2023 JACQUES ROUGERIE FOUNDATION AWARDS

Award's category : Architecture et Innovation related to Climate and Rising Water

Project's Name	Living Green Community
Description	Adaptive and Self-sufficient Community, Harvesting water, Negetive CO2 , Green farming, Bio-mimicry

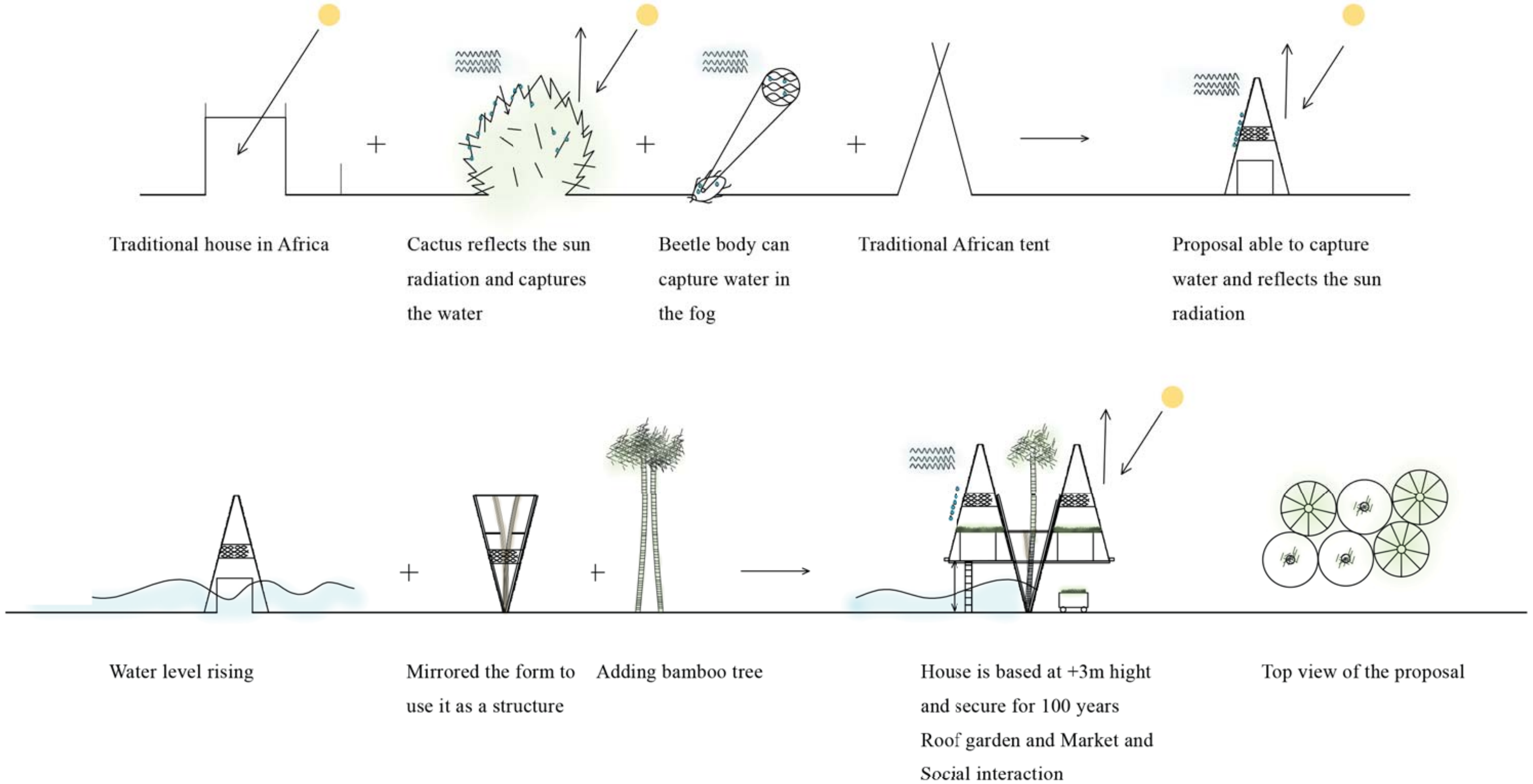
FONDATION JACQUES ROUGERIE GÉNÉRATION ESPACE MER ACADÉMIE DES BEAUX-ARTS

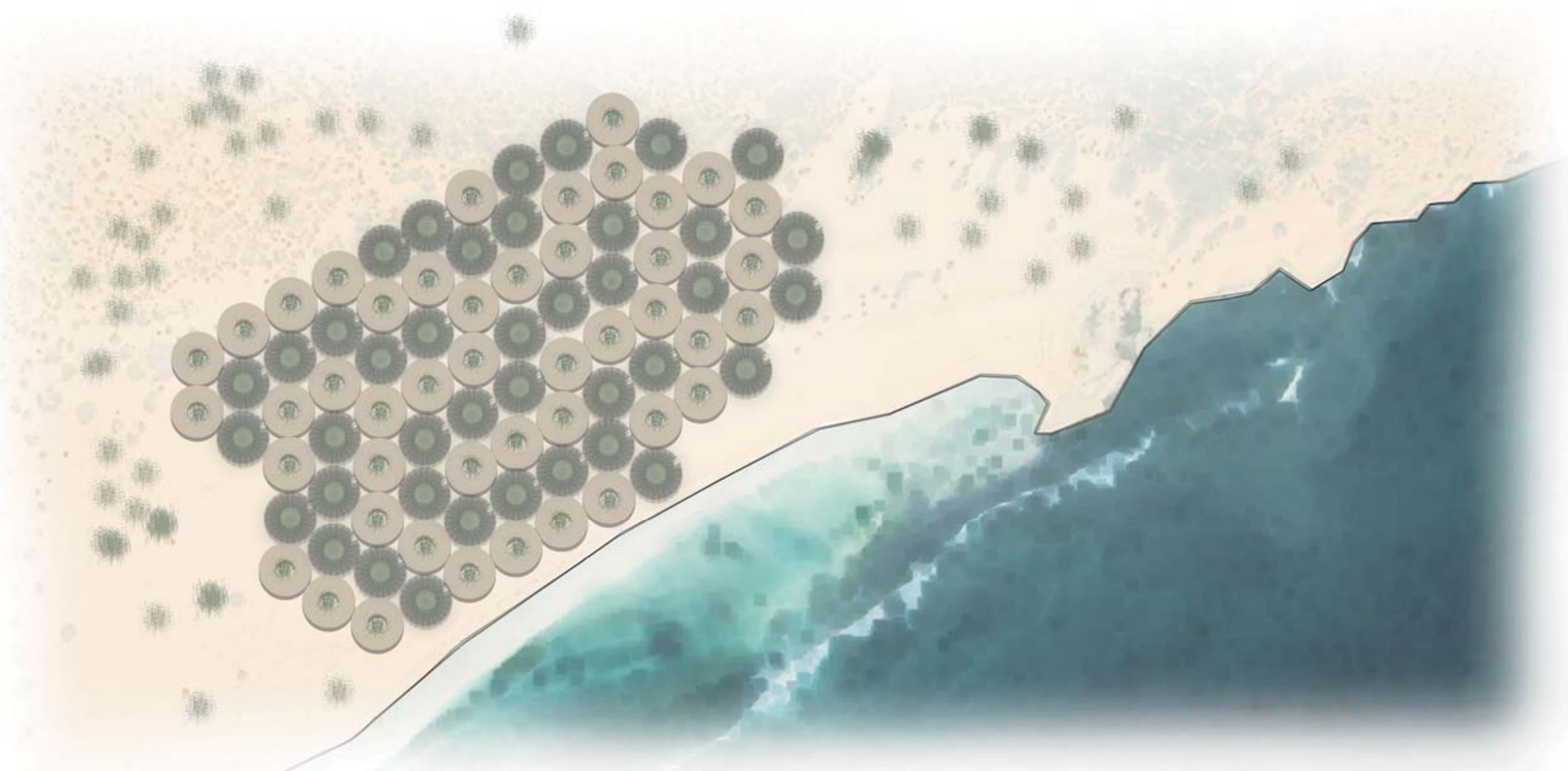
In East Africa, severe and prolonged drought has resulted in poor crop and livestock productivity for the fifth consecutive time in bi-modal parts of Somalia, Kenya, and southern Ethiopia.
Somalia is currently experiencing a drought, and the rising sea levels Up to 60 cm by 2100, pose a threat to the livelihoods of coastal communities, especially in southern Somalia. In order to tackle these challenges, the population needs to adapt and sometimes revert to historical strategies. For example, they construct platforms for bush farming and raise small livestock. Additionally, a floating school has been established to ensure that children can continue their education despite isolation caused by the unusable infrastructure.

The site is located in a coastel city named Gendershe.Although this concept may initially seem independent, its necessity within the context is crucial to its value. Therefore, it can be readily implemented to meet the need for safe and prosperous living on flooded land or along the coast.

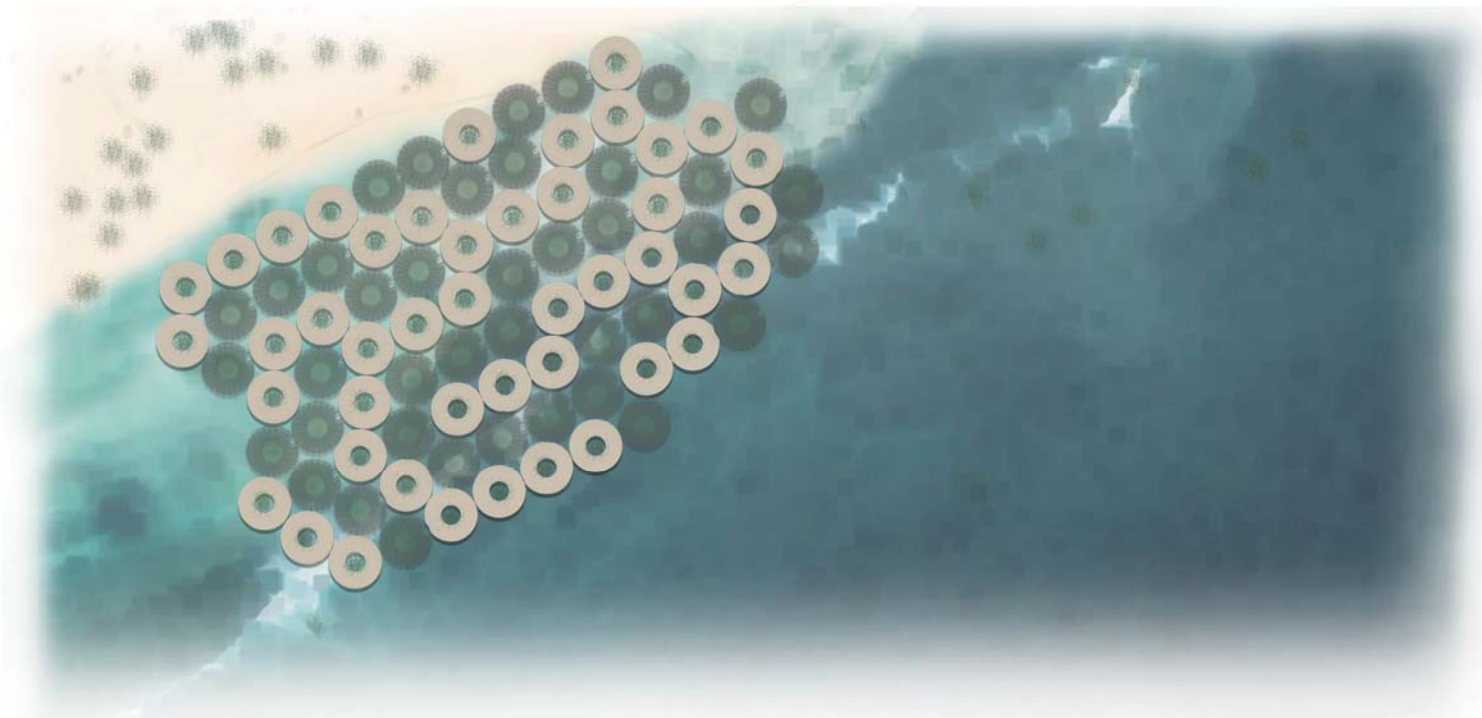
Concept

was originally designed to fulfill the needs of a small family by Somali standards. However, it can be scaled up to create a "community island" that is connected to the "community hub," a fixed island containing public resources and functions. This community hub is especially vital in the early stages of development. The design is self-sufficient, but scaling up is highly recommended as it provides numerous opportunities to improve people's living conditions. The concept includes four stages of colony development based on communal services and building development.





Current Gendershe, Somalia



2100 Gendershe, Somalia

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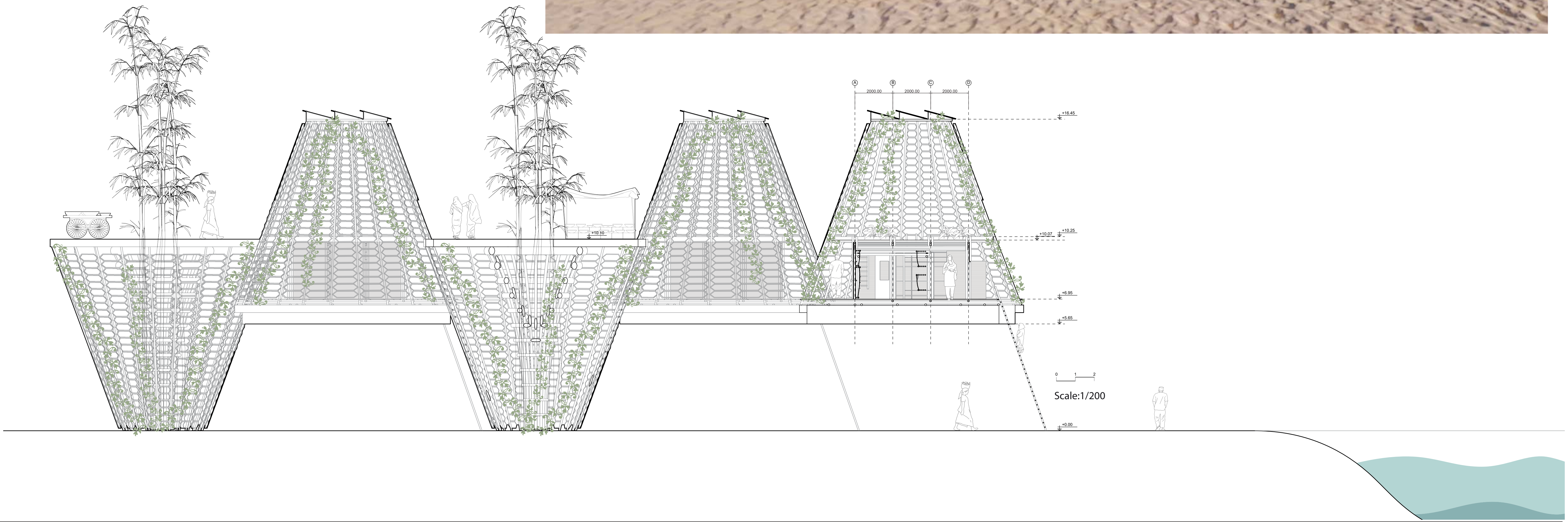
Development plan:

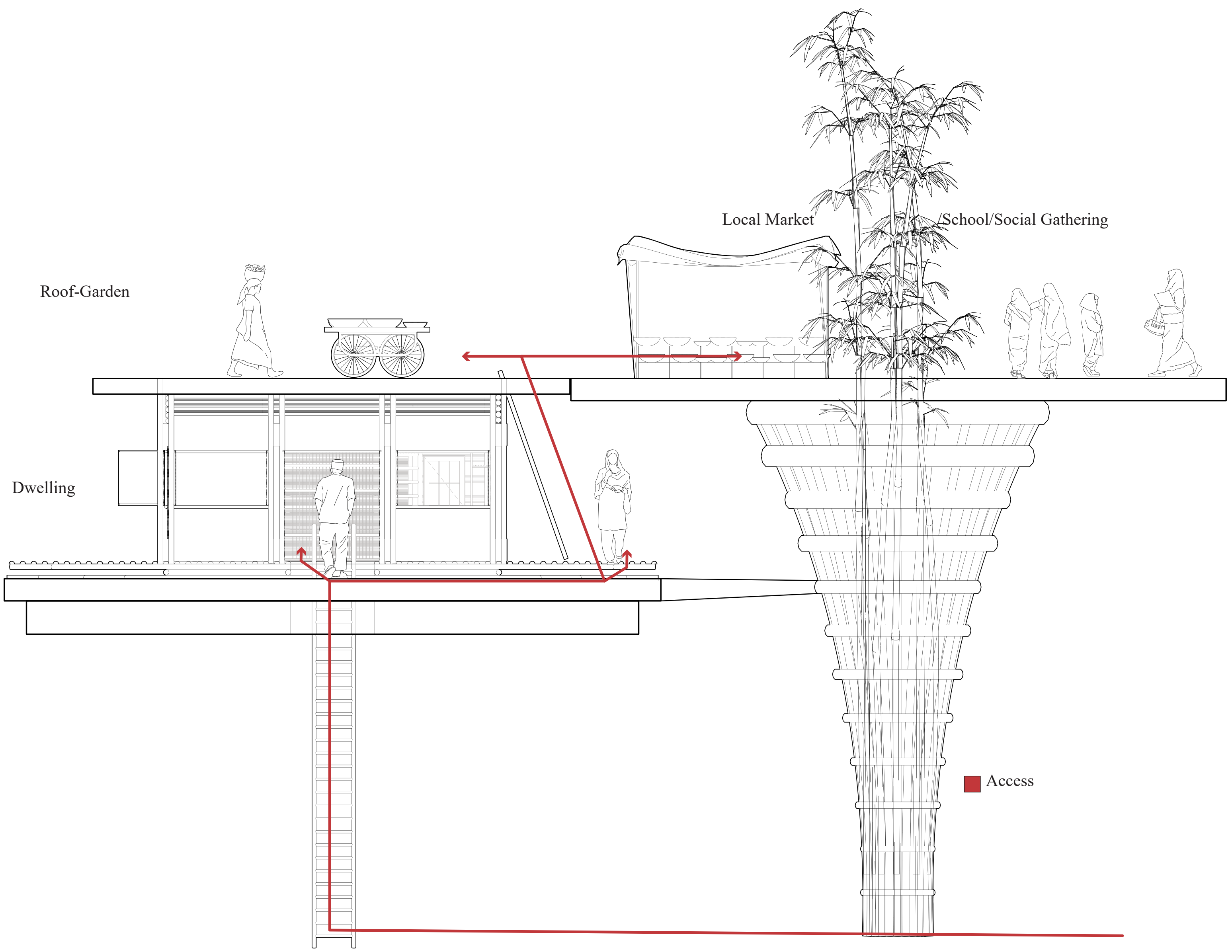
1)The initial phase involves constructing the community hub and the first islands. During this stage, the community hub serves as a gathering place, construction site, and storage facility.

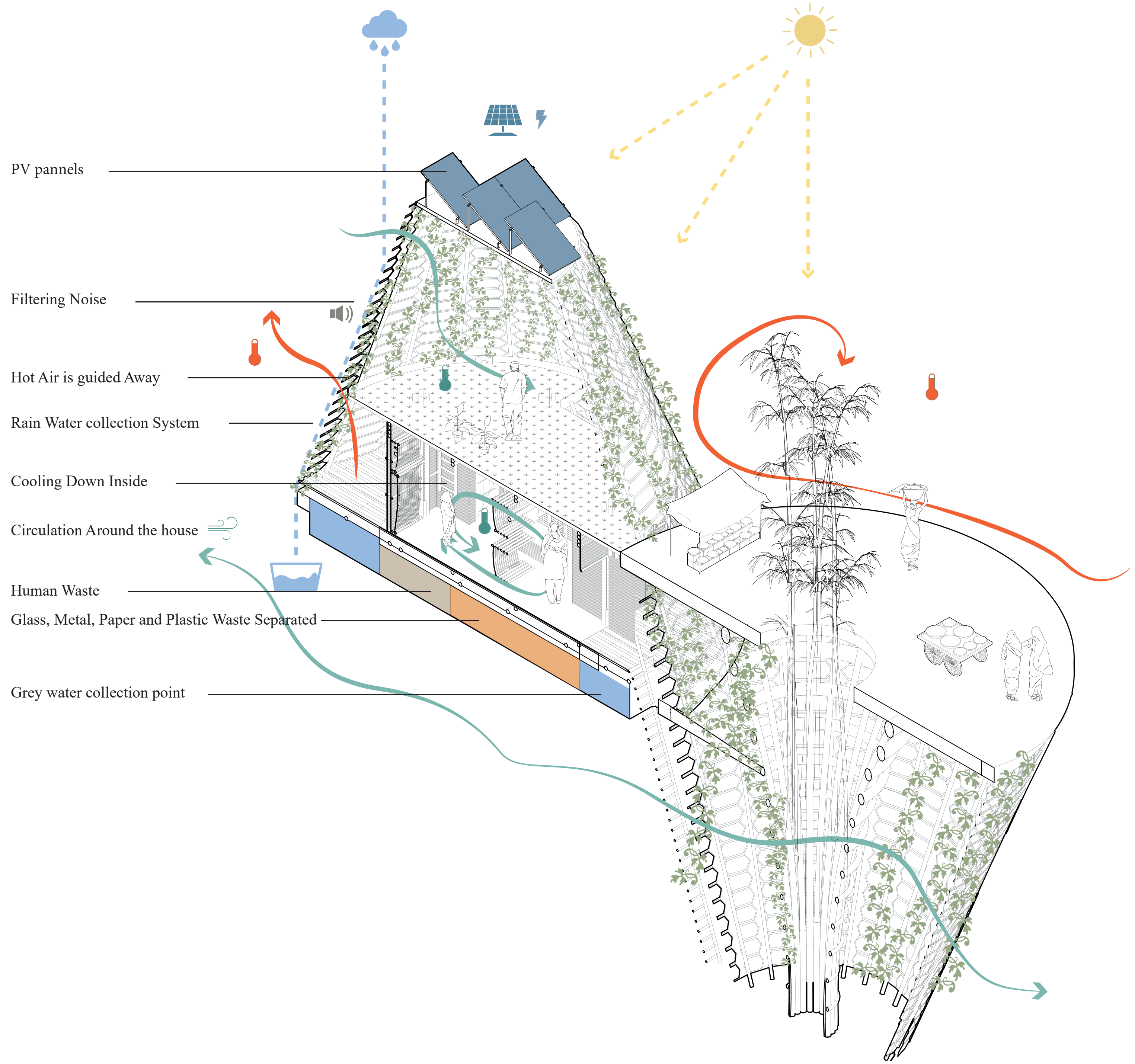
2)It also provides a small plot of farmland. As the community's population grows, the island network expands accordingly. Construction of smaller platforms for on-water farming diversifies the food supply and maintains the community's flexibility as it expands. Establishing education and digital connectivity (e.g., trade, securing finance, and accessing online health advice) are crucial for social and material development.

3)As the community develops through scaling, finance, and education, a surplus of food is generated, enabling non-agricultural work. Small commercial and production cooperatives are formed to meet service demands, such as entertainment, restaurants, waste collection, and furniture. Dwellings can initially accommodate small shops and later adapt to house production cooperatives.

4)As inter-communal trade becomes more affordable compared to regional standards, electrification accelerates, public services become available, and dwellings improve. Eventually, poverty becomes a thing of the past.







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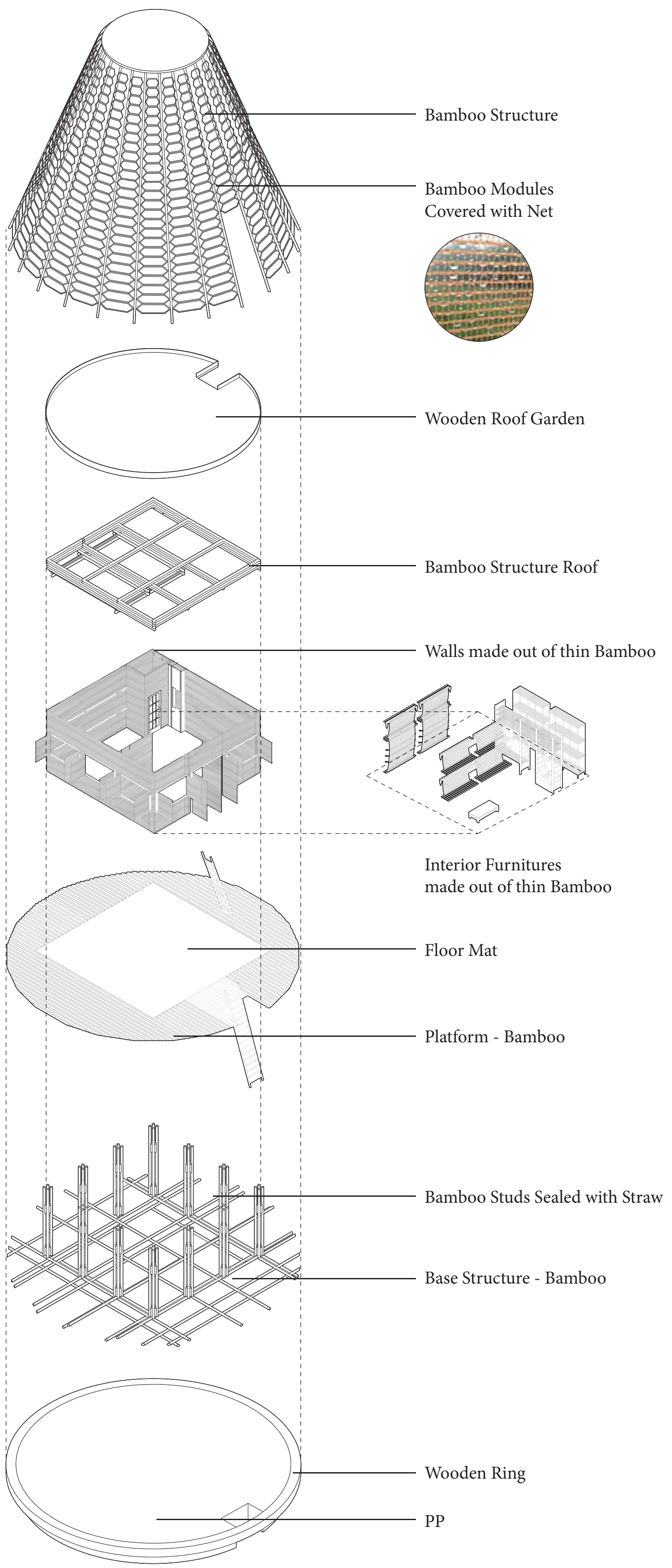

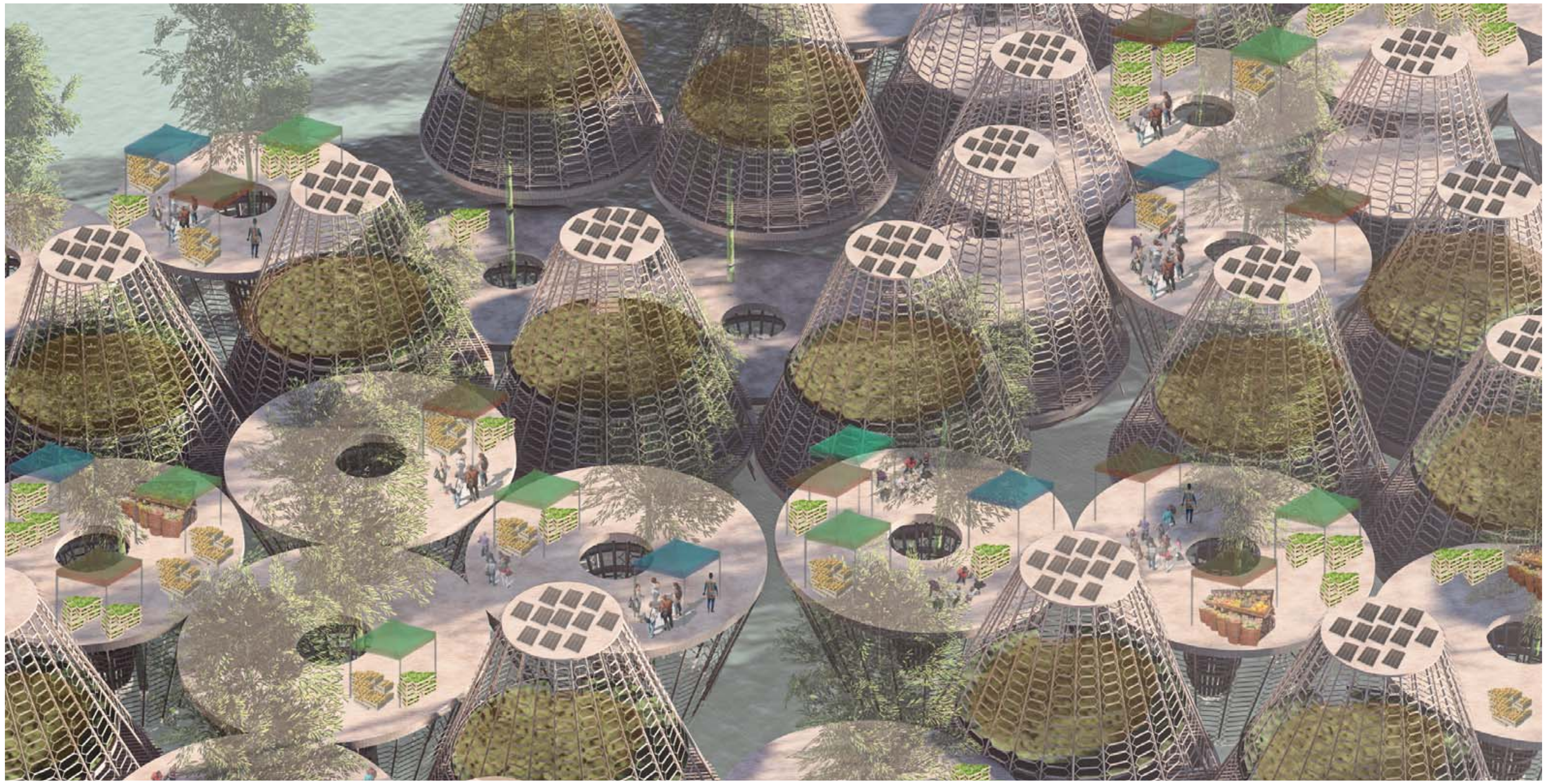

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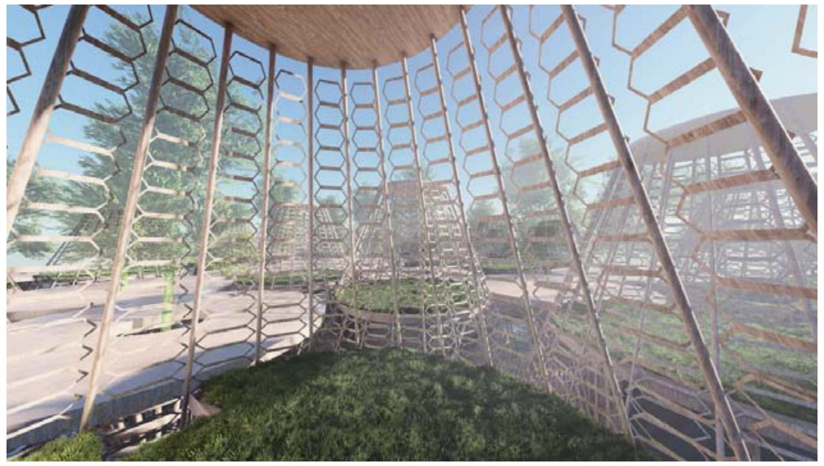
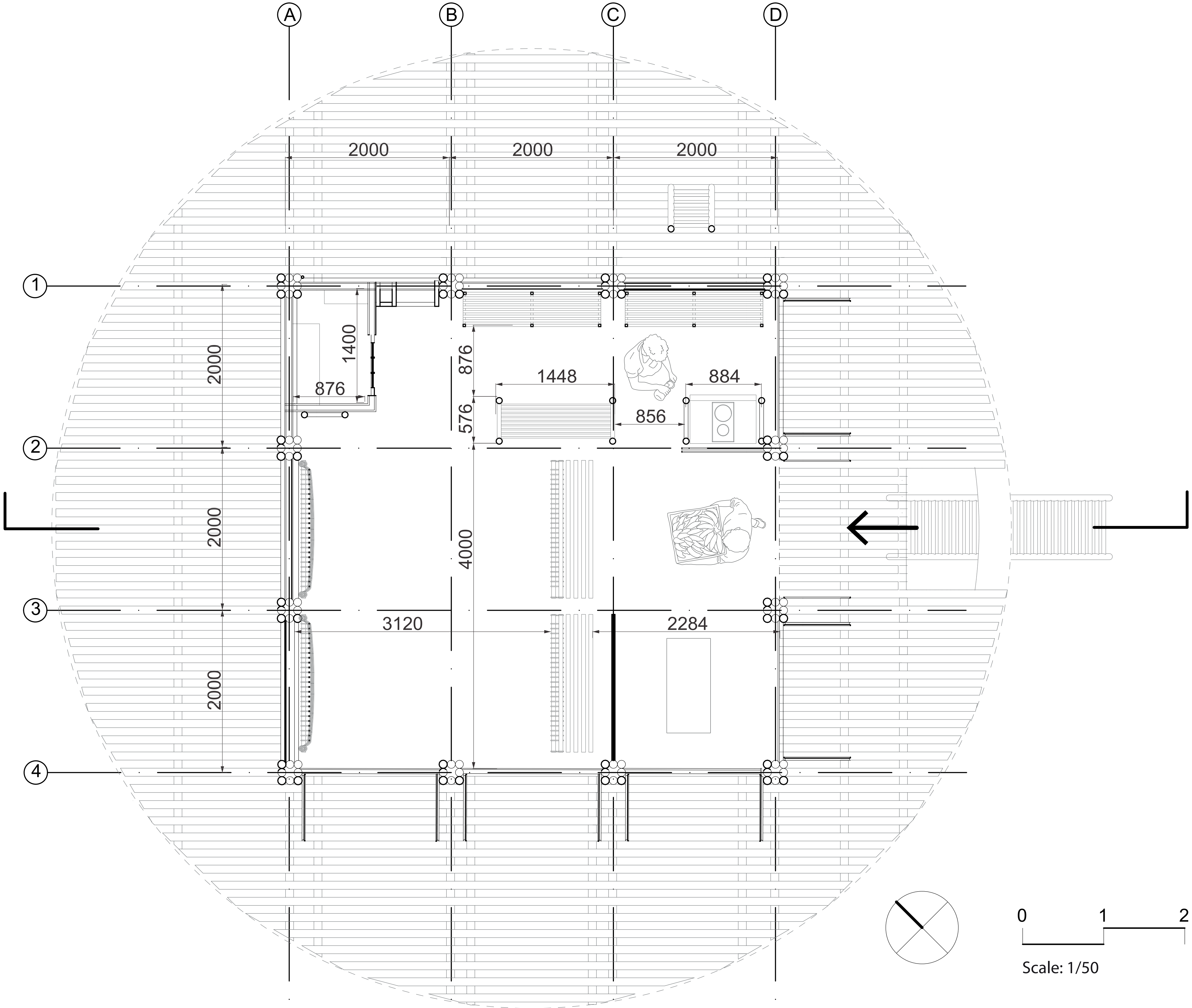
As the community scales, its high level of flexibility diminishes. However, flexibility also loses its purpose as the community establishes itself and finds satisfaction in its new life. To adapt to changing needs, inhabitants can convert specific islands to accommodate facilities and services, as well as create secondary anchors to enhance scalability and organize functions that may have a negative impact, such as waste processing.

The aim of the project is to design a floating off-grid community in Somalia using bamboo. The community will capture water from the fog during the night, drawing inspiration from the pattern on a beetle's body. During the day, the houses will be shaded from the sun, taking inspiration from the pattern of a cactus, to enhance indoor comfort. The community will generate electricity using solar panels and have a waste storage system at the bottom of the structures, while the roofs will be utilized for farming so that every household can have its own farm and grow food and vegetables.

The design of the houses and the façade prototype will be based on another prototype, which is mirrored and includes an internal space for a market. In the core of this prototype, bamboo trees will be planted to provide shade and increase the number of trees by expanding these modules into a community.





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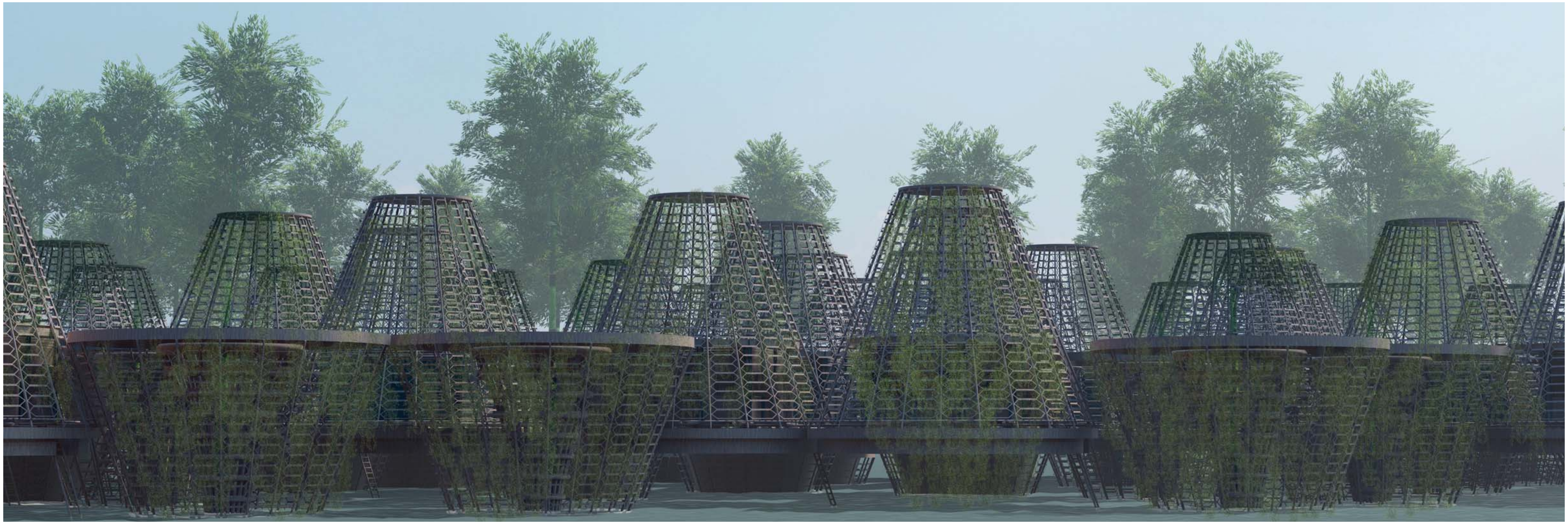

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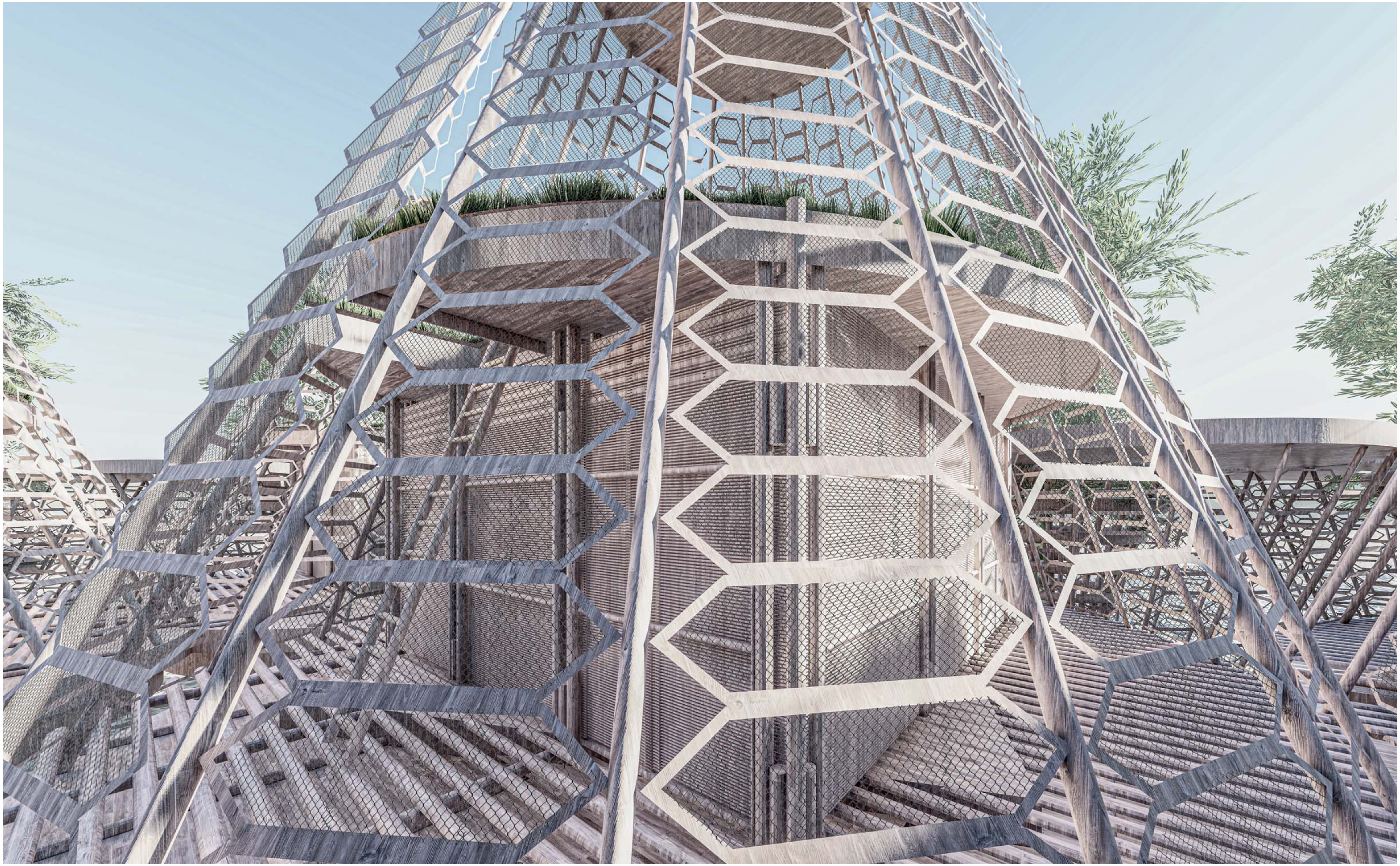

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Reference:

1-Superhydrophilic-Superhydrophobic Water Harvester Inspired by Wetting Property of Cactus Stem,Wang, 2021
https://pubs.acs.org/doi/full/10.1021/acssuschemeng.9b01113

2-Climate risk profile Somalia:
https://weatheringrisk.org/sites/default/files/document/220214_SomaliaClimateRiskProfile-05.pdf

3-Warka Tower
https://inhabitat.com/warka-water-tower-that-pulls-drinking-water-from-thin-air-wins-world-design-impact-prize/

Innovation Details

The Warka Tower is constructed using a bamboo frame that provides support for a mesh polyester material. It is a cost-effective and easily constructible solution. The tower leverages atmospheric water vapor, be it from rain, fog, or dew, which condenses against the cold surface of the mesh. This condensation process forms droplets of liquid water that gradually trickle down into a reservoir located at the tower's bottom. This mechanism is reminiscent of how a darkling beetle collects water from fog. To prevent the collected water from evaporating, a fabric canopy is employed to shade the lower sections of the tower.

Atmospheric water vapor condenses against the cold surface of the mesh on the Warka Tower, resulting in the formation of droplets of liquid water. These droplets then trickle down into a reservoir.

Biological Model

Darkling beetles inhabit the Namib Desert, known as one of the driest environments globally. They obtain the necessary water from dew and ocean fog present in the air. These beetles possess specialized wing scales with tips and bumps that aid in water collection. As moisture in the air condenses, it forms water droplets on the tips. Subsequently, the droplets flow from the bumps into the beetle's mouth, enabling it to acquire water for survival.

4- https://www.youtube.com/watch?v=xv44VPqf1QU&t=252s

Sea Level Rise:

Sea levels in Somalia are projected to rise with high certainty under both future emission scenarios. The median climate models project a rise of 12 cm by 2030, 20 cm by 2050, and 36 cm by 2080 under RCP2.6 compared to the year 2000. Under RCP6.0, the projections show a rise of 11 cm by 2030, 21 cm by 2050, and 42 cm by 2080.

Water Availability:

Projections of water availability in Somalia are highly uncertain under both GHG emissions scenarios. Without considering population growth, models suggest a slight increase aligned with future precipitation projections. However, when accounting for projected population growth, per capita water availability is expected to halve by 2080 under both emission scenarios. Nevertheless, uncertainty surrounding current and projected water volumes is extremely high, suggesting the need to anticipate increasing uncertainty in future water availability.

Agricultural Yields:

Projections for crop yields in Somalia exhibit high uncertainties. Cowpeas show a positive trend in yields, while rice yields are projected to improve with considerable uncertainty regarding the extent of the increase. Future projections for millet, sorghum, and maize demonstrate high inter-annual variability, with no clear trend discernible in yields.

Infrastructure:

While projections indicate a relatively small future exposure of major roads and urban areas to flooding, reliable estimations regarding the impacts of river floods cannot be made. Therefore, this data should not be used for long-term planning related to river floods.

GDP:

The exposure of Somalia's GDP to heatwaves is expected to significantly increase under both GHG emissions scenarios. Median model projections for RCP2.6 suggest an increase from 8.3% in 2000 to 17.1% in 2030, 19.4% in 2050, and 22.7% in 2080. Under RCP6.0, exposure is projected to reach 19.0% by 2030 and 23.7% by 2050 and 2080.

Ecosystems:

Model projections show high agreement regarding changes in species richness in northern and southern Somalia, but low agreement for central Somalia. The models project an increase in species richness in the mountainous regions of northern Somalia, while most other parts of the country are expected to experience a decrease in the number of species. Projections related to changes in tree cover show very low model agreement, indicating high uncertainty. As a result, no reliable information can be derived from these projections.

Biomimicry:

Water-Capturing Cactus:

The cactus is one of the species studied for its ability to collect water from fog [1]. It possesses small barbs on conical spines that assist in intercepting water droplets from desert fog. Water droplets accumulate on the barbs and then move onto a spine with a curvature gradient, resulting in a Laplace pressure gradient. This gradient facilitates the movement of the droplet toward the base of the spine, where it can be collected by the cactus. Several attempts have been made to develop water collection systems inspired by the cactus.

How Cactus Works:

Contrary to popular belief, the spines on cacti do not primarily serve as protection against predators. Their main purpose is to retain water and shield the plant from solar radiation. In fact, in milder climates, many cacti species are spineless. The spines disrupt airflow around the plant, reducing evaporation, and they also help draw water from the ambient humidity. Additionally, the cactus can adjust the orientation of its spines to protect itself from intense sunlight.

With this clarification, let's delve into the technology developed by Julia R. Greer, the director of the Kavli Nanoscience Institute. She has designed a membrane inspired by the structure of cactus spines, capable of evaporating and purifying water during the day and capturing it at night. The biomimetic design, utilizing microstructures resembling Christmas trees, enables the collection of microscopic droplets of water that flow downward and merge into larger ones. The base material is a flexible and non-toxic hydrogel composite called PVA/PPy.

Dr. Greer, along with other researchers, refined the density of these structures using computer modeling to determine the optimal size, shape, and distribution of the nanoforests. In nighttime tests conducted with samples of the material ranging from 55 to 125 square centimeters, the technology successfully captured up to 35 mm of water from ambient humidity.

Water from Solar Vapor:

However, this innovative technology not only captures atmospheric water but also integrates another functionality. Solar evaporation is another method of obtaining fresh water, and Dr. Greer has incorporated this into the same device. The hydrogel is printed on a thin membrane that is covered with a transparent material.

Throughout the day, the membrane absorbs solar heat, causing the water to evaporate. The evaporated water then condenses on the top cover. At night, the transparent cover is removed, exposing the hydrogel. This system allows for the collection of up to 125 mm of water from solar vapor.

The results of this research have been published in Nature Communications under the title "All-day Fresh Water Harvesting by Microstructured Hydrogel Membranes."

Purifying Water and Cleaning Up Oil Spills:

Inspiration from cactus structures has led to other innovative technologies. For instance, Chinese researchers designed thin copper needles with a conical shape, inspired by cactus spines. These needles are capable of separating oil droplets from water. Similar to Dr. Greer's work, this bioinspired design was also published in Nature Communications.

These technologies derived from cactus structures serve as excellent examples of biomimetics. This field has given rise to numerous inventions, ranging from bullet trains mimicking the kingfisher's beak to desalination systems inspired by root behavior and ultrahard cement resembling crustacean and beetle exoskeletons.

Strategy:

The strategy employed by Darkling beetles and certain body positions helps condense water from humid air. Researchers are studying these beetles and developing synthetic surfaces inspired by their bodies to understand the role played by structure, chemistry, and behavior in capturing water from the air.

Micro-sized grooves or bumps on the beetle's forewings aid in condensing and directing water toward the beetle's mouth. The combination of hydrophilic (water-attracting) and hydrophobic (water-repelling) areas on these structures enhances efficiency in harvesting fog and dew. Fog-basking behavior, where the beetle faces into the foggy wind and raises its rear end, is believed to be just as crucial as body surface structure in successfully harvesting water from the air.