SPECULATING A SWARM-BASED SYMBIOTIC ARCHITECTURE IN THE ERA OF MOTHERING NATURE

Heidy Sekardini
*Rini Suryantini**

Department of Architecture
Universitas Indonesia
Indonesia

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Abstract

This experimental design study explores forms of adaptive architecture that reflect the symbiotic connection between humans and nature. Responding to the growing ecological between human and nature, this paper speculates how architecture can be an entity that coexists and co-evolves with nature. Instead of positioning architecture as a static entity, this symbiotic architecture introduces the conceptual figure of *Homo botanicus* as human species that grows and regenerates nature as its imperative, initiating the era of Mothering Nature. The study starts by investigating the adaptive strategy of plants that grow symbiotically within their natural biomes. The biological growth mechanism of plants across three biomes—tropical, savannah, and coastal wetland—was examined, mapped, and translated into computational scripts. Such scripts serve as the basis of *H. botanicus*' living world: *Verdantia*, *Aridstepia*, and *Aqualandis*, exhibiting a close intertwine between species and their living system. The design envisions an architecture as a symbiont that regenerates nature together with its natural ecosystem. This study demonstrates the understanding of architecture not as exploitative but co-evolving, growing with nature's innate logic and contributing to its ecological resilience.

Keywords: symbiotic architecture, Homo botanicus, *living world*, *swarm intelligence-based*, *computational design method*

Correspondence Address: Rini Suryantini, Department of Architecture, Faculty of Engineering, Universitas Indonesia, Kampus UI Depok, 16424, Indonesia. Email: r.suryantini@ui.ac.id

Introduction

This design study speculates how architecture may reconnect humans and nature through the idea of symbiosis. It argues that through an act of symbiosis, a living entity may adapt and grow within its natural context, providing a basis for generating a co-evolving architecture (Bulatović & Bunjak, 2013; 2016). This perspective challenges the traditional and static view of architecture (O'Donnell, 2015), shifting architecture to a dynamic entity that evolves alongside its natural ecosystem

The global ecological crisis disconnects the relationship between humans and nature, causing harm to the environment and also endangering its ecological health. The study urges an alternative approach to designing architecture rather than just creating a passive response to the crisis (Anker, 2005). This study believes that architecture can actively integrate human life and natural systems (Kurokawa, 1977), emphasising the cohabitation of organic and inorganic entities within design.

This study views architecture as a symbiont in the natural evolutionary process. Swarm-based computational scripts based on organism adaptive strategy are employed to generate a speculative figure of the *Homo botanicus*. It is a conceptual species that symbiotically grows, lives together and co-evolves within its natural biomes while supporting the ecosystem in which it resides. Representations generated from the script through the swarm intelligence algorithm visualise and simulate the growth of *H. botanicus*, allowing for a computational nature of the emerging design method (Parisi, 2017), emphasising a meticulous and modular data-driven approach to architecture.

Being as nature: A symbiotic relation

The evolution of human civilisation highlights a transformative journey driven by adaptations to environmental and technological changes (Harari, 2015), allowing significant societal advancements on a broader scale based on complexity. However, it leads to situations where human civilisation has overwhelmingly impacted nature's ecosystems and caused environmental degradation (Steffen et al., 2007). Such an anthropocentric situation calls for a shift to position the role of humans as a species that strengthens the connectedness to nature, as a way to improve the qualities of the natural ecosystem (Paramita et al., 2023; Zelenski et al., 2023).

Connectedness with nature allows humans to address the detrimental impacts of the Anthropocene on climate and ecosystems, in which ecological boundaries are respected and restored (Riechers et al., 2021). Being connected with nature after an extended time allows an affective experience that stimulates the maintaining and sustaining of nature (Zylstra et al., 2014). A human-nature connectedness becomes a pathway to improve the condition of the whole ecosystem (Barragan-Jason et al., 2021; Zelenski et al., 2023).

Departing from the connectedness with nature, this design study proposes the idea of *being as nature* instead, as a further step towards a more intimate and profound connection with nature that allows humans to exist as organisms that grow, live together, and co-evolve with nature. *Being as nature* positions humans as an integral entity of nature, inseparable beings of natural systems. It provides a basic understanding of an intertwined relationship between humans and nature (Harari, 2015), which fosters a holistic understanding of life in which all organisms as interconnected manifestations of nature.

Building on these insights, this study argues that the notion of *being as nature* represents an evolutionary step beyond connectedness with nature. *Being as nature* adopts a more profound ecological perspective, positioning humans as organisms involved in natural symbiotic relations. It shifts the paradigm towards a more inclusive ecological framework where humans and the environment coexist.

Being as nature employs symbiosis as a core mechanism in biological evolution, a way to integrate human life with the ecological processes. It becomes a key to the evolutionary process, constructing a symbiotic relationship between organisms and their environment in shaping the natural world over billions of years (Margulis, 1981/1992; Šijaković & Perić, 2018). The process of symbiotic relations between organisms and their natural environment can be driven by genetic variation, natural selection, and environmental interactions (Chomicki et al., 2022).

In the long term, symbiotic relations lead to the emergence of new life forms and the morphology of living things (Margulis, 1981/1992). Such complex relations trigger not only morphological evolution but also the adaptive strategy and mechanisms to support and enhance the survival of both (Smith & Read, 2008). For instance, mutual symbiotic relations can be seen in the morphological evolution of plants, their key stages and adaptive mechanisms, including their interactions with microbes in the surroundings, which eventually support their reproduction and survival (Delaux & Schornack, 2021; Faegri & van der Pijl, 1979; Szövényi et al., 2019). The idea of symbiosis sets the basis of *being as nature*, which allows for redefining architecture as a dynamic organic entity of the natural ecosystems.

Symbiotic architecture of *Homo botanicus*: From coexisting to co-evolving

This speculative design study embraces symbiotic relations between humans and nature through coexistence and a reciprocal evolutionary process of *being as nature*. Kisho Kurokawa (1994) describes symbiosis as a mutually beneficial relationship between entities and proposes an architecture to exist in nature with such relations. The idea of symbiosis offers a compelling framework for rethinking how architecture can interact with nature, positioning humans as co-inhabitants and co-evolving agents within the natural world (Kurle et al., 2023). Such a deep understanding of ecological system interactions, dependencies, and correlations leads architecture to innovative spatial design methodologies (Coray, 2020; Harrison, 2013). By rooting design in ecological interactions and co-evolutionary processes, symbiotic architecture opens possibilities to grow, live, and adapt in harmony with nature.

Central to this proposition is the recognition that architectural design must view nature not as a resource for exploitation but as an intrinsic subject of space. Architecture with symbiotic relationships embodies the living characteristics of an organic entity, with flexible membranes and responsive structures that can mediate specific human-environment interactions. Architecture as a living entity, a mutual species, within a specific natural ecosystem, can grow, adapt, and co-evolve (Jackson, 2002).

Based on mutual symbiotic relations, this study investigates the plants' adaptive strategy in particular biomes, focusing on their growth and living mechanisms, with speculation of co-evolving with the surrounding context. Natural growth mechanisms serve as critical foundations for architectural methodologies, emphasising the dynamic interplay of independent variables, such as climate adaptation and the integration of natural elements, with dependent variables like spatial variations created through adaptive manipulation.

To further elaborate on the symbiotic relation, this study introduces *H. botanicus* as a conceptual species that integrates human and plant genetic traits to foster natural symbiosis with the natural environment as its living ecosystem. It transcends mere physical adaptation, offering a framework for developing more effective symbiotic architectural systems. Its presence allows for the reimagination of human interaction with nature, positioning it as a species that stewards and 'mothers' the ecosystem, which then initiates the era of Mothering Nature. In this era, mothering becomes imperative within architectural practice, signifying the cultivation of habitats that sustain both human and ecological life while addressing the critical need to reconnect with nature.

This design study proposes *H. botanicus* to redefine architecture as an integrated component of the natural system that actively cares for and enriches its surroundings. It embodies adaptability, enabling the creation of architecture that promotes sustainability and restores ecosystem balance through mutual symbiotic relations between natural and artificial components. This design study employs *H. botanicus* to demonstrate how symbiotic architecture coexists adaptively and embodies co-evolution within nature.

Method of study: Exploring the symbiosis as the basis of architectural creation

This section outlines the process of generating architecture based on the symbiotic relation between the speculative *H. botanicus* and its living world. It starts with exploring the potential of the adaptive strategy of plants: their phylogenetic evolution and growth mechanisms, spawning and spatial structures, and the possibility of regeneration of the biome as a living ecosystem. The biological growth patterns of particular plants across three spatial zones or biomes, tropical, savannah, and coastal wetland, which later will become the living world for

H. botanicus, were conducted. These three biomes are utilised based on their ecological diversity and complexity as challenges and opportunities, including their unique climatic conditions, ecological interactions, and variations of plant adaptations.

The mapping of the phylogenetic evolution of plants from algae to angiosperms reveals specific adaptations across the biomes, exhibiting particular physiological and morphological adaptations. It also provides the possibility of co-evolution from simple to complex life forms—from microalgae to bryophytes, which enabled adaptation to terrestrial environments, to the evolution of seeds in gymnosperms and the development of flowers in angiosperms, which enhanced reproductive capabilities. This process informs how each *H. botanicus* species can coexist and co-evolve with the biomes.

In this explorative study, the biological logic becomes a basis of the computational workflow in designing the *H. botanicus*, the living world, and the symbiotic relations between them. The patterns of evolution and growth mechanism of specific plants are analysed and translated into computational script, particularly to determine the algorithm used to further create the symbiotic architecture, consisting of *H. botanicus* and biomes as its living world. The study employs computational methods, such as the swarm intelligence algorithm generated in the Grasshopper script, to simulate how these processes can be shaped.

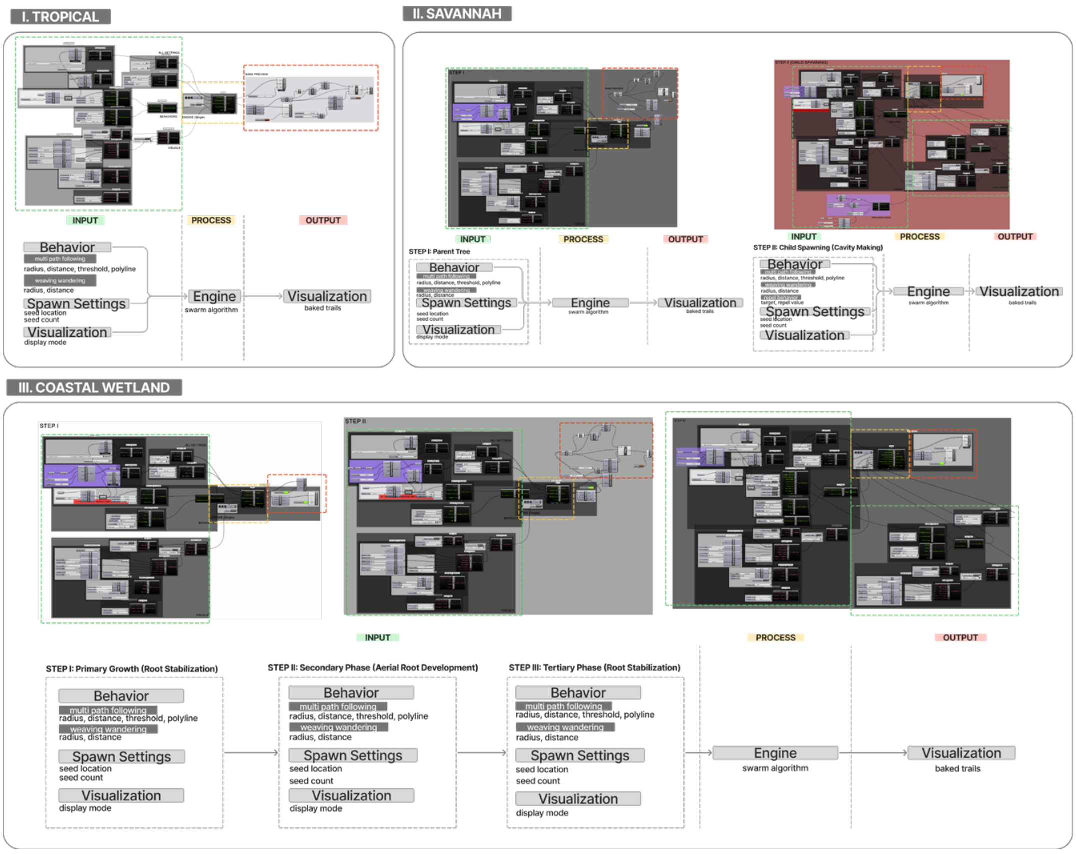


Figure 1. The script-based computational process of creating the symbiotic architecture (Image by authors)

The process involves multiple iterations to imitate the growth mechanism and interaction pattern, aiming to best represent the morphological evolution of the symbiotic process. Such speculative design proposes alternative concepts of symbiotic architecture for a better connection between humans and nature. This process helps to visualise and design architecture that coexists and co-evolves with its natural context.

The symbiotic architecture of *Homo botanicus* species and its living world

In developing the speculative concept of *H. botanicus*, the study maps the phylogenetic evolution of plants associated with specific adaptations across biomes, creating the living world for the species of *H. botanicus*. Three biomes are examined—the tropical, the savannah, and the coastal wetland (Figure 2).

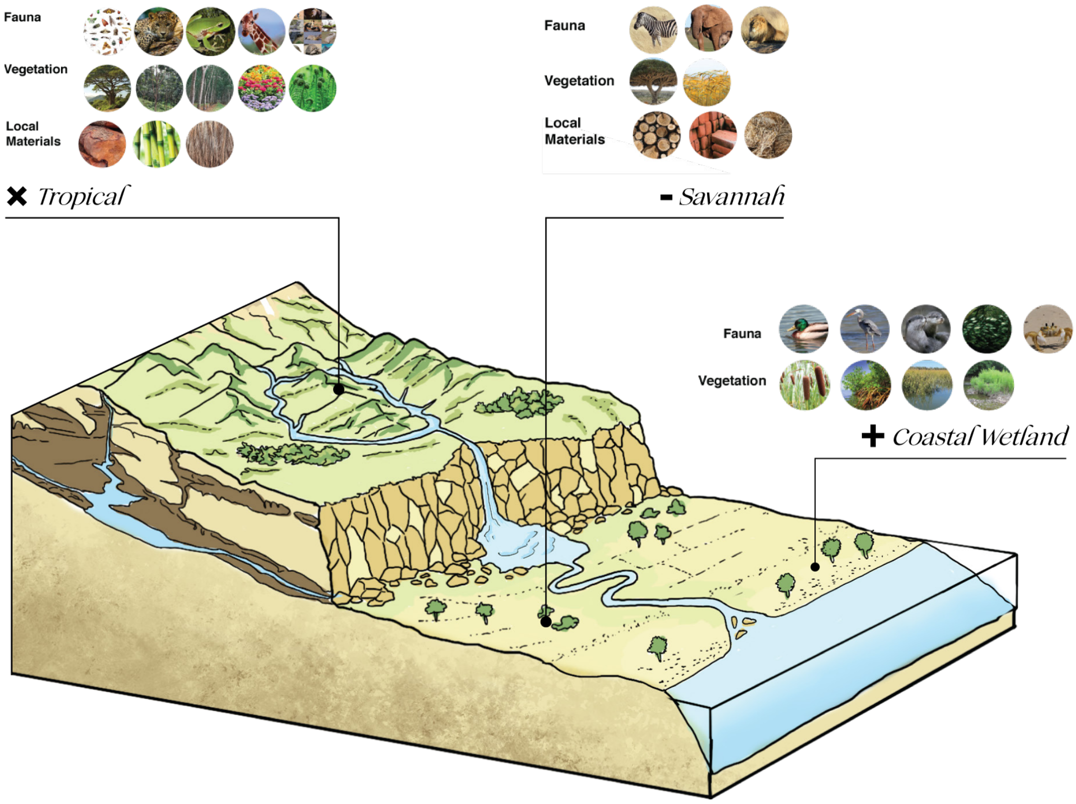


Figure 2. Living world of H. botanicus (Image by authors)

The tropical biome represents lush forests with high biodiversity and complex ecosystems. This biome was chosen for its high biodiversity, containing rich interactions between plants and pollinators, such as epiphytes and host trees. This biome has plants with large leaves for light capture, and a specialised root system growth as a feature to adapt to high rainfall to tackle water runoff. The plants create a layered canopy as the vertical structure, a basis for the spatial organisation of the symbiosis. The second biome is the savannah, which showcases ecosystems that endure seasonal extremes by growing deep-rooted plants with thick bark as drought-resistant adaptations that make them stress-resilient. The plants develop a regenerative mechanism after fires and a strategy for sustaining hydrological balance through underground storage organs for water management. The third biome is the coastal wetland biome, which highlights the dynamic nature of ecosystems influenced by land and water

Figure 3. Plants' evolution according to biomes to characterise H. botanicus species (Image by authors)

and shows a high salt tolerance, which is characterised by mangroves. Mangroves grow aerial roots and vivipary as their reproductive strategy, developing seeds while still attached to the roots. The mangroves' morphology reflects their ability to stabilise shorelines and support biodiversity around them.

The above plant growth characteristics and adaptive ability across biomes become the basis for creating and developing the *H. botanicus* species. Leading further to the characteristics of six *H. botanicus* species to coexist and co-evolve within the living world (Figure 3). These species and their living world become scalable insights into designing symbiotic architecture for a diverse ecosystem.

***Creating the speculative species*: Homo botanicus**

Analysis towards the complex morphological, physiological, and reproductive adaptations respond to challenges from its living world. A pair of *H. botanicus* species is developed in each biome, creating an uttered symbiotic architectural system (Figure 4). The interaction between *H. botanicus* and the living world highlights ecological interactions and functional changes over geological time.

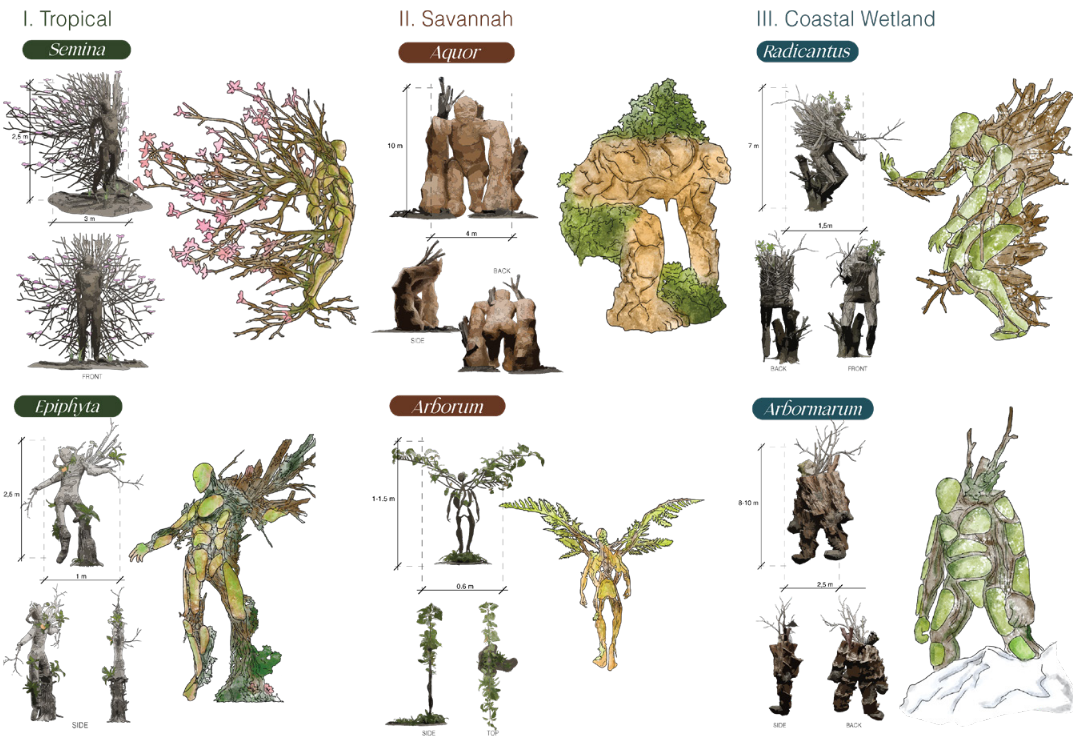


Figure 4. H. botanicus species of the tropical, savannah, and coastal wetland (Image by authors)

In the tropical biome, there are the *Epiphyta* and *Semina*. *Epiphyta* denotes a plant that grows on another plant non-parasitically (in Greek, *epi-* means upon and *phyton* means plant). In the context of *H. botanicus*, *Epiphyta* designates a species that lives symbiotically on surfaces, absorbing nutrients and moisture from the air, embodying adaptive traits of tropical epiphytes such as orchids and bromeliads. *Semina* (in Latin, *semina*, the plural of *semen*, meaning seeds) symbolises the agents of propagation—dispersers and pollinators—that perpetuate life cycles in tropical ecosystems. *Semina* acts as a

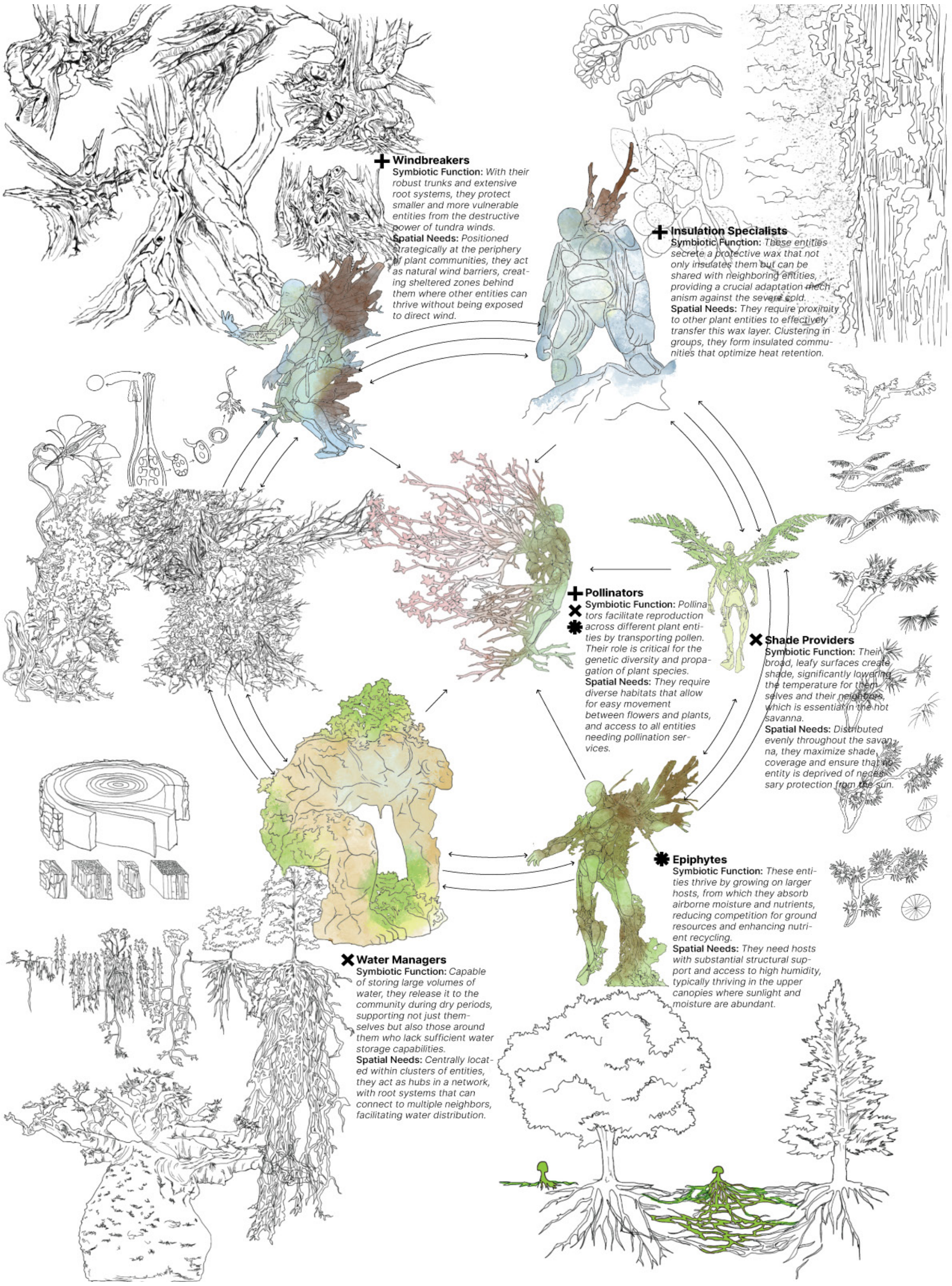


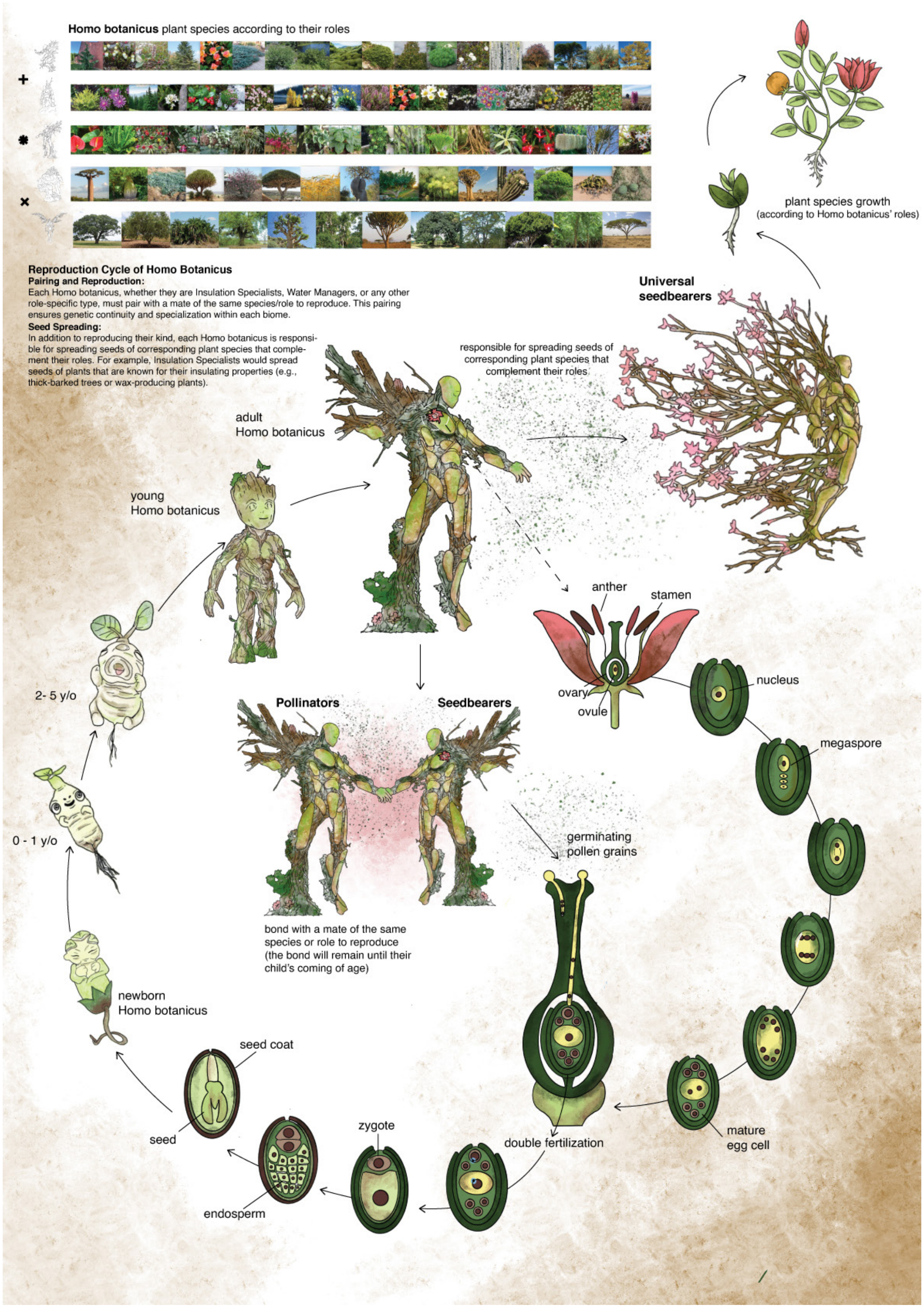
Figure 5. H. botanicus symbiosis within the living world (Image by authors)

reproductive catalyst for a species, mirroring the ecological role of fauna that transport pollen and seeds to ensure biodiversity.

In the Savannah, there are *Aquor* and *Arborum*. *Aquor* (in Latin, *aqua* means water) manages or embodies water. *Arborum* (in Latin, *arbour* means tree) signifies a collective or elemental form, giving it the meaning of 'of the trees' or 'tree-being' in the Savannah biome.

Radicantus and *Arbomarum* are the variant species of *H. botanicus* in the coastal wetland. *Radicantus* is named after a hybridised Latin construct, combining *radix*, meaning root and the suffix -*antus*, which suggests one who roots. *Radicantus* refers to a species specialised in soil interaction, stabilising terrain and enhancing nutrient absorption through root-like appendages, echoing the ecological roles of mangrove and savannah flora. On the other hand, *Arbomarum* combines the Latin words *arbour*, which means tree, and *mare*, which means sea, implying the tree of the sea. *Arbomarum* describes *H. botanicus* species that guards the coastal biodiversity, particularly in mangrove ecosystems. It embodies traits of arboreal species adapted to saline environments, acting as a protector and stabiliser of intertidal ecologies.

Figure 6. The reproductive regeneration system of H. botanicus (Image by authors)



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Each species interacts both within its biome and across different biomes (Figure 5). For instance, *Semina* plays a crucial role across all biomes by dispersing seeds, thereby supporting plant regeneration. Similarly, *Aquor* and *Arborum* are essential during the dry season, migrating across biomes to offer mutual support based on their specialised ecological functions. These interspecies interactions strengthen ecosystem resilience and highlight the collaborative dynamics envisioned in the *H. botanicus* framework.

Each *H. botanicus* plays a role in the reproductive regeneration. Each reproduction consists of interspecific and intraspecific pollination (Figure 6). For example, the *Semina* produces seedlings that are suited to their climatic ecosystem. The seedlings are then dispersed, grow and mature in a specific designated way to fulfil ecological functions in their living world. The symbiotic interactions between the pair of *H. botanicus* strengthen the health and stability of ecosystems, demonstrating advanced adaptations and evolution that ensure the survival and well-being of their environment.

***Constructing the living world of* Homo botanicus**

H. botanicus works with plants based on the specific conditions of each biome. In the tropical biome, plants grow through multiplication; in the savannah, through reduction; and in the coastal wetland, through amplification. These operative

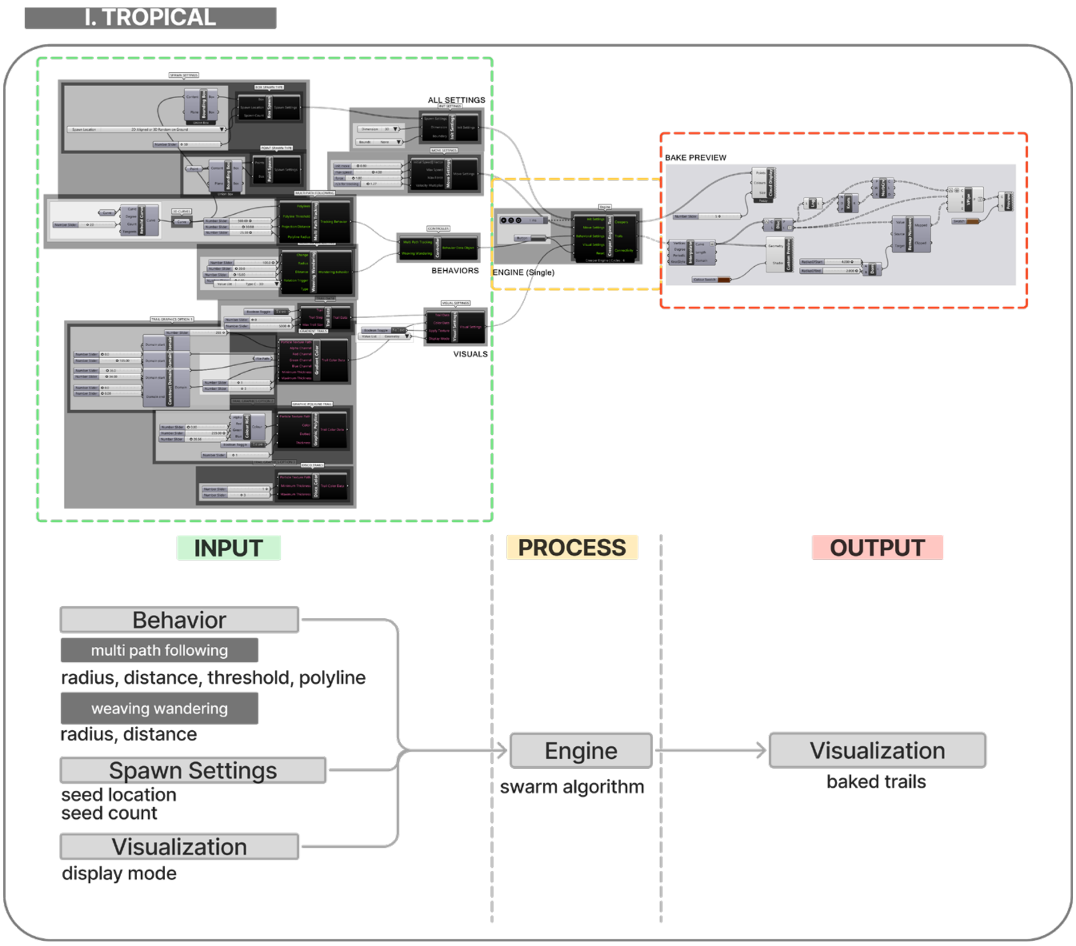

Figure 7. Creating the living world based on the strangler fig's growth mechanism (Image by authors)

mechanisms of each biome and particular plants as biological logic are combined with computational control to create the living architectural system that expands, deforms, and intertwines within its natural context. A symbiotic seedcraft is also created as an architectural strategy to make architecture function like a natural organ, supporting the ecosystem and its growth.

In the tropical biome, the multiplication mechanism of the strangler fig or *Ficus sp.* is employed to create the computational design. Beginning as an epiphyte, the fig germinates in the crevices of a host tree, utilising its vertical and horizontal structures to grow. As it matures, the fig develops an intricate network of roots and branches that envelop the host tree. This ecological behaviour directly informs symbiotic seedcraft that mirrors the fig's vertical layer stratification.

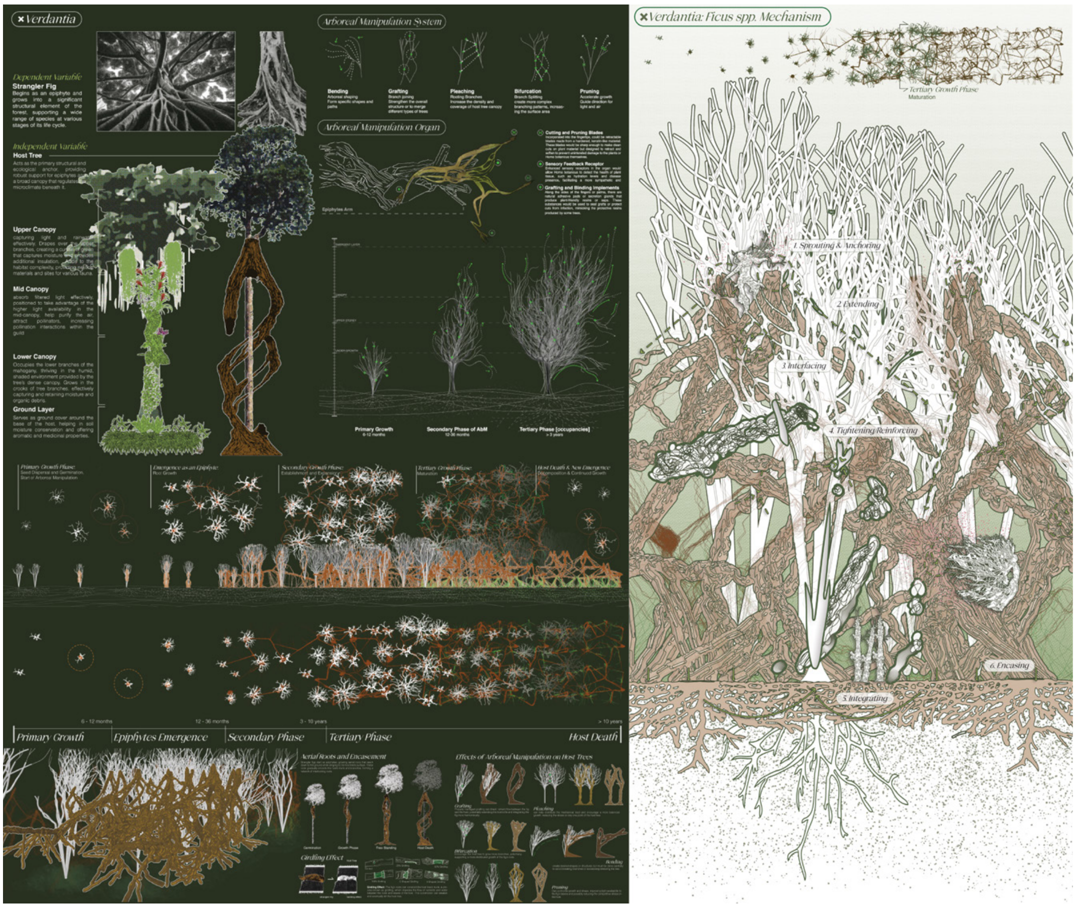

Figure 8. Multiplication mechanism as a basis for the symbiotic architecture of the tropical biome (Image by authors)

To imitate the growth mechanism of the strangler fig, the computational work starts with setting a growth agents that follow paths and wander according to the number of agents and intended locations (Figure 7). A line or mesh representation can be chosen to visualise the growth, generating the most suitable representation. In this process, a swarm algorithm control determines how agents grow, branch, and react to the environment. As an output, this process generates baked trails that show the fig's form, including canopy and root networks as the symbiotic architectural system in the tropical biome (Figure 8).

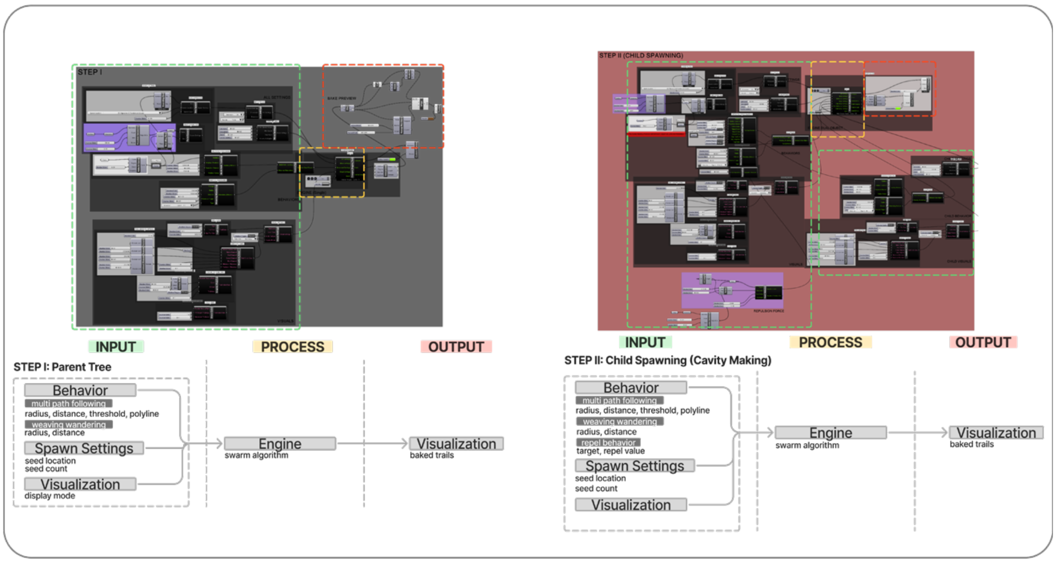

Figure 9. Creating the living world based on the baobab's reductive mechanism (Image by authors)

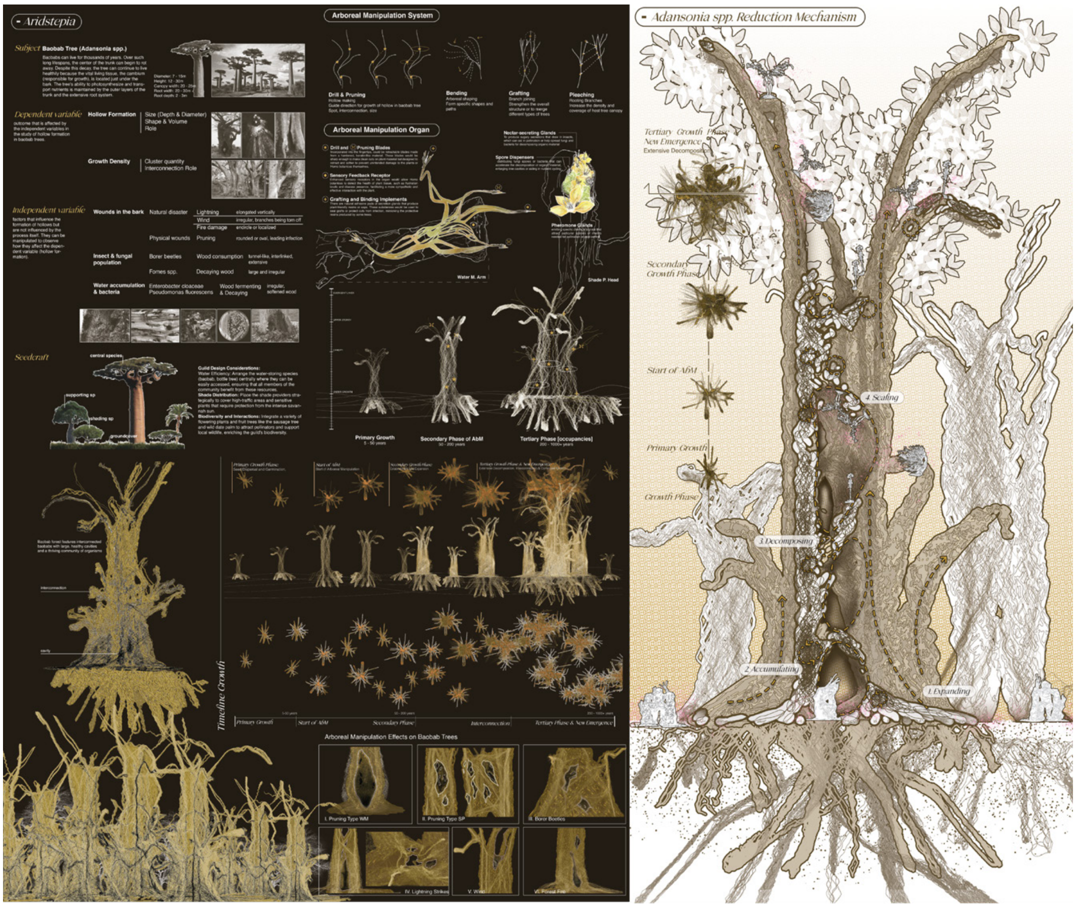

Figure 10. Baobab's growth mechanism as a basis for the symbiotic architecture of the savannah (Image by authors)

In the savannah biome, the creation of symbiotic seedcraft focuses on drought-tolerant species, with the baobab tree (*Adansonia sp.*) as the central figure. Known for its water-storing trunk and ecological resilience, the baobab serves as a natural water manager, supporting biodiversity in dry environments. To operate in this living world, *H. botanicus* intervenes using arboreal manipulation, forming strategic hollows and modifying tree structures to enhance water retention, habitat space, and environmental adaptation. These actions are influenced by independent variables (climate, diseases, natural damage) and dependent variables (cavity size, tree growth, intervention outcomes). Thus, the creation of the living world follows the reductive mechanism of the tree (Figure 9).

This simulation models (Figure 10) the baobab tree's growth and internal cavity formation using a two-step swarm algorithm—growing the parent tree and child spawning or cavity making sequentially. After the growth agent follows a path and wanders to simulate the baobab's trunk formation based on the intended number and location in the first step, the process generates vertical and radial growth, visualising the main tree form. The first step is followed by the second one, by setting the growth agent to follow, wander, and make a repulsive behaviour to form cavities which are already intended in numbers and position. This step employs a second swarm algorithm to create hollow spaces inside the tree. As a result, it generates form as a combination of structure and cavities.

Lastly, red mangroves (*Rhizophora mangle*) exhibit amplification mechanisms in the coastal wetlands to thrive in brackish, oxygen-poor soils. These mechanisms rely on aerial roots' growth, allowing the tree to absorb oxygen from the air and stabilise its structure in fluctuating tidal zones. This adaptive strategy supports biodiversity and plays a vital role in maintaining ecosystem health and shoreline resilience. Thus, the *H. botanicus* species in this biome performs arboreal manipulations, such as pruning, bifurcation, grafting, and enlarging, to encourage dense root networks and enhance nutrient flow, structural support, and reproduction.

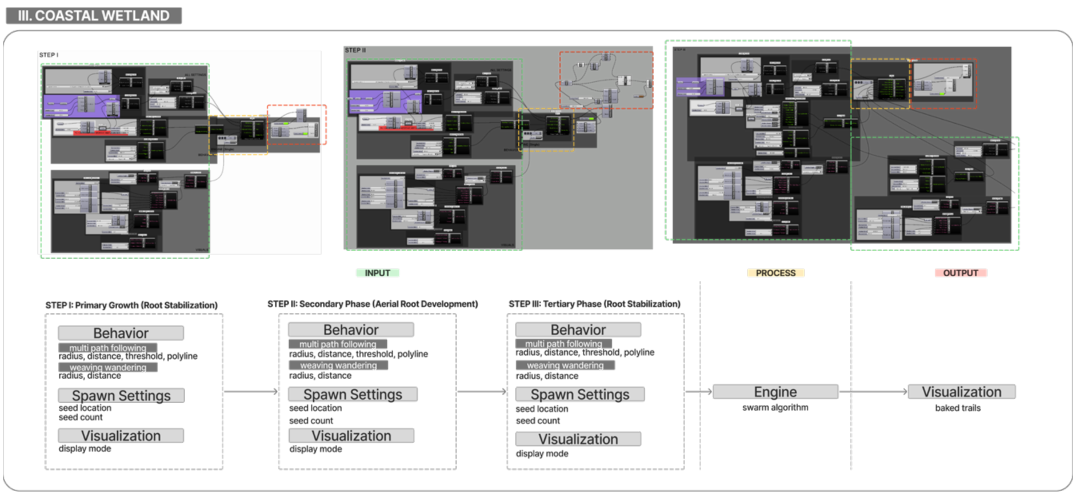

Figure 11. Creating the living world based on an iterative process of root amplification (Image by authors)

The growth simulation of red mangrove roots can be generated through a three-step iteration, using a swarm algorithm (Figure 11). They are primary growth to exhibit root stabilisation, the secondary process of aerial root development, and the tertiary phase to reinforce the root system. As the growth agent follows paths and wanders to form the base root structure, the seed location and count are defined, showing the trails of basic roots. The step is followed by aerial root development, in which the growth agent is assigned new parameters to simulate aerial root branching, generating upward and outward root growth. This step results in trails as expanding aerial structures. Continuing with the last step, the iterative process uses the final agent to reinforce root systems and create connections. The third algorithm refines the spread of the roots and their integration. As a result, the combined trails can be displayed as a whole root network.

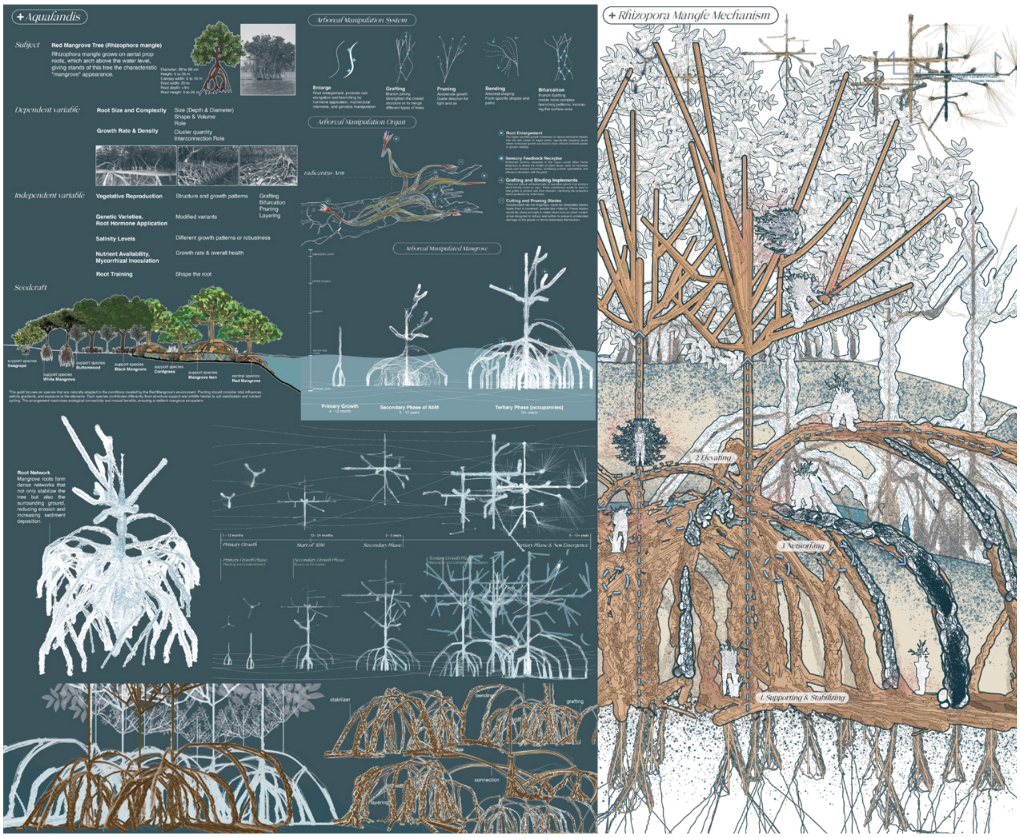

Figure 12. Red mangrove's amplification mechanism as a basis for the symbiotic architecture of the coastal wetland (Image by authors)

The simulation helps to visualise the red mangrove's amplification mechanism, which involves sequential root adaptations for its survival and expansion in a challenging coastal environment (Figure 12). The basal roots form early to anchor the plant in soft, shifting substrates to stabilise. As the aerial roots rise above the waterline, the plants can access atmospheric oxygen, which is crucial in low-oxygen, saline mud. Through guided manipulation, aerial roots branch and interweave, creating a living infrastructure that strengthens the mangrove's ecological functions and supports surrounding biodiversity. Translating the growth mechanism into computational design, the simulated biome can emulate the mangrove's adaptive stability, oxygen regulation, and modular expansion. It indicates a stronger intertwining of biological logic and computational process as the basis of architecture programming.

Assembling the symbiotic architecture of the *Verdantia*, *Aridstepia*, and *Aqualandis*

This section elaborates on how the mapped plant systems across the three biomes shaped the architecture and informed the integration of *H. botanicus* as a catalyst, denoting how symbiotic architectural strategies can align with the dynamics of each biome. The integration of both elements serves as a coexistence and co-evolution strategy in each biome, through the spatial mechanism and spatial zone arrangement.

The first symbiotic relation in the tropic biome, the *Verdantia*, exhibits the multiplication mechanism of the strangler fig-inspired vertical living systems that imitate the canopy stratification, optimising light capture and nutrient distribution while providing habitats for diverse species (Figure 13). In *Verdantia*, the spatial arrangement creates spaces such as the Solar Funnel and Canopy Web, facilitating light distribution, nutrient exchange, and pollination gardens that encourage biodiversity. These spaces allow *H. botanicus* to interact with the canopy layers, contributing to pollination and nutrient cycling, and fostering a co-evolutionary relationship where biodiversity thrives alongside each other.

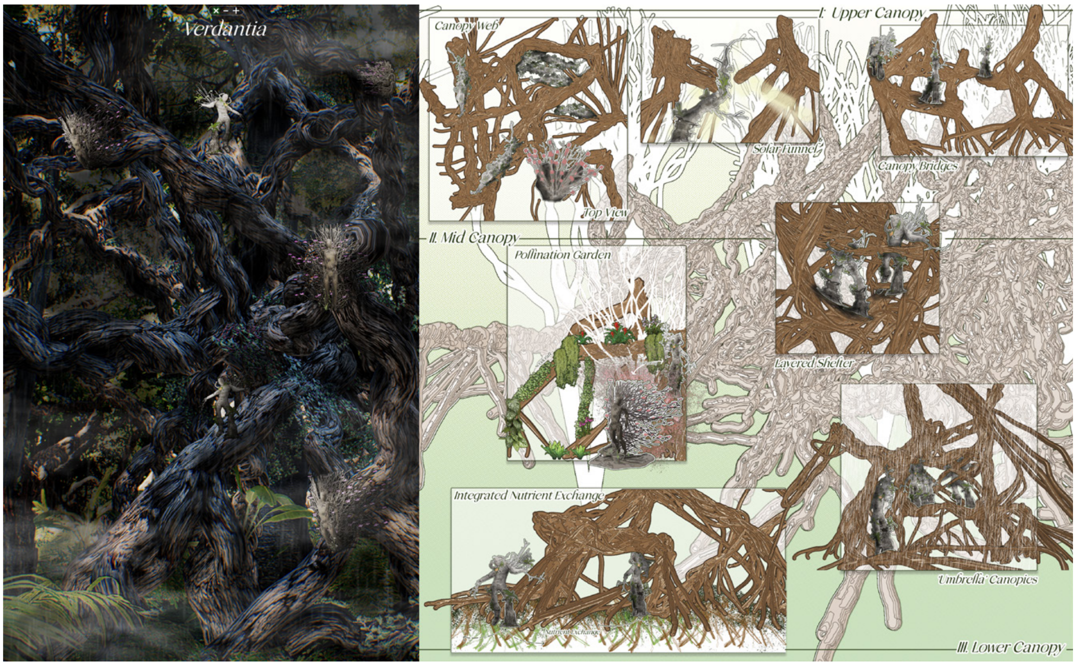

Figure 13. Verdantia as a canopy-based layered symbiotic architecture (Image by authors)

Furthermore, the vertical layered of *Verdantia* acts as spatial zoning to be differently occupied by the *H. botanicus*. The spaces created in the *Verdantia* are structured vertically depending on the possible biological process. For example, the upper canopy consists of a Solar Funnel and Canopy Web, as they relate to the direct sunlight that needs to be further distributed to the lower layer. The Solar Funnel maximises light absorption in shaded areas, ensuring that lower-layered plants beneath the canopy still receive sufficient light. On the same layer, the canopy web spreads a network of roots and branches across the treetop, capturing sunlight and distributing it to lower layers. The mid-layer canopy is utilised for the pollination garden where *H. botanicus* actively carries out pollination, supporting targeted reproduction and enhancing biodiversity within the ecosystem. Meanwhile, the lower canopy facilitates nutrient and water exchange, ensuring efficient distribution throughout the biome. It supports a range of species and strengthens the overall ecological balance.

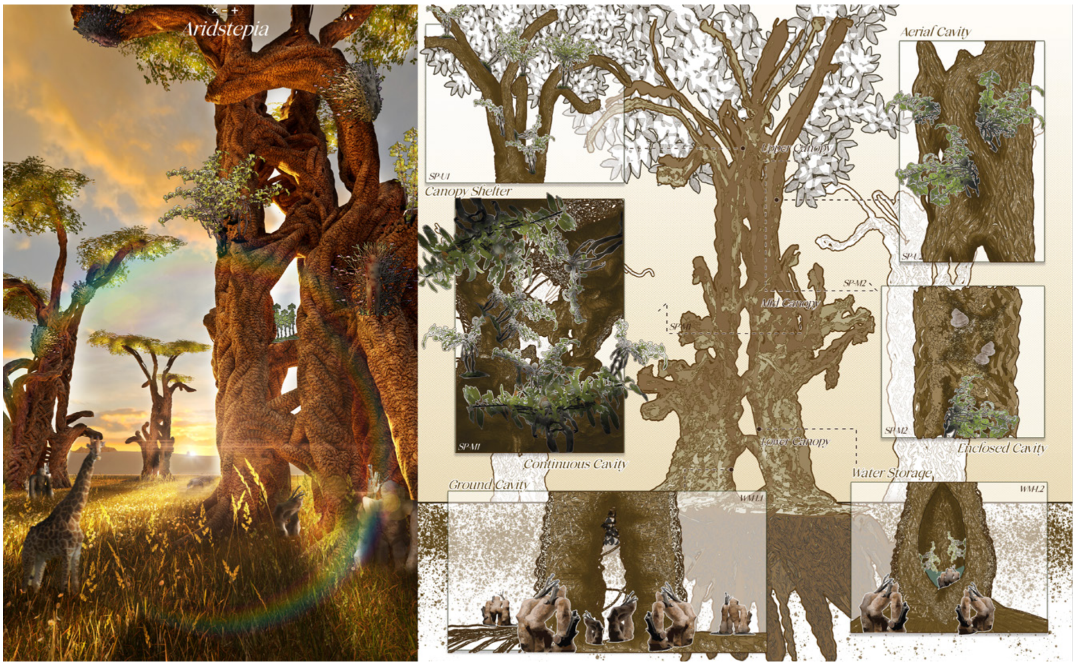

Figure 14. Aridstepia as the cavity-based symbiotic architecture (Image by authors)

Aridstepia's symbiotic design centres on the baobab tree, with architectural structures leveraging its capacity for water storage and habitat creation (Figure 14). The baobab's water-storing ability and self-healing mechanisms relate to the natural water management and the nurture of nutrient-rich microhabitats, essential for biodiversity and ecosystem resilience in arid environments. The cavities insinuate spaces that serve as ecological hubs, supporting microbial life, plant growth, and interaction with *H. botanicus*.

The cavities' positions play a vital role in enhancing biodiversity and creating interaction spaces for the *H. botanicus*. The upper-positioned cavities are related to the wide, open branches that allow birds and insects inhabitation. This area receives strong and direct sunlight, making it ideal for photosynthesis and pollination and enabling *H. botanicus* to place seeds here for fast and efficient growth. The mid-positioned cavities are shaded, thus enhancing biodiversity by creating spaces for the microhabitat species that thrive in cooler, damp conditions. *H. botanicus* uses these cavities for the seedcraft, fostering interactions between diverse plant types. Meanwhile, the lower-positioned canopy acts as a centre for ecosystem activity that supports nutrient-rich soil and biodiversity. These lower zone cavities are the most active ecologically, as they are large enough to house small animals and microbes that drive nutrient cycling, aside from collecting water, which creates ideal moist environments for seed germination and the growth of water-dependent plants.

Meanwhile, *Aqualandis*' architectural system focuses on the red mangrove's aerial root systems and tidal adaptability-informed dynamic structures, stabilising wetland ecosystems and facilitating nutrient transfer (Figure 15). These strategies allow *H. botanicus* to perform arboreal manipulation to interact with natural processes as regenerative forces, ensuring its active participation in ecology.

Here, the symbiotic architecture integrates the aerial root and the tidal fluctuations. Such an animated condition influences the intertidal spatial creation that adapts to changing water levels. Three spatial zones are identified based on their ecological role and symbiotic potentials—the elevated canopy, the in-between zone, and the intertidal zone. The elevated canopies optimise sunlight capture and support photosynthesis, and ample sunlight boosts mangrove growth, which is most frequented by *H. botanicus*. Through tree-shaping techniques, they enhance light capture to support photosynthesis and pollination.

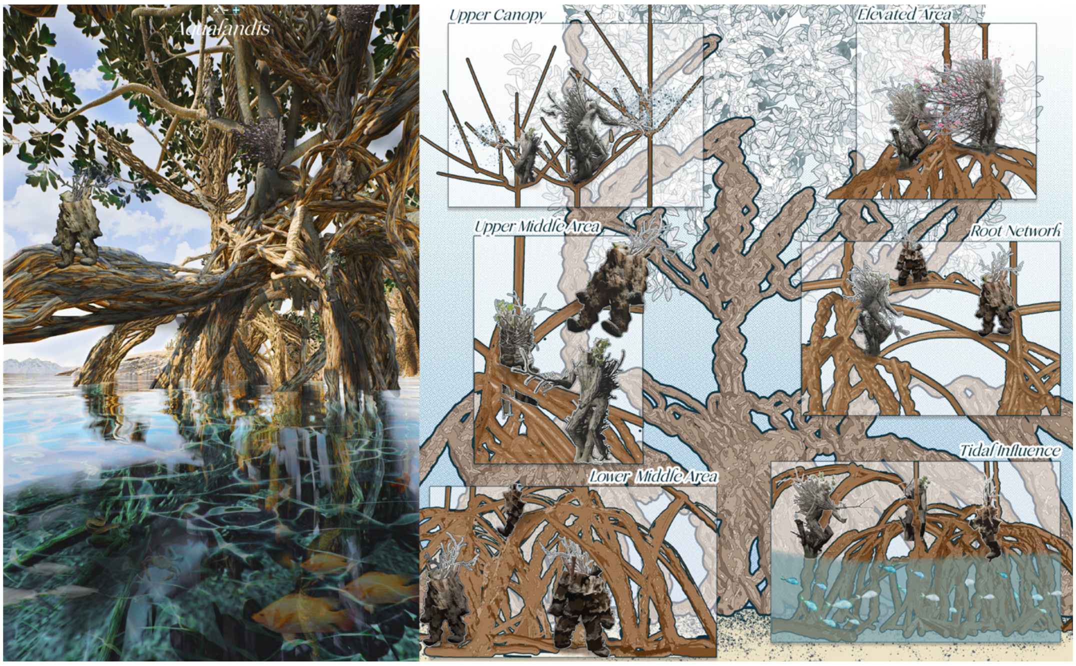

Figure 15. Aqualandis as a tidal-layered symbiotic architecture (Image by authors)

The in-between and submerged layers enhance nutrient exchange and provide habitats for both aquatic and terrestrial organisms. In the in-between zone, *H. botanicus* strengthens the mangrove's root network, maintaining nutrient exchange and communication between plants. This zone also supports epiphytes and other plant species that rely on the stability of the mangrove structure. Meanwhile, the intertidal root zone is always influenced by tides, with some parts submerged. In this zone, *H. botanicus* cultivates aquatic species and their biodiversity through seed dispersal. These lower two zones enable *H. botanicus* to maintain the mangrove ecosystem through activities like root stabilisation and nutrient cycling.

Conclusion

This design study proposes a speculative inquiry into the idea of symbiotic architecture as a way to reconnect human-nature, shifting from *connectedness with nature* towards *being* *as nature*. Drawing from such positions, this design study calls for a paradigm shift where humans act as active contributors to ecological balance, not just consumers who exploit nature. Expanding Kurokawa's (1977) idea of symbiotic architecture, this study shifts from conventional architectural thinking by positioning humans and their built environments as part of nature's symbiotic process.

In this study, *H. botanicus* is introduced as a conceptual human species that coexists and co-evolves with nature, initiating the era of Mothering Nature. The symbiosis between *H. botanicus* and the living world demonstrates a mutual coexistence and co-evolution as mechanisms, systems, and spaces that enhance ecological balance and foster meaningful reconnection between humans and nature. In this vision, symbiotic architecture is not only a sustainable but also a regenerative entity.

H. botanicus species as a symbiotic agent pushes the boundaries of architecture's static and exploitative nature. By exploring three different biome—tropical, savannah, and coastal wetland—and their particular plants, this study can identify the biological logic which allows the script-based computation to generate the design of six different *H. botanicus* species, the living world, and their interactions. Integrating information to generate design, such as mapping phylogenetic plant evolution and analysing the growth mechanism and environmental characteristics, has demonstrated how architecture can take natural cues. Tools such as Grasshopper and swarm intelligence algorithms are used to simulate plant growth and manipulation, enabling architecture to reflect the adaptive logic of natural systems.

Verdantia, *Aridstepia*, and *Aqualandis* are not just biomes; they exhibit the mutual symbiotic relation of human nature by allowing the *H. botanicus* to coexist and co-evolve through the vertical layers, cavities, and ever-changing tidal conditions. Together, they perform the growth, creation of hollow spaces, and networking, exhibited by the multiplication, reductive, or amplification computational processes, while ensuring the continuance of natural processes through the seedcraft. These designs show how architecture as a symbiont can be an active participant in natural processes.

This study highlights the transformative potential of symbiotic architecture. The symbiotic architecture of the *H. botanicus* species and the living world provides a framework for a co-creative future architecture that evolves alongside nature, fostering a resilient human-nature relationship. By framing architecture as an integral part of nature's systems, this study offers a foundation for new design methodologies rooted in mutual care, adaptation, and ecological integration, opening new directions for an innovative and sustainable living architecture.

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