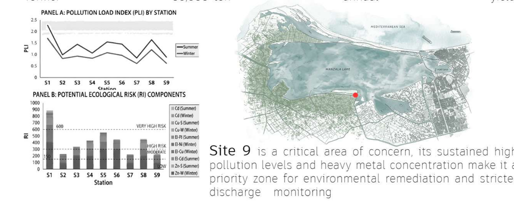
AQUAPONIC FIELDS EL-MANZALA LAKE, PORTSAID

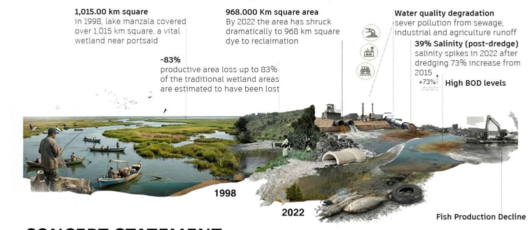
A living research center where saline agriculture treats water

PROBLEM DEFINITION:

Lake Manzala in Port Said, Egypt, has shrunk dramatically from over 1,015 km^2 in 1998 to 968 km^2 by 2022 due to erosion, land reclamation, and encroachments, losing up to 83% of productive area in some estimates. Water quality is severely degraded by sewage, industrial effluents, and agricultural runoff, with salinity spiking to 39‰ post-dredging (up 73% since 2015) and persistent high BOD levels hindering fish production, which has plummeted despite the lake's former 50,000-ton annual yield.



Site 9 is a critical area of concern, its sustained high pollution levels and heavy metal concentration make it a priority zone for environmental remediation and stricter discharge monitoring



CONCEPT STATEMENT

An integrated aquaponic–wetland system at Lake Manzala treats lake water through sedimentation and filtration, achieving 70–99% BOD/ammonia reduction, before circulating it through Salicornia beds producing ~1.85 kg/m^2/year of fresh biomass. Treated water returns to the lake through reconstructed wetlands, while harvested Salicornia serves as livestock fodder replacing berseem, potentially freeing irrigated land for wheat cultivation; nationally, shifting one-third of berseem area could yield ~2 million tons of wheat.

Project Goals

- Restore local water quality
- Boost lake ecology
- Address food security

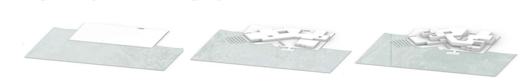
AQUAPONIC SYSTEM

Aquaponics is a closed-loop system that combines fish farming and soilless plant cultivation, where fish waste provides natural nutrients for plant growth. In return, plants filter and purify the water, which is then recirculated back to the fish, creating a sustainable ecosystem

SALICRONIA PLANT (SEA ASPARAGUS)

Salicornia removes 60–80% of heavy metals (Cd, Pb, Ni, Zn) common in Lake Manzala while improving water quality and fish habitats through wetland-based treatment. As a fodder crop, it produces 80–100 tons/ha of biomass on saline land, replacing berseem and potentially freeing one-third of its cultivated area for the production of ~2 million tons of wheat annually)

FORM GENERATION:



PHASE 1: Site grid is generated and aligned toward the south to maximize sunlight for salicornia growth

PHASE 2: Building masses are oriented and pushed outward along key axes, opening toward the southern exposure

PHASE 3: Building form based on zoning of public and private zones and floor plan levels

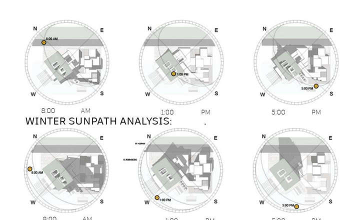
PHASE 4: Program volumes are stacked and stepped to follow the curved slope and maintain solar access

PHASE 5: A curved envelope is introduced, shaping wind flow and optimizing southern light for aquaponic planting

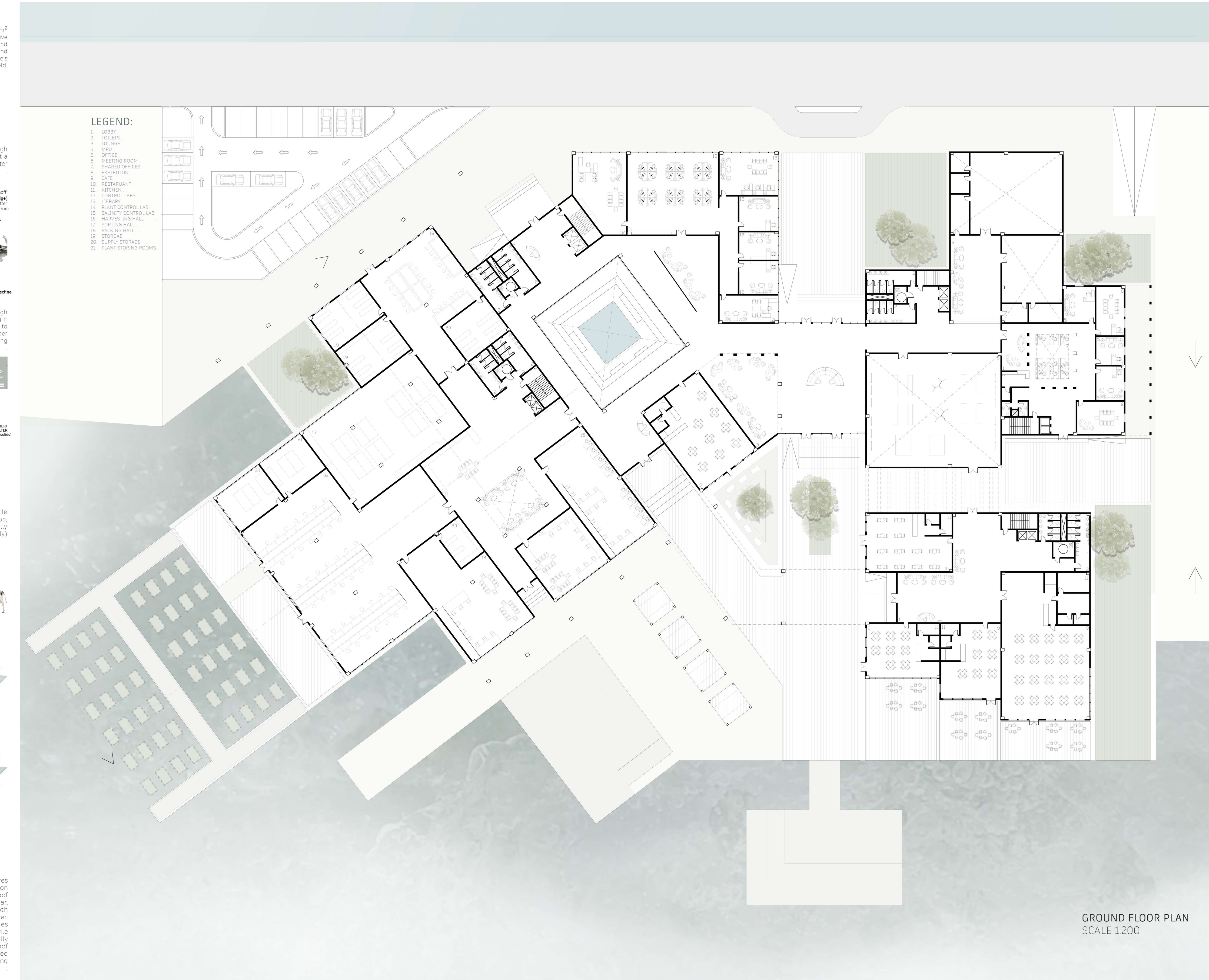
SOLAR ANALYSIS:

SUMMER SUNPATH ANALYSIS:

WINTER SUNPATH ANALYSIS:



The design ensures maximum sun exposure on the green Salicornia roof beds throughout the year, optimizing growth in both summer and winter. Summer sun provides strong, direct light, while winter sun angles are fully captured by the roof orientation and stepped massing, minimizing shadows

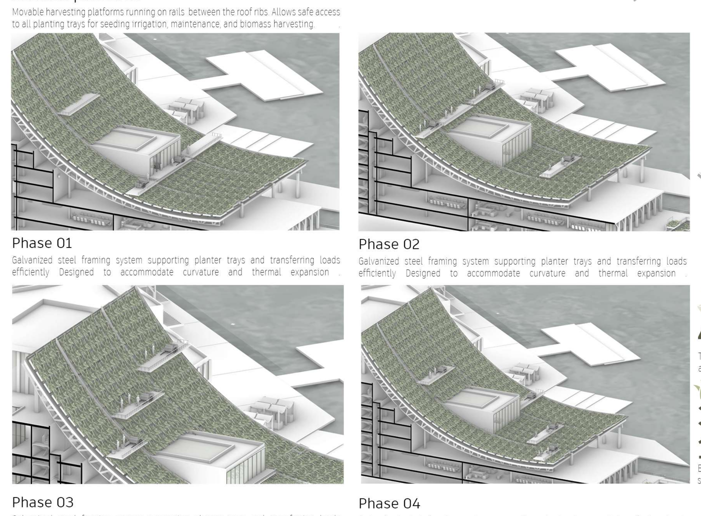


GROUND FLOOR PLAN
SCALE 1:200

Harvesting system

Movable platfroms

Movable harvesting platforms running on rails between the roof ribs. Allows safe access to all planting trays for seeding irrigation, maintenance, and biomass harvesting.



Phase 01
Galvanized steel framing system supporting planter trays and transferring loads efficiently Designed to accommodate curvature and thermal expansion

Phase 02
Galvanized steel framing system supporting planter trays and transferring loads efficiently Designed to accommodate curvature and thermal expansion

Phase 03
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Phase 04
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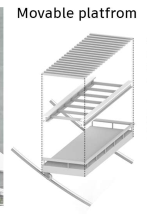
Movable platfrom



Adjustable Rails
Galvanized steel rails Corrosion-resistant components Adaptable to roof curvature

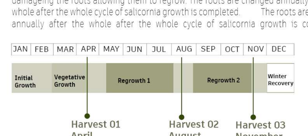
Platform Structure
Lightweight galvanized steel frame Timber walking surface Integrated safety railing

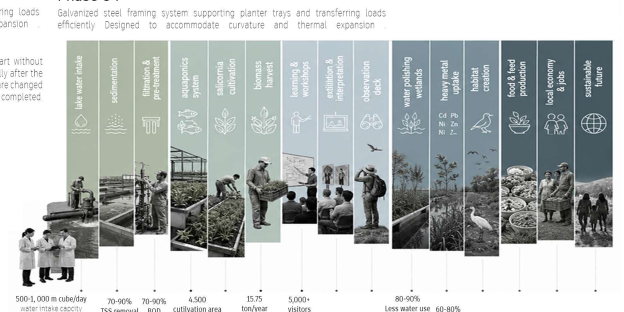
Cultivation Area
4,500 meter square
Total roof area dedicated to Salicornia cultivation and experimental agricultural research.

Biomass production
3.5 Kg/m^2/year
15 Ton/year
Estimated annual Salicornia biomass production under Lake Manzala saline cultivation conditions

Annual Timeline (Three Harvest Window)

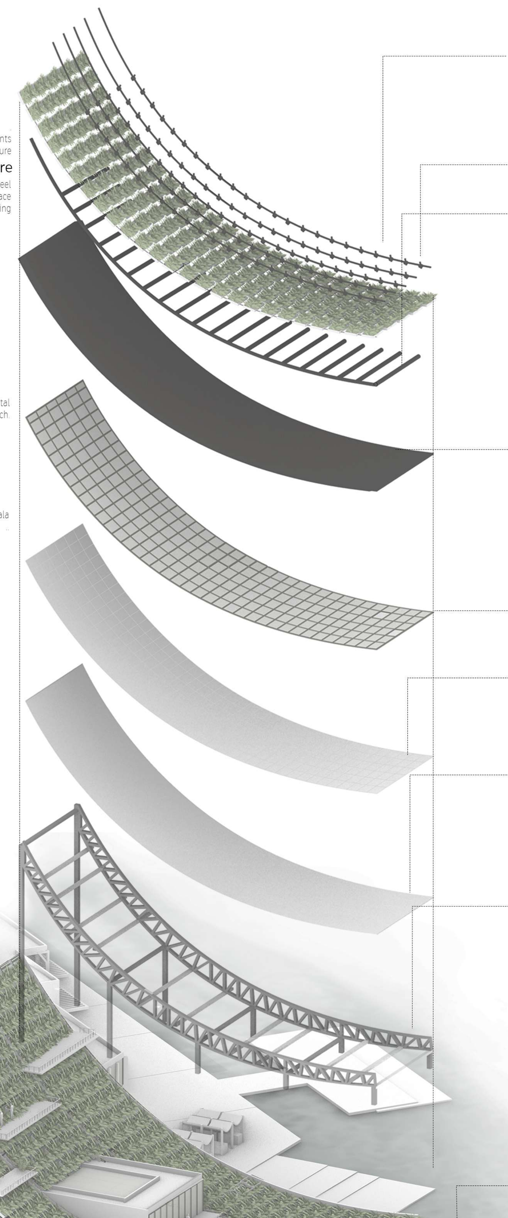
Salicornia plant is harvested 3 times per year, trimming only its upper part without damageing the roots allowing them to regrow. The roots are changed annually after the whole after the whole cycle of salicornia growth is completed. The roots are changed annually after the whole after the whole cycle of salicornia growth is completed.





Salicornia plant uses

Salicornia is a versatile plant with multiple practical applications across food, environmental, and industrial sectors. It is commonly used as an edible crop, valued for its salty flavor and **high nutritional content**, making it suitable for fresh consumption, pickling, or as a natural salt alternative. In environmental systems, salicornia plays a key role in **water purification** by absorbing excess salts, nutrients, and heavy metals, supporting wetland filtration processes. It is also used in sustainable agriculture as it can grow in saline soils where conventional crops cannot, reducing **pressure on freshwater resources.** Additionally, salicornia has potential in biofuel production due to its **oil-rich seeds**, and it contributes to ecological stability by **improving soil conditions** and supporting biodiversity in coastal and wetland environments.



Agricultural Layer
Final productive surface with crops integrated into the architectural form
This layer transforms the roof into a functional landscape, supporting saline-tolerant crops such as salicornia. It contributes to food production, microclimate regulation, and visual identity, merging ecological performance with architectural expression.

Irrigation & Growth System
Linear distribution lines ensure controlled water flow and uniform crop growth across the sloped geometry.

Drainage Layer
Allows controlled water flow along the curved surface, preventing accumulation
This layer regulates excess irrigation and rainwater, directing it efficiently along the slope. It reduces hydrostatic pressure on the membrane and helps maintain optimal moisture levels for plant growth while preventing waterlogging or structural stress

Water Management System
- Prevents water accumulation that could overload the structure
- Channels excess water toward collection points or reuse systems
- Maintains balanced moisture levels for plant health
- Reduces pressure on the waterproofing membrane
- Can integrate slope direction logic of the architectural form

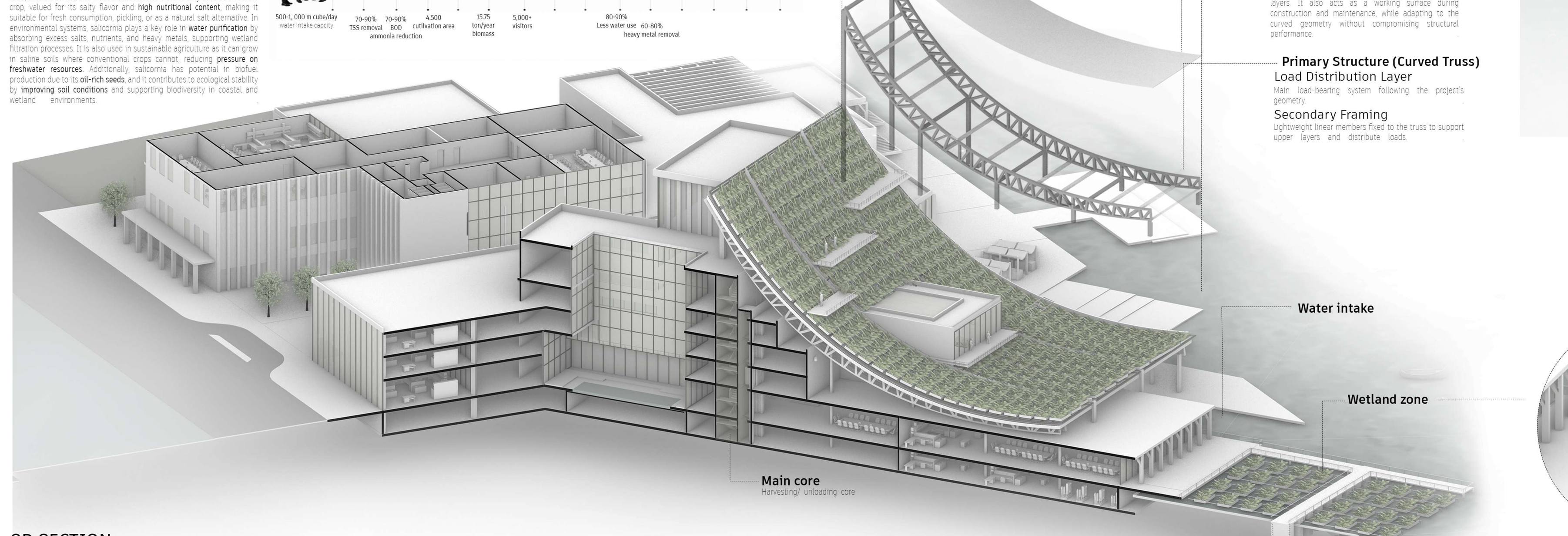
Growing Medium
Lightweight Engineered Substrate: Specially formulated, low-density soil matrix optimized for deep root development while minimizing structural weight.
Nutrient & Aeration Balance: Provides the essential macro-nutrients, aeration, and moisture-retention capabilities required to sustain long-term plant health.
Designed for Saline Conditions: Chemically tailored to withstand and buffer salt accumulation, ensuring a viable habitat for coastal or saline-tolerant agricultural crops like salicornia

Protection Layer
: Acts as a heavy duty cushioning mat that protects the waterproofing from puncture during construction and heavy maintenance

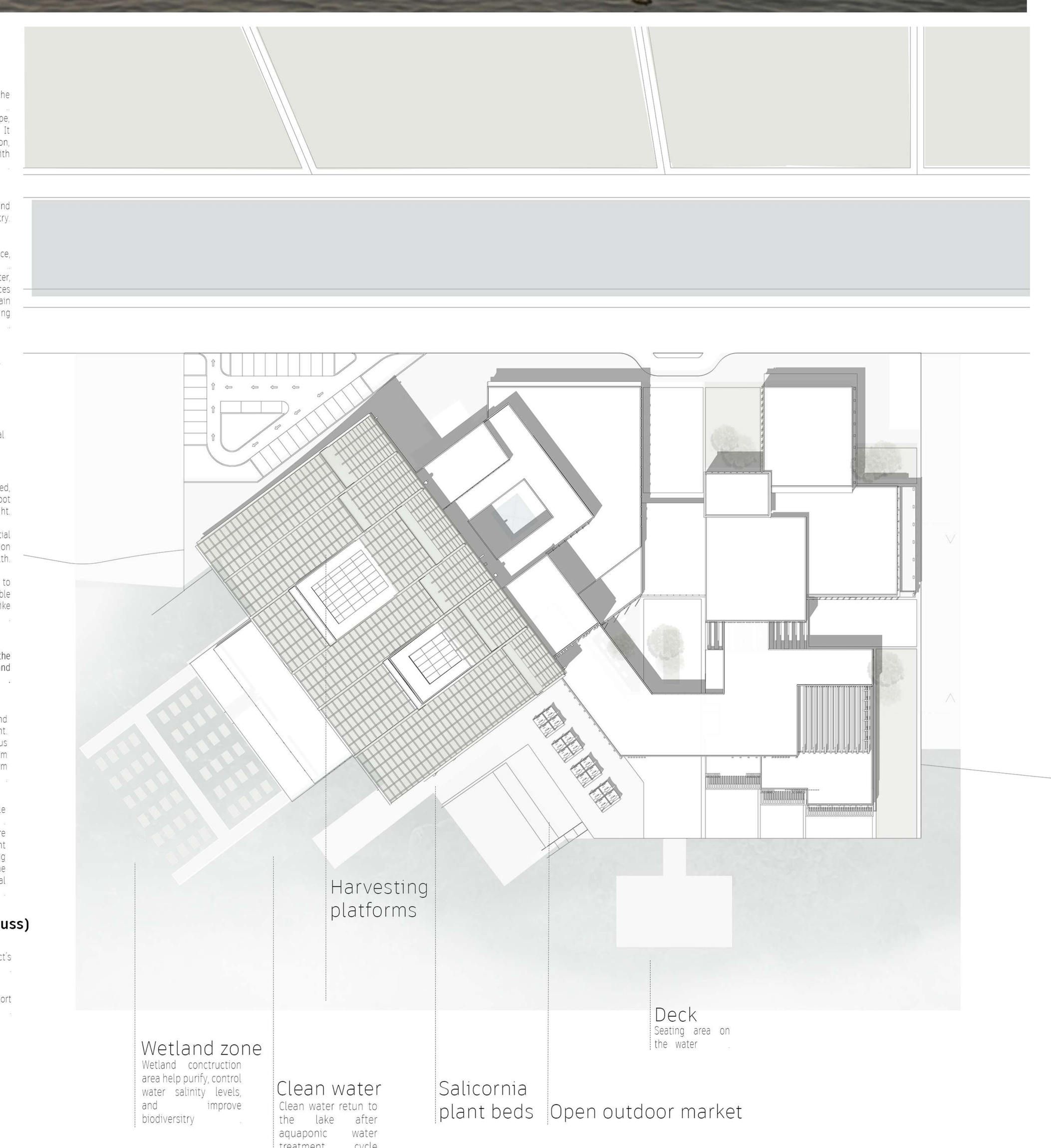
Waterproof Membrane
Protective layer preventing water penetration and ensuring durability in a humid/saline environment. A continuous sealed system (such as EPDM or bituminous membrane) safeguards the structural layers below from moisture damage. It is critical in maintaining long-term performance

Structural Deck
Continuous surface (timber or metal) providing a stable base for the roof assembly
This layer ensures diaphragm action, tying the structure together and providing a rigid platform for subsequent layers. It also acts as a working surface during construction and maintenance, while adapting to the curved geometry without compromising structural performance.

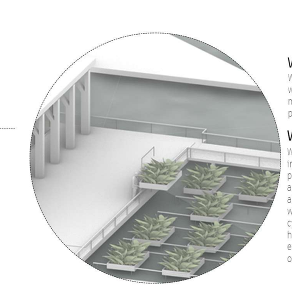
Primary Structure (Curved Truss)
Load Distribution Layer
Main load-bearing system following the project's geometry.
Secondary Framing
Lightweight linear members fixed to the truss to support upper layers and distribute loads.



3D SECTION

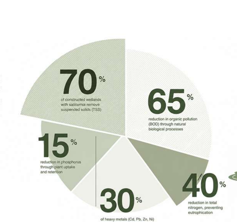


LAYOUT PLAN
SCALE 1:400



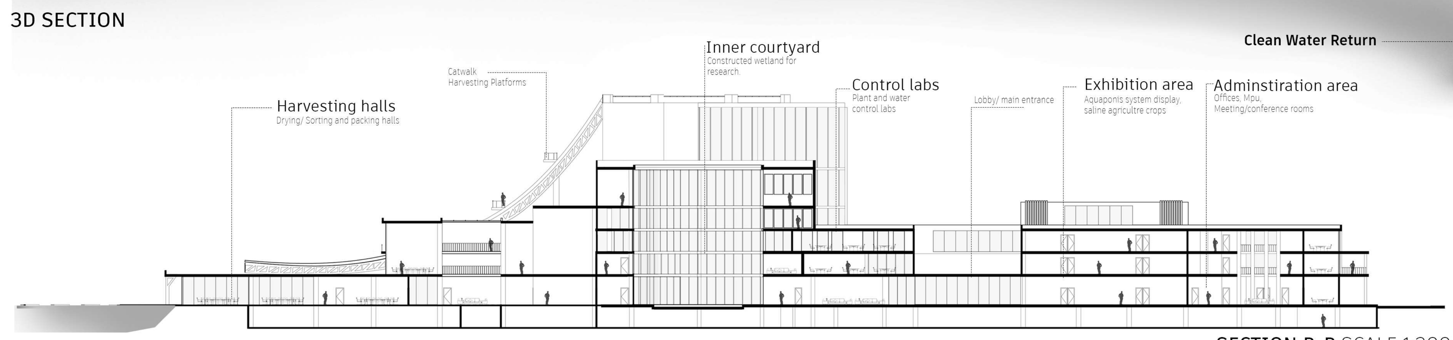
Wetland Zone system
Workers place the plant bed trays into a rail in water that allows the plant to be fixed and easily maintained, through movable rails to access the plant beds

Wetland
Wetlands function as a vital ecological infrastructure, acting as natural systems that purify water, regulate environmental conditions, and support biodiversity. They filter pollutants and excess nutrients, improving water quality while enabling its reuse within agricultural cycles. At the same time, wetlands provide habitats for diverse species, strengthening ecological balance and promoting regeneration of native flora and fauna

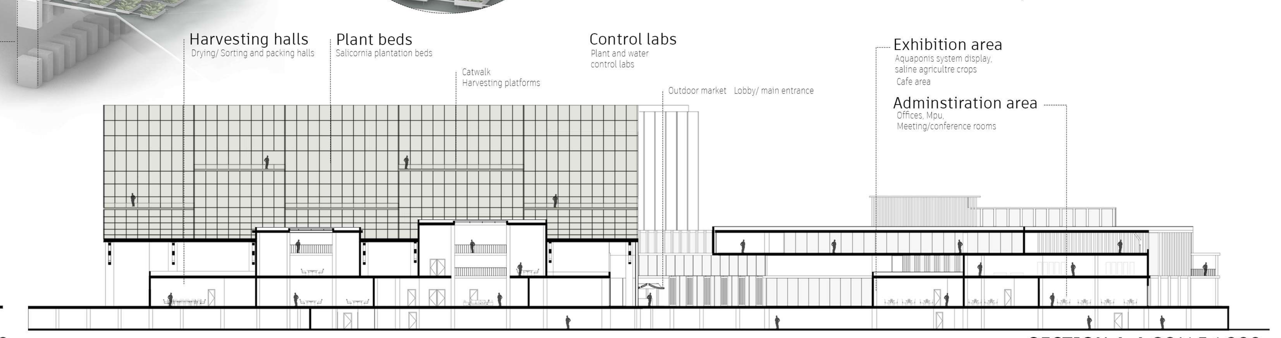


Water Purification Efficiency
Constructed Wetlands
Constructed wetlands demonstrate high performance in improving water quality through natural processes. Around 70% of suspended solids are removed, while 65% of organic pollution is reduced through biological activity. These processes rely on plant–microbe interactions that filter, decompose, and stabilize contaminants, transforming polluted water into a reusable resource.

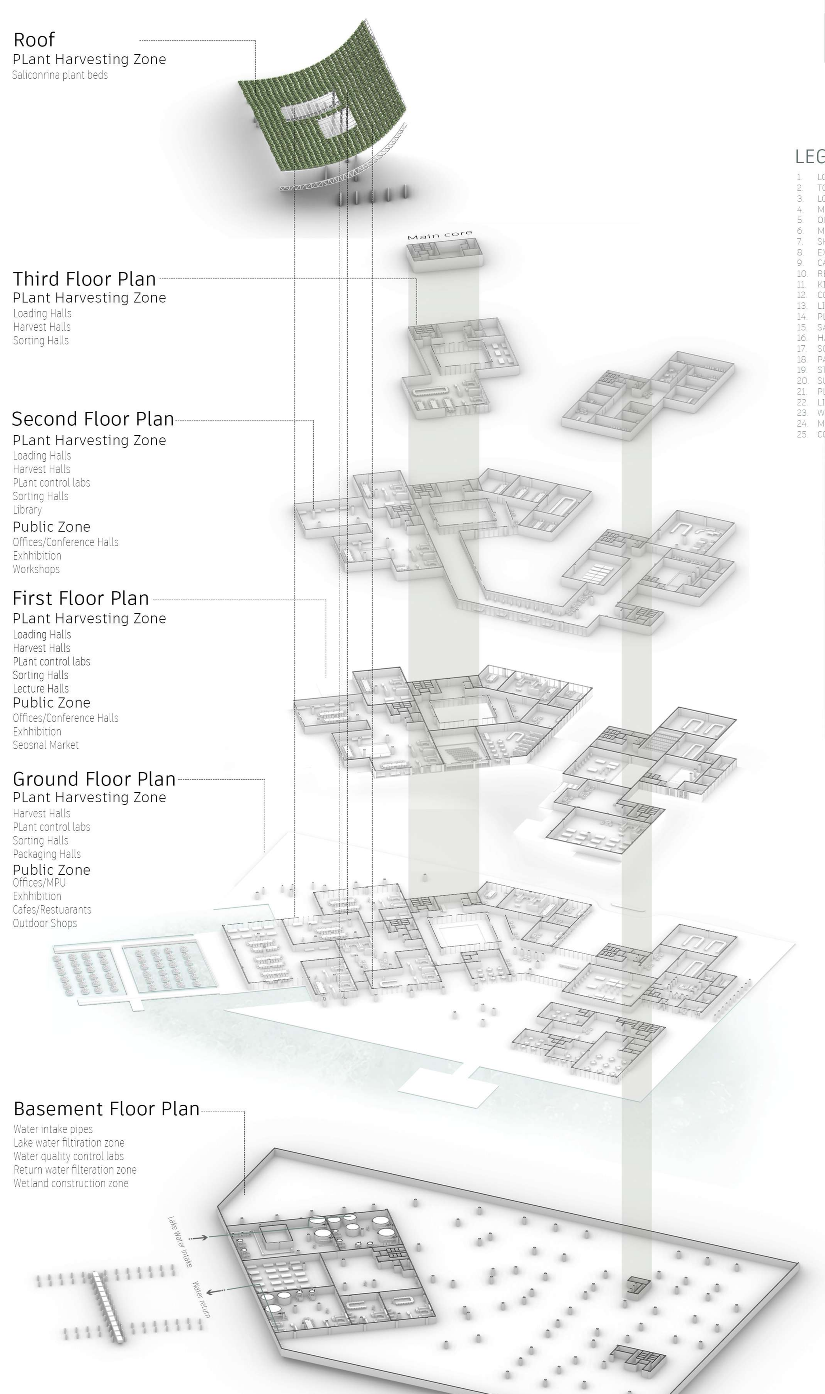
Nutrient & Heavy Metal Reduction
Wetland systems also play a key role in controlling harmful substances. They achieve up to 40% reduction in nitrogen, helping prevent eutrophication, and 15% reduction in phosphorus through plant uptake. Additionally, plants such as salicornia absorb 30% of heavy metals, making wetlands an effective, low-energy solution for both environmental protection and sustainable agricultural integration



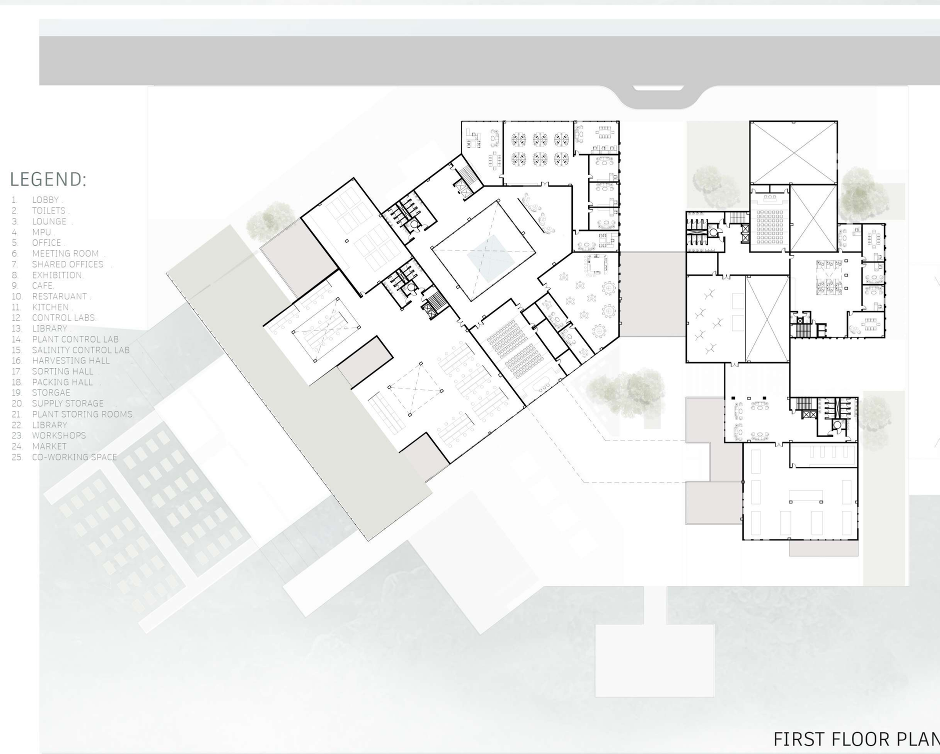
SECTION B-B SCALE 1:300



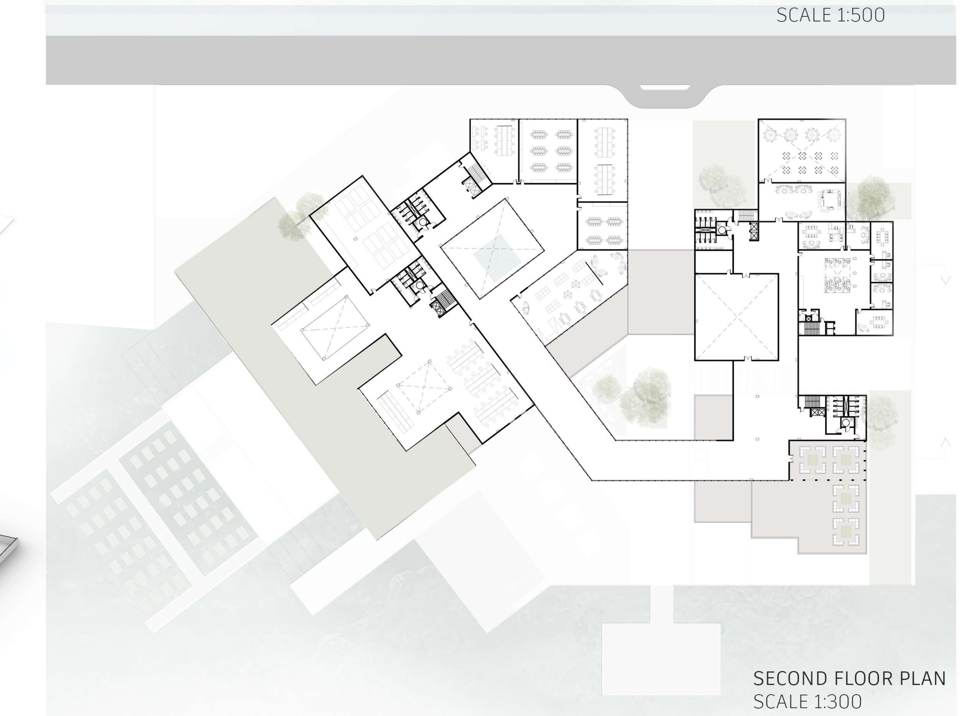
SECTION A-A SCALE 1:300



EXPLODED DIAGRAM



FIRST FLOOR PLAN
SCALE 1:300



SECOND FLOOR PLAN
SCALE 1:300

FRONT ELEVATION
SCALE 1:300