forty, 2004). In such confrontation, nature and the built environment either exist in a commensalism or parasitic relationship, where nature is either unaffected at best or more commonly being harmed instead (Šijaković and Perić, 2018). 'The traditional construction processes aim to form a barrier between human habitation and the natural environment where no capacity exists to engage with the environment they inhabit' (Flynn, 2016, p. 21). The dependence of human life with natural resources has been dominantly one-sided, which is heavily favoring human and neglecting nature (Flynn, 2016; Paramita *et al.*, 2023; Ewida, 2024).

Symbiotic discussion between architecture and nature expands such application of how biology can inform architectural practice. Current literature highlights how the integration of biological systems of nature and technical systems of architecture requires different kinds of agency (Schaumann *et al.*, 2025). Biological systems, such as plants that grow from soil and harnesses sunlight from their surroundings are self-sustaining and dynamic, while technical systems are programmed with close-ended objectives (Lucas, 2018; Schaumann *et al.*, 2025).

Architecture as symbiosis between nature and the built environment consists of a living system that exchanges between people and their surroundings which contribute and become a productive part of the system (Flynn, 2016; Harani, 2023). Such productivity can be seen in how nature has been providing us with every substance and material for living; from soils that grow plants which provide a variety of food as fuel. The plants also absorb carbon emission and produce oxygen during their lifetime. Not to mention animals and insects which consume the plants provide food and also take their role as growth catalysator of nature. At the end of the plants' lifecycle, they are also consumed microbiology organisms, which take roles of composing or decomposing from one into other substances. The processes involving microbiology organisms provide variety of nutrition and medicine produced from such decomposition that then allow healing and regrowth. There is a need to consider how the varying productive roles of nature can be integrated with the technical system of architecture.

Architecture should no longer simply become consumers of the biosphere but should promote the connection between humans and nature (Zhong, Schröder and Bekkering, 2022). We need to overlook how humans and nature operate in order to get a better picture of the current situation and what can be improved in the future. However, when the plants are transformed into technical systems, they are then appropriated into timber for the material of the building, creating isolations of the building's system. A new understanding is needed to develop an innovative approach as architects and designers, which consists of a shareable point of view that constitutes the many factors influencing the environment that can coexist coherently (Alexander, 2005). For example, the existence of turf vernacular houses in Iceland, where parts of the buildings are created from layers of earth and grass that allow the overall building to be immersed with the landscape and create a living system that accommodates surrounding biodiversity (Birch, 2020).

Gibson (2015) argues there should not be any separation between nature and built-form as if there were two environments. Basically, humans cannot live without nature and its natural resources (Suryantini, Paramita and Ren, 2024); which raises the question of how our existence will also benefit nature in return. The search for innovative and alternative ecological design and manufacturing propositions is an integral part of our ability to transition to a sustainable future (Collet, 2021). 'Human beings create barriers and boundaries while in contrast nature operates without such confines and has no rigid boundaries' (Ewida, 2024, p. 117). Architecture as a manufacturing means of natural resources transforms the built environment not only as consumers but also as producers. It unfolds as open and collaborative systems that would change, grow and metabolize (Karpouzou and Zampaki, 2023).

This study highlights the need of new methods to 'produce new architectural typologies and new ways of living in and with nature' (Cruz & Parker, 2022, p. 53). This study aims to discuss such shifts in understanding and designing architecture as artificial nature. Indeed, 'architecture is considered as a form of artificial life', where symbiotic behavior and metabolic balance that it generates 'are characteristic of the natural environment' (Frazer, 1995, p. 9). The search of new architecture as artificial nature requires the need to 'move away from ideas of sustainability that think in terms of closed loop ecologies, that assume life runs like a machine' (Flynn, 2016, p. 22). Corbusier (1986) argues that architecture should reflect integration between artificial mechanisms and life. Architecture is the manifestation of our image of nature and governed by laws of nature (Le Corbusier, 1986). There is a 'need to urgently move beyond the destructive impact of the Anthropocene and … create an integrated system where newly conceived human habitats feed from the inexhaustible resources of sunlight, carbon and water' (Cruz & Parker, 2022, p. 53). This new approach requires an interdisciplinary approach (Flynn, 2016; Pasquero and Poletto, 2020; Collet, 2021; Cruz and Parker, 2022; Thomsen and Tamke, 2022).

Understanding architecture as artificial nature perceives the built environment to be 'less as a collection of distinct autonomous buildings and infrastructures but rather as nodes that become conduits or producers of energy and nutrients (materials) in a complex cyclic system' (Karpouzou & Zampaki, 2023, p. 105). There needs to be a new system of production that can reconnect humans to other species and appreciate diverse ecological elements (Cruz and Parker, 2022; Ewida, 2024). Such new system can be seen in the symbiosis between architecture materials and microorganisms, turning 'waste and pollution into nutrients and raw material' (Pasquero & Poletto, 2020, p. 123). Integration of natural organism reflects a form of symbiosis to enable particular process to happen. Architecture as artificial nature requires rethinking of biological resources and processes to create materials and systems that are productive and sustainable.

Further identification of elements and their capacity to be incorporated with our architecture is essential in creating artificial nature that symbiotically integrates with the built form and nature system. A deeper understanding of ecological processes is crucial, recognizing the interconnectedness and interdependence of all organisms within an ecosystem, including humans. The following section explores the design development of artificial nature that symbiotes with its broader context.

RESULTS AND DISCUSSION

Designing the Artificial Nature as Living System

Programming Symbiotic Relationships of Architecture and Nature

This study creates an exploratory design project of artificial nature as built-form which enables growth of biological organisms that metabolize the spatial systems and their surroundings with certain objectives, focusing its capacity for feeding, healing and fueling. The study starts by establishing spatial programs and its subsequent operations for multispecies users (See Figure 1). It focuses on utilizing nature's complex system and capabilities to meet those objectives. The design exploration then follows by developing the spatiality of such programs that demonstrate symbiotic relationship between architecture and nature. Based on such design exploration, this article concludes on architectural design method based on the symbiotic relationships of architecture and nature.

The study focuses on developing self-sustained facilities for non-human and human occupants as actors within the provided space. The project will accommodate the growth of plants, animals, and other related biological processes and mechanisms. The design process also focuses on highlighting relevant natural systems for adaptation, in relation to its actors and their living needs. The involvement of non-human becomes necessary as part of the system that produces resources involved for feeding and fueling. However, this system also requires significant engagement with humans, who can assist in activating the built environment that supports the overall symbiotic system. It is argued that such different emphasis on human roles decenters the anthropocentric position of human in the built environment, focusing on non-human as the driver of the living system. Understanding the unique roles of all actors and how they contribute to the living systems becomes the basis of spatial elements that are dependent on them to operate. These elements then become the basis of the architectural assembly of artificial nature.

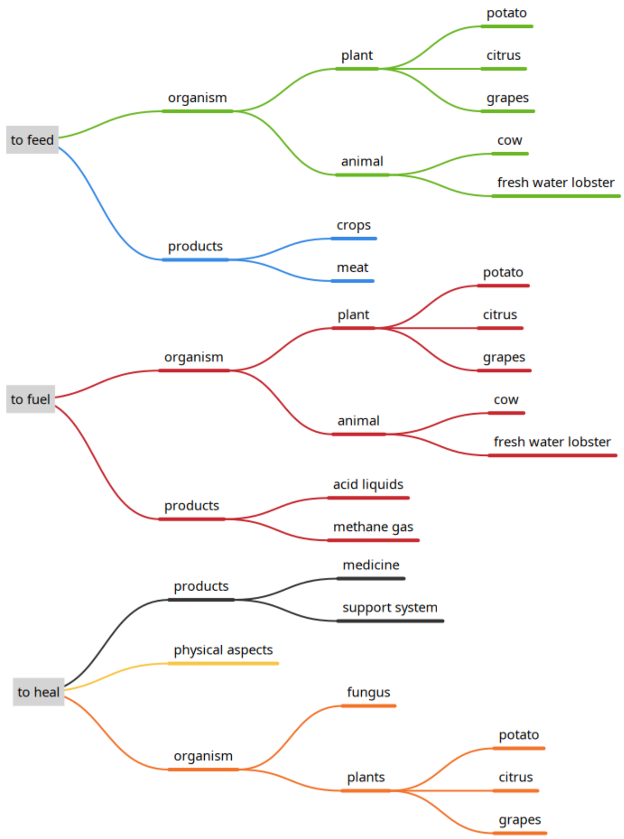

Figure 1. Program and Mapping of Actors

Programming architecture as artificial nature is established by translating given objectives into spatial programs to produce sources of food, sources of nutrition and medicine and also sources of energy. Important plants, animals, and matter are mapped in Figure 2 based on specific objectives, in order to understand their characteristics and metabolic relevance. The programmatic objective of feeding and healing provides appropriate space and other elements needed to promote growth for selected organisms which can later be harvested as sources of food, be it for other non-humans or for humans. There are plenty of options of organisms which exhibit such capability, however this study chooses organisms such as potato plants as source of carbohydrate, shrimp and cow as protein provider and also grapes and lemon as source of vitamin, antioxidants and fiber. These organisms become the actors, the main subjects whose needs and requirements will be accommodated in the proposed architecture.

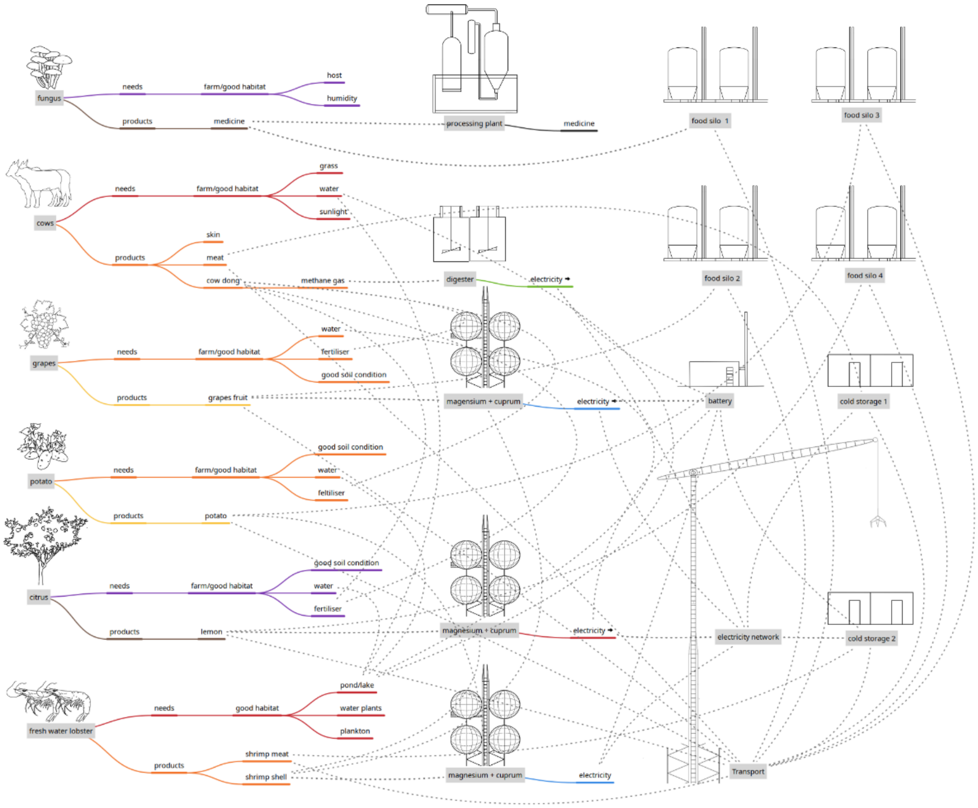

Figure 2. Diagram of Actor and Spatial Elements Interrelation

These programs involve multiple actors supplying various food products, some ready for direct use and others requiring processing. The variations of food condition demonstrate the interrelation between processes, where food may act as resources for other species for their livelihood, but also to support certain environmental processes to maintain the quality and longevity of these products before use. The architectural program of artificial environments offers appropriate storage solutions, enabling on-demand access. The type of storage—ranging from simple facilities to complex silos or cold storage—should be determined by the specific preservation needs of each product. Together with the space to plant and harvest, the physicality of these storage elements is illustrated in Figure 2, in relation to the different actors planted and their main objectives.

This design objective aims to provide artificial living systems that can act symbiotically with nature. In terms of energy use the study identifies several types of energy consumption purposes. One of the types is the energy as fuel to process food, while other types may be used to generate electricity needed to energize certain equipment to function. Understanding types of energy and their use in specific functions may suggest relevant actors or organisms to provide certain products. This understanding also suggests specific mechanisms to process the product in order to produce or generate certain kinds of energy suitable for different functions. Particular organisms and their by-products can be further processed to generate energy. For example, 'farmed cow dung can be processed to produce methane gas and can be converted into a source of energy' (Shaibur et al., 2021, p. 2). Methane gas is also useful when used as fuel for food processing. 'Residue of cow dung will be used as fertilizer' (Shaibur et al., 2021, p. 2) in the farming system useful for plants within the structure.

The design scenario developed in this study proposes how the design of artificial nature possesses a capability to generate electricity to power elements or equipment in the structure. Electricity sources should be provided independently from the grid line power systems and also free from fossil fuel to provide cleaner energy sources. Electricity can be generated by using biological-based process, such as reduction-oxidation (redox) chamber (Rojas-Flores et al., 2020a), containing manganese and copper flakes, in combination with the reduction-oxidation reactions of chitosan (from shrimp shells) as electrodes and acid fluids extracted from citrus and grapes (Rojas Flores et al., 2020b). Shrimp is a process-enhancing actor because the chitosan contained on its shell allows higher bioelectric generation (Lee *et al.*, 2019) while shrimps are also considered as protein providers. Redox chamber produces energy alongside a digester which processes cow dung to extract methane gas contained in the substance and convert them as various energy sources. Therefore, other elements which require electricity to operate are being energized by energy generated within the building. They do not need to import energy to run which makes them great potential for minimizing carbon footprint and carbon emission assuming our current energy source comes from fossil. Ultimately, the presence of all plants in artificial nature will produce oxygen that is useful for the survival of animals and humans, while the presence of animals and humans will produce carbon needed in the photosynthesis process. Artificial nature is an architecture that is present to support and accommodate processes needed for nature to grow.

In order to achieve this function, artificial nature should programmatically provide space to accommodate the growth of actors and the process that they take. For example, growing citrus and grapes to produce bioelectricity requires certain specific spatial qualities for growing which provide adequate sunlight, good soil conditions, pollinating agents, and so on. After identifying all elements needed to feed, to fuel, and to heal, the following section explores the symbiotic spaces of the overall artificial nature project, to understand how each element assembles with each other and operates in space.

Spatializing the Symbiotic Systems of Architecture as Artificial Nature

To establish the program's spatial framework, the next step involves pinpointing the spatial programs of its participating actors. A thorough evaluation of their respective needs and requirements is done based on the identification of participating actors of nature in the previous section. Contextually, artificial nature can inhabit areas that deteriorates and requires acceleration to improve imbalanced condition of natures, such as industrial or mining areas, or other form of areas that are facing certain environmental pressures. The artificial nature environment is populated by diverse actors, broadly categorized as originating from plants and fungi, and animal actors. Plant and fungi-derived inhabitants necessitate growth spaces characterized by fertile soil conditions, sufficient sunlight exposure to facilitate photosynthesis, and appropriate levels of humidity to support their biological processes. Conversely, animal actors within the artificial nature context typically demand more extensive spatial allocations, often best accommodated in areas, external to enclosed structures. For instance, bovine actors, such as cows, require open fields with a substantial supply of healthy grass to serve as their primary food source. Similarly, crustacean actors, such as shrimp, depend on aquatic ecosystems with specific water quality parameters to thrive.

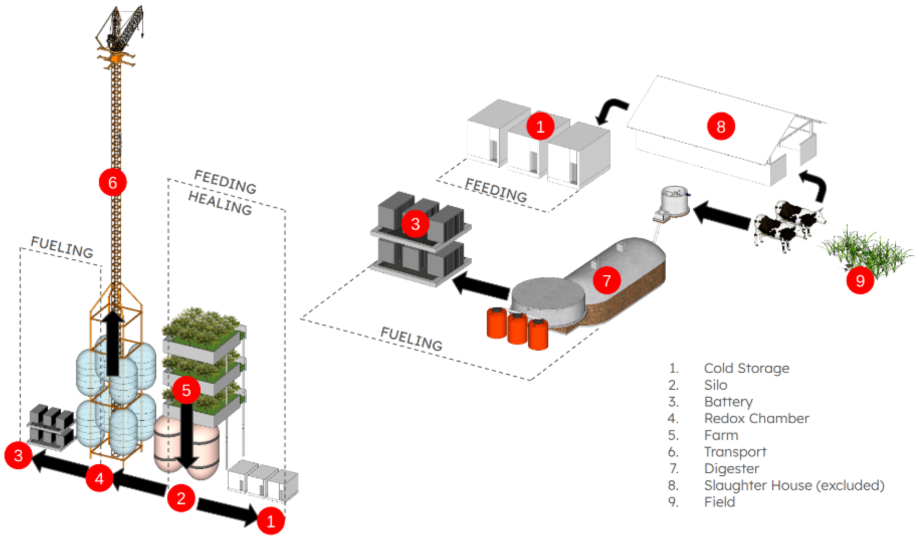

Figure 3. Operational Diagram and Mechanisms of Spatializing the Artificial Nature

These actors generate initial outputs or products that are then systematically identified to define their spatial needs. Certain primary products may necessitate specialized storage facilities, such as silos for grains or cold storage units for perishable items, to maintain their quality and prevent spoilage. Furthermore, some primary products may undergo subsequent processing to transform them into secondary products with enhanced utility or different applications, such as the conversion of biomass into energy or the creation of specialized food products through further refinement.

After a thorough assessment and identification of all constituent elements within a program, the study explores the explicit specification of the interrelationships between each element. Figure 3 illustrates these interrelationships, showing the program's operational logic, often visualized as a structured flow or architecture. It is argued that these connections can be seen as symbiotic connections that are not universal but are highly contextual, dictated by the specific nature of the program and their inherent requirements for particular actors, products, and internal components.

Understanding this intricate web of interdependencies within the program provides crucial insights into its assembly mechanism.

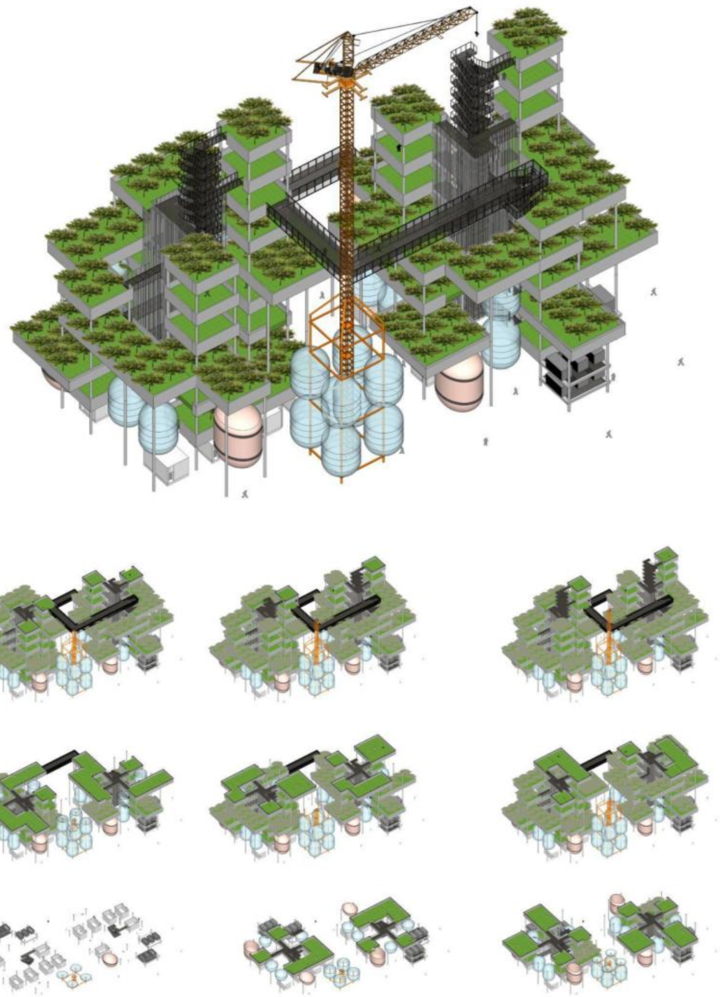

Figure 4. Spatiality and Assembly of the Artificial Nature Design Project

Figure 4 highlights how the individual elements interact and contribute to the overall functionality and execution of the program. The connection and interdependencies of identified in Figure 3 is further systematized in Figure 4, to enable interrelations between spaces and its material flow. The output from feeding, for example, can be used as resources for other processes such as fueling. The bottom figures of Figure 4 showcase a more detailed understanding of these interrelationships. Such detailed understanding becomes necessary for essential tasks in running the facility, such as debugging, optimization, and future development or modification of the spaces. Humans that manage and develop this space may trace the

flow of data and control, identify potential bottlenecks or points of failure, and ensure the program operates as intended by effectively orchestrating its constituent parts.
Based on the connection identified in Figure 3, this study follows by assembling all spatial programs in the architecture of artificial nature (See Figure 4). Each space is defined by actors and their requirements. The height of each floor is defined to accommodate optimum height of actors in this case citrus plants and also to allow maximum sunlight penetration into the interior as it becomes an essential element required by plant-based actors in order to perform a photosynthetic metabolism. Stacking arrangements of floor plates have been put in relatively random order to consider variation of sunlight exposure to reach each level and to ease pollinator agents, such as insects or physical elements, to access plant-based actors, which will help them to grow.

CONCLUSIONS

Symbiotic architecture as artificial nature

This article explores the idea of symbiotic in developing architecture that integrates between the built environment and nature, titled as artificial nature. Whilst current discussions of architecture create separation between architecture and nature, symbiotic architecture promotes collaborative systems between the two to appropriate natural resources. This study proposes to address such architecture as a form of artificial nature, where its space ecologically enables growth of biological organisms that metabolize the spatial systems and its surroundings. Such metabolization creates differences between architecture that does not engage with nature in the production and distribution of material that is produced in its systems.

The study follows by designing architectural programs for artificial environments with the objectives of feeding, healing, and fueling based on the foundational understanding of biology and physics. Exploring spatial and material systems that follow such objectives informs and expands the conception of integration architecture and nature in current discourse. Nature should not any longer be placed as simply existing in the background, but can offer an advancement to our architecture and technology. The study finds that adopting three programs of feeding, fueling, and healing enables architecture to transform collaboratively in relation to nature, immersing as the living systems. The study also highlights how the interdependence between actors of the programs enables integration of processes, to ensure how outputs from one process can be appropriated as resources of another. Activating such processes in collaboration with nature, and ensuring interdependencies between processes, reflect an expanded form of symbiotic relationship between architecture and nature. Such findings expand symbiotic discussion in architecture that tends to focus on singular exchange between programs instead of the systematic presence of such relations.

Design research on symbiotics between built-form and nature offers further potential which may shift our perspective of resources from the extraction of finite material into a renewable and sustainable production of matter. This transformation not only affects physical aspects in our built-form but also affects the future practice of architecture, which requires understanding and involvement of expertise from other disciplines. Future research may address the more calculated design scenarios that are needed to develop more precise and integrated living systems of architecture in relation to nature. Such research allows a more interdisciplinary outlook in the development of symbiotic architecture, where multiple fields in the engineering discourse can be included. Such discussion expands architectural design to move towards more ecologically responsible use of resources, involving various non-human actors in a sustainable and ethical way.

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