BIODIVERCITY

Restoring and embracing biodiversity through design.

BIODIVERCITY

A Design Thesis Submitted to the
Department of Architecture
North Dakota State University

By
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In Partial Fufillment of the Requirements
for the Degree of
Master of Architecture

May 2021

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THESIS ABSTRACT

With a population of nearly 40 million people, California is the nation's most populous state. As the largest city in California, and the second largest in the United States, Los Angeles, continues to grow in population. Due to continuous growth, cities like Los Angeles are using up more natural resources and becoming more congested and polluted than ever before. As these cities grow, they are being forced to expand. Along with expansion comes the demolition of natural habitats. BiodiverCity is an opportunity for a structure that needs no outside sourcing of energy and that can completely sustain itself, all the while returning nature to its original home within the "concrete jungle" that is downtown Los Angeles, California.

NARRATIVE

BiodiverCity is, as the title suggests, a microcity based on restoring and maintaining biodiversity within a large city environment. The goal is to restore the bond between humans and nature through biophilic design. Here residents, employees, researchers, and visitors will embrace the biodiversity found within their natural environment as they strive to restore the broken bond between humans and nature. Especially that within cities today, where green space can tend to be a rarity. With the goal of restoring this partnership, users will partake in the year-round cycle of production, cultivation, and consumption of crops, all done within the structure consisting of two main towers that make up the microcity. If they may choose to do so, a person could live, work, and play all within the comfort of their own sustainable microcity. Food will be naturally and locally sourced, waste will be reduced, electricity will be produced, water will be collected and recycled, temperatures will be regulated, solar power will be generated and used all from within the microcity. This will be accomplished primarily through a large vertical farm, solar panels, rainwater harvesting, sustainable envelope design such as green roofs and skins, and locally sourced materials. The first tower will house the vertical farm, while sustainable office, retail, and living spaces will be located in the other tower.

NARRATIVE

Urban farming provides a means to increase access to locally grown food and introduces the public to aspects of farming that are being lost in today's culture, especially within large cities. It is important to be aware of where food is grown, how it is treated after being harvested, and how it is transported from one place to another before it arrives in your home. By creating a building that utilizes urban farming, occupants will gain understanding of the processes their produce goes through before it is received by them. Urban farming along with other vegetation will provide an environment that promotes both mental and physical well being. The implementation of plants throughout the spaces as well as other biophilic design components will make occupants feel more closely related to nature, thus defining the idea of biodiversity. Strategic planning of location, geometry, orientation, materials, and structure are vital in creating a zero energy building. In an environment where food and energy are both produced from within the building itself, occupants will thrive within their own microcity, where they have the opportunities to live, work, and play. This idea of uniting humans and plants in an environment where they can coexist and be dependant on one another for resources defines the idea of a microcity focused on biodiversity, thus creating BiodiverCity.

FIGURE 2 | Dewy Leaf

PROJECT TYPOLOGY

BiodiverCity will be a fully self-sustaining microcity within the "concrete jungle" that is Los Angeles, CA. The project will be a multi use high-rise structure consisting of two main towers. One of the towers will house a vertical urban farm that will provide year-round crops, air purification, temperature regulation, and an increased feeling of well-being for its occupants. The urban farm will grow crops utilizing methods such as hydroponics, aquaponics, and in-soil planting. The adjacent tower will include office spaces as well as apartments and condos. The bottom space connecting the two towers will be home to retail spaces, such as restaurants where greens are sourced from the building itself, and a market where the fresh produce grown in the building can be sold. The building aims to be zero energy, thus creating, using, and restoring all energy needed for the microcity.

CASE STUDIES

1

FIGURE 3 | Rice

PASONA GROUP HEADQUARTERS

2

FIGURE 4 | Porous Facade

JAKOB FACTORY

3

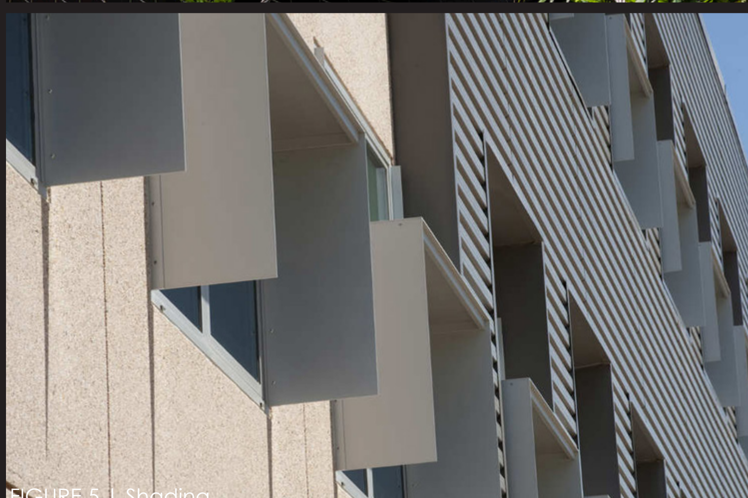


FIGURE 5 | Shading

RESEARCH SUPPORT FACILITY

FIGURE 3 | Rice

PASONA GROUP HEADQUARTERS
TOKYO, JAPAN

LOCATION: Tokyo, Japan
ARCHITECT: KonoDesigns
YEAR: 2010 renovation to existing building built in 1960
TYPOLOGY: office building
SIZE: 215,000 sqft.

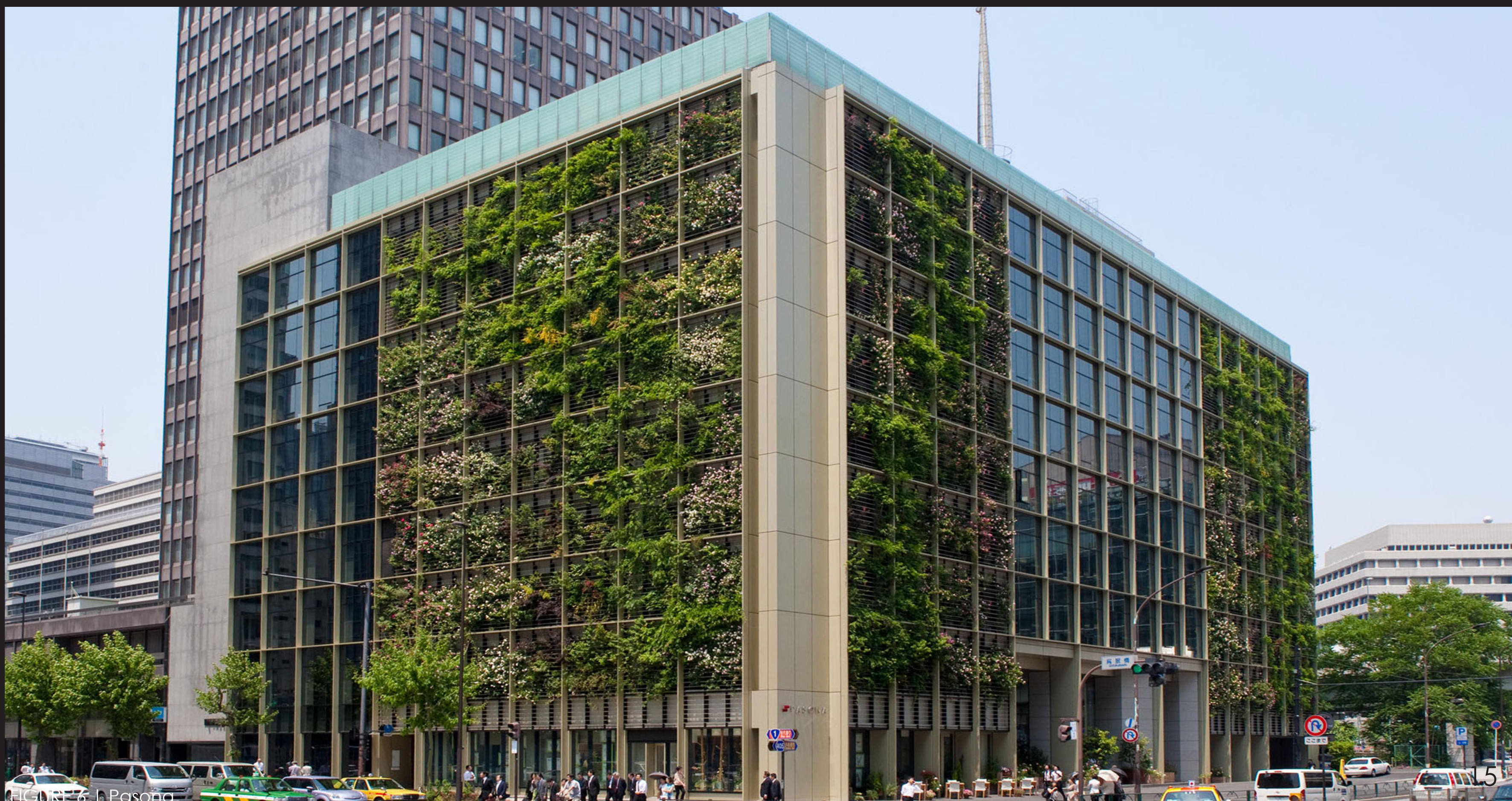


FIGURE 6 | Pasona

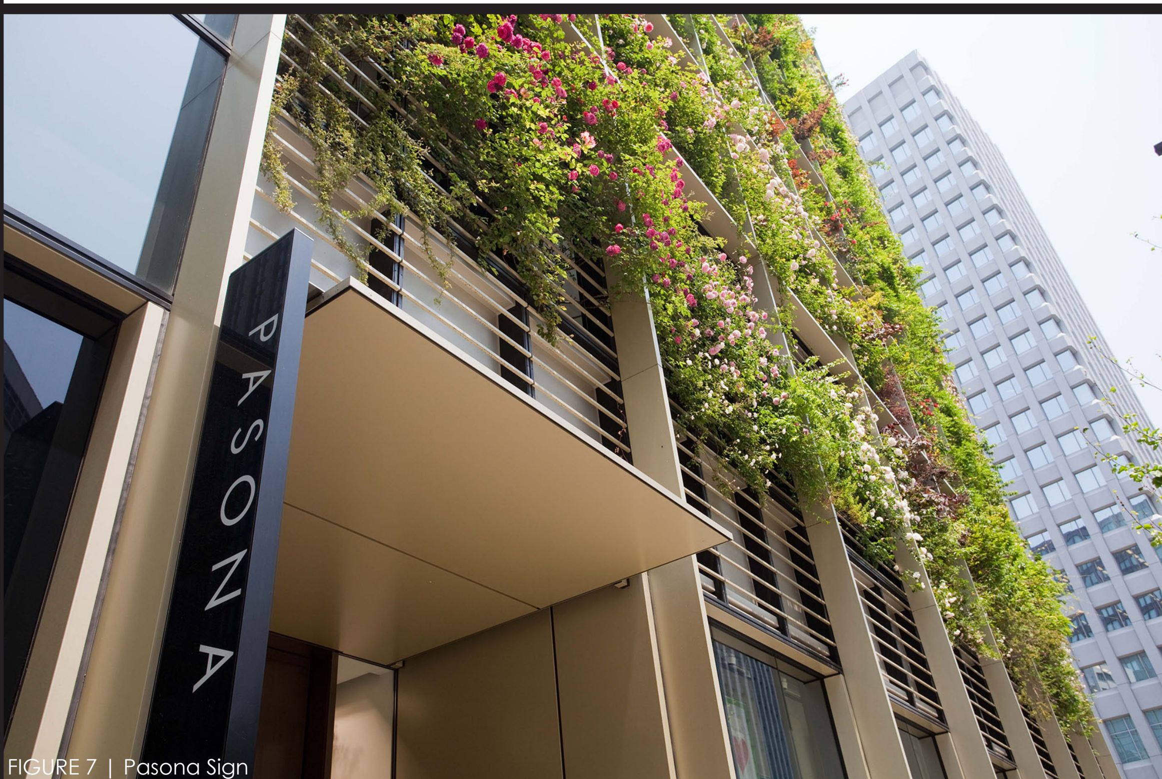


FIGURE 7 | Pasona Sign

FIGURE 8 | Green Facade

Pasona Group Headquarters is a corporate office building located in downtown Tokyo, Japan. The 215,000 square foot, nine story building is home to the Japanese recruitment company, Pasona Group. The existing 50 year old building was completely renovated in 2010, leaving behind only the original existing building envelope and superstructure. New elements in the renovation include offices, an auditorium, cafeterias, a double skinned green facade, a rooftop garden, and most remarkably, urban farming facilities. The new green spaces cover over 43,000 square feet of the building and are home to over 200 species, including fruits, vegetables, and rice. The plants that are grown within the building are harvested, prepared, and served at the several different cafeterias located inside.

FIGURE 9 | Cafeteria

FIGURE 10 | Work Space

PROJECT ELEMENTS:
offices
auditorium
cafeterias
rooftop garden
urban farming
living green wall

FIGURE 11 | Pasona 2

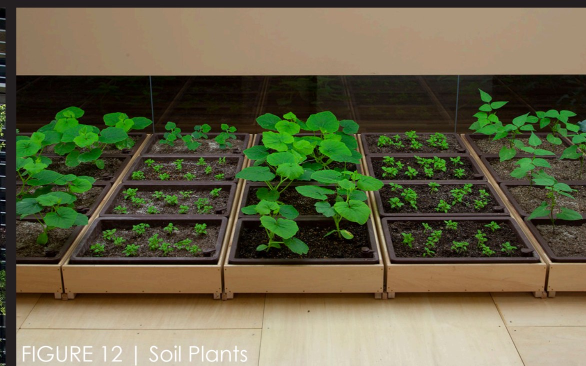
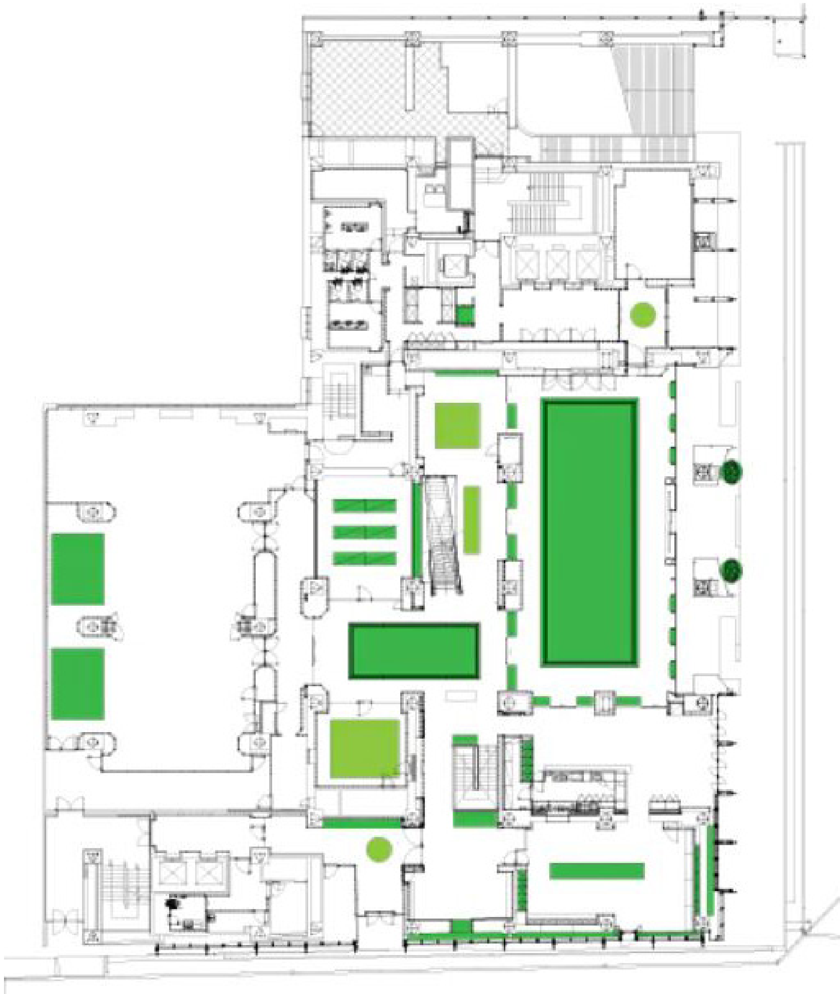


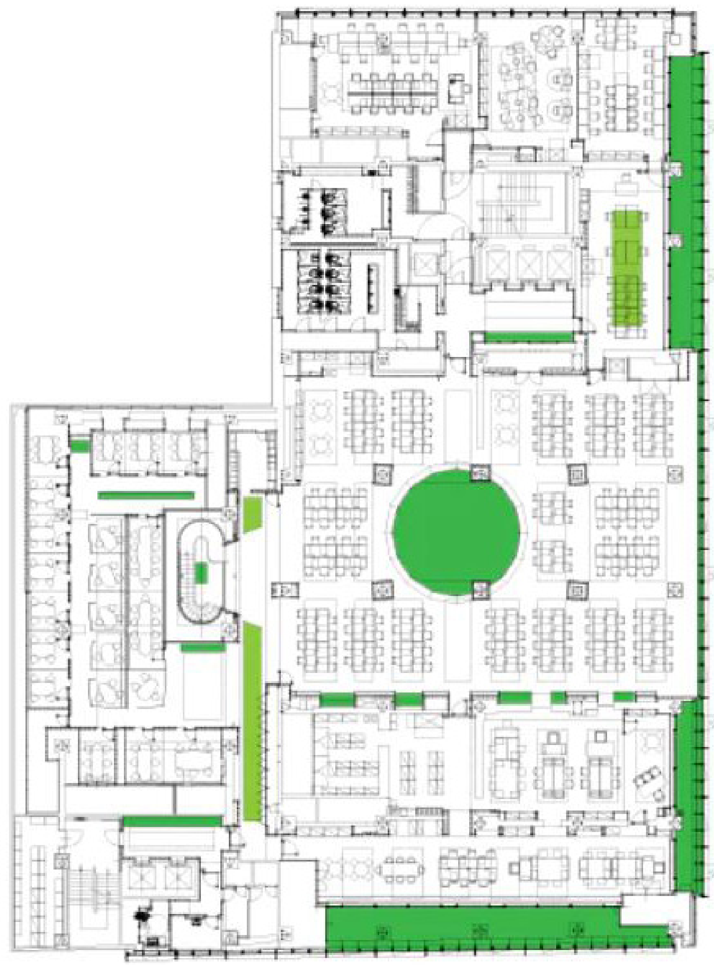
FIGURE 12 | Soil Plants

FIGURE 13 | Planters

MAIN PUBLIC LOBBY



TYPICAL OFFICE FLOOR



GREEN / FARM SPACE

GREEN / FARM CEILING

FIGURE 14 | Pasona Floor Plans

GREEN / FARM SPACES

FIGURE 15 | Farm Space

FIGURE 16 | Farm Space 2

FIGURE 17 | Farm Space 3

GREEN / FARM CEILINGS

FIGURE 18 | Ceiling Space

FIGURE 19 | Ceiling Space 2

FIGURE 20 | Ceiling Space 3

ENVIRONMENTAL IMPACT

The building's double skinned facade features three foot deep balconies, that were created for planting and farming, which make up the exterior living green wall. These balconies help shade the interior spaces while also insulating them, keeping the cool air in. The facade of the building is wrapped in a deep grid shading system with operable windows in it that allow for fresh air intake. The many plants located throughout the building filter the air as well as provide fresh crops that are grown using both soil based farming and hydroponics.

SOCIAL IMPACT

The urban farming facilities and green spaces located throughout the building enhance the well-being of employees by reducing stress levels, promoting creativity, and encouraging social interaction, thus providing a more productive workplace.

CULTURAL IMPACT

The urban farm provides a rural farming experience for those located in a large downtown urban area.

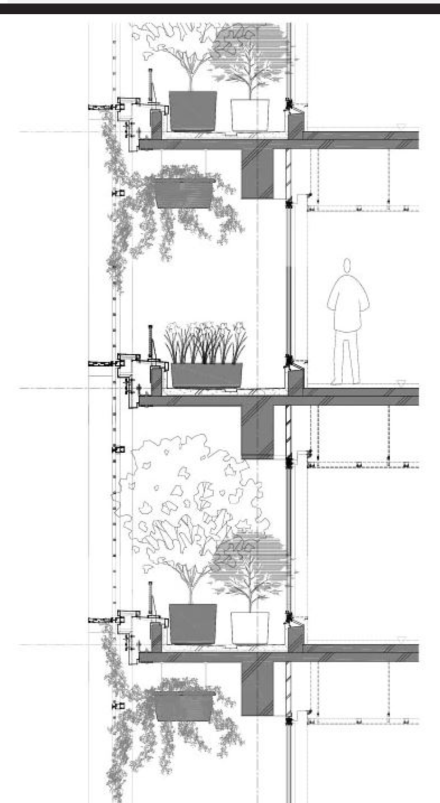


FIGURE 21 | Facade Section


FIGURE 22 | Harvest


FIGURE 23 | Harvest 2


FIGURE 4 | Porous Facade

JAKOB FACTORY
HO CHI MINH CITY, VIETNAM

LOCATION: Ho Chi Minh City, Vietnam
ARCHITECT: G8A Architecture & Urban Planning, **rolli**marchini Architects
YEAR: 2020
TYPOLOGY: factory
SIZE: 140,000 sqft.

FIGURE 24 | Factory Entrance


FIGURE 25 | Night View

The goal of this project was to create a highly innovative manufacturing space as a factory for Jakob Rope Systems. Located in the center of one of Ho Chi Minh City's industrial parks, the project focuses on the environmental impact that it has rather than other factories in the area where the sole concern is economic gain, leading to high pollution. The designers, G8A Architecture & Urban Planning and **rolli**marchini Architects, applied their knowledge in sustainable design, both environmentally and socially, to all phases of the project. Passive design was a key element in designing a structure that proposes alternatives to the detrimental practices of typical manufacturing buildings.

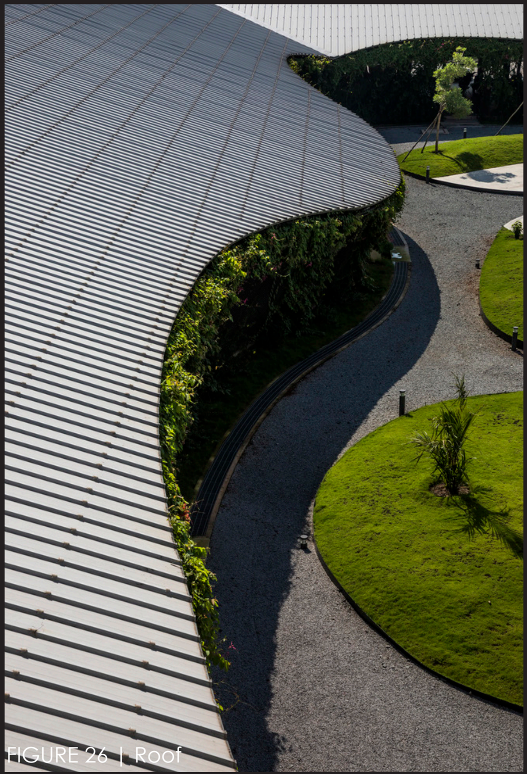


FIGURE 26 | Roof


FIGURE 27 | Courtyard

PROJECT ELEMENTS:
work spaces
outdoor spaces
porous facade


FIGURE 28 | Corridor

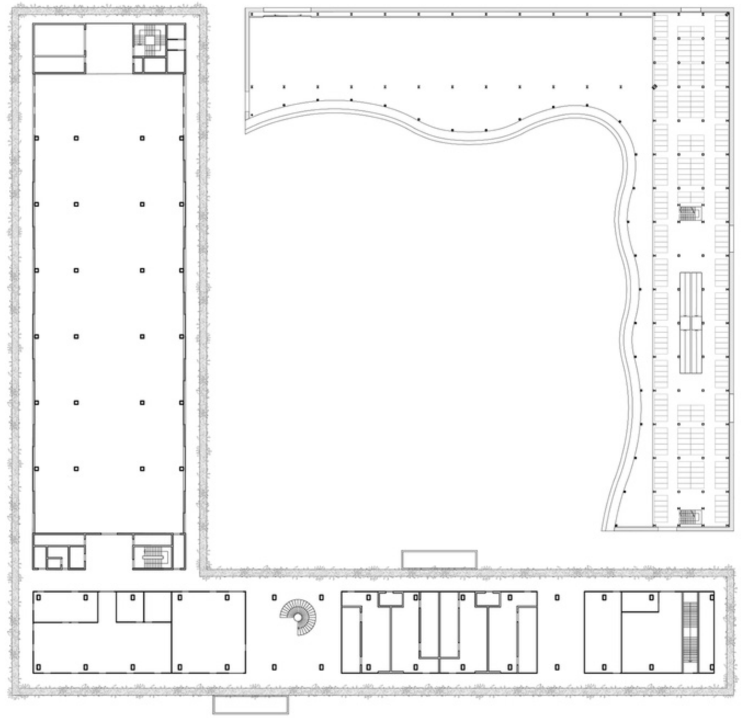


FIGURE 29 | Upper Floor Plan

UPPER FLOOR PLAN

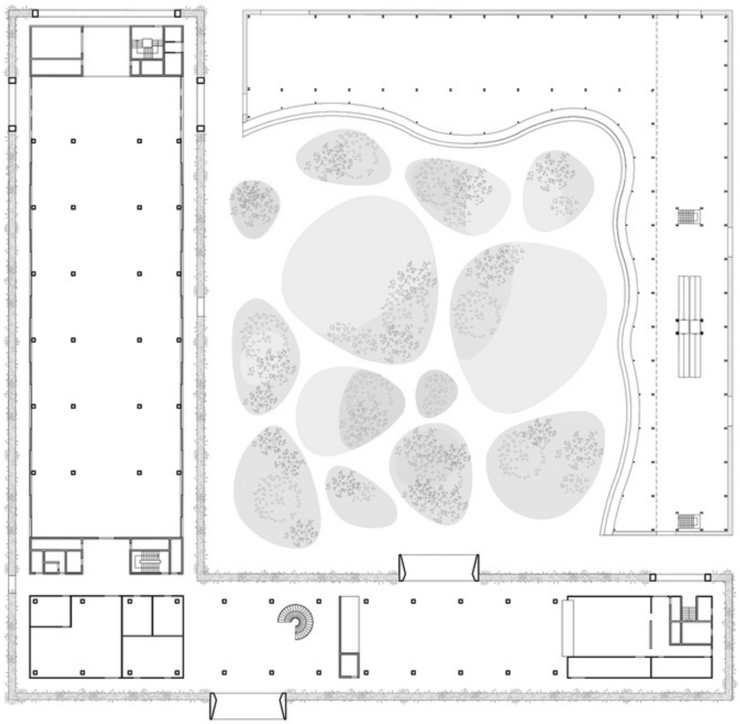


FIGURE 30 | Ground Floor Plan

GROUND FLOOR PLAN

The factory consists of an innovative vertical design strategy to avoid unecessary ground usage and land development. The site offers workers pleasing outdoor spaces where they can relax and clear their minds. The building's facade features a lush plantation "skin". This skin consists of horizontal geotextile planters. This porous facade naturally filters rain and sun, and lowers temperatures through evaporation, which also purifies the air. It's structure is suspended and supported by a double rope network that extends all the way from the ground to the roof.

FIGURE 31 | Horizontal Planting

FIGURE 32 | Intersection

ENVIRONMENTAL IMPACT
The porous green facade of the Jakob Factory provides natural ventilation, shading from the sun, and protection from weather conditions such as rain. The vertical orientation of the factory is an environmentally friendly alternative compared to tradional horizontally spread factories, avoiding unnecessary land development and land usage.

SOCIAL IMPACT
The factory has implemented several outdoor green spaces where workers can escape the factory scene to spend time outdoors relaxing and clearing their minds.

CULTURAL IMPACT
The Jakob Factory has changed the view of the traditional manufacturing building. Rather than large sprawling factories that take up copius amounts of land, the Jakob Factory utilizes a vertical system where usable zones are stacked. Along with this innovative structure, another unique feature of this design are the green spaces that were created for the employees' well being.

FIGURE 5 | Shading

RESEARCH SUPPORT FACILITY
GOLDEN, COLORADO

LOCATION: Golden, CO
ARCHITECT: RNL Design
YEAR: 2010
TYPOLOGY: office building/laboratory
SIZE: 360,000 sqft.

FIGURE 33 | RSF Night

FIGURE 34 | RSF Side

The Research Support Facility (RSF), located in Golden, Colorado, is home to both the National Renewable Energy Laboratory (NREL) and the Department of Energy Golden Field Office (DOE). This world class office facility and laboratory is a prime example of an aesthetically pleasing, high performance building. The building was designed to meet the LEED Platinum rating and is the first of its kind to be a Zero Energy Building. Showcasing sustainable high performance design, RSF features advances in renewable and energy efficient technologies.

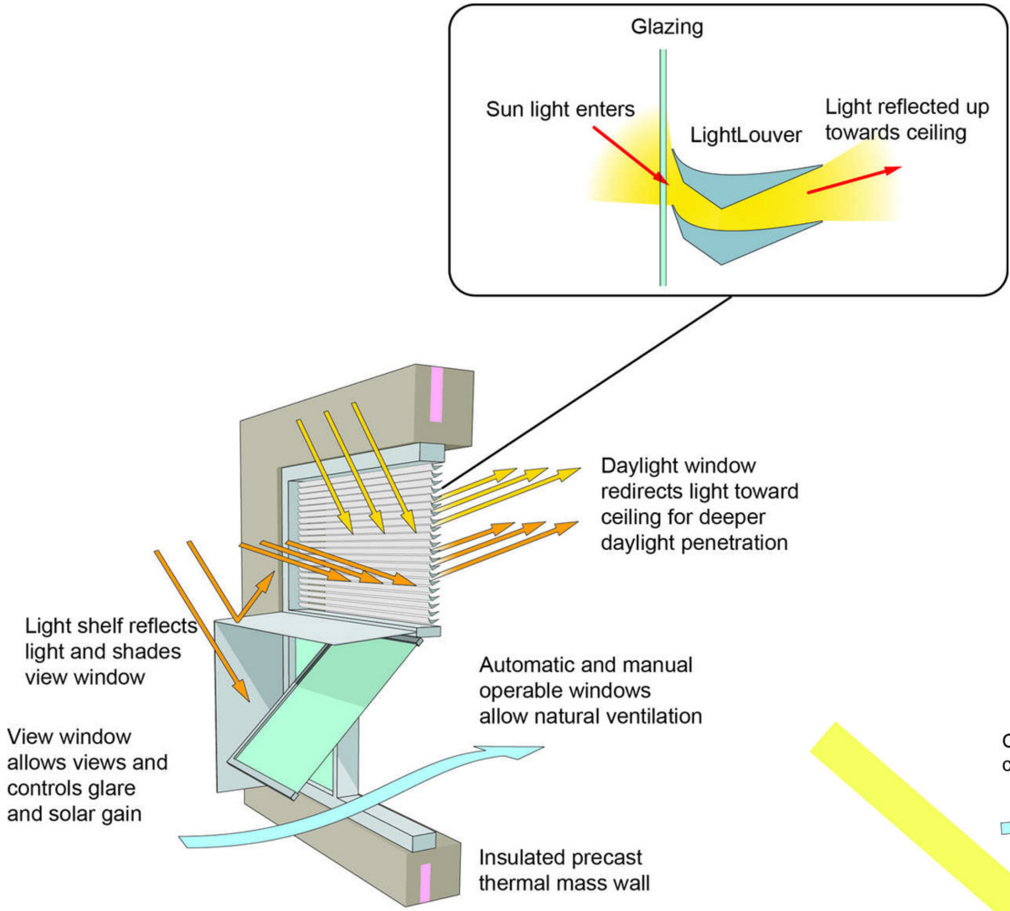


FIGURE 35 | Glazing Diagram

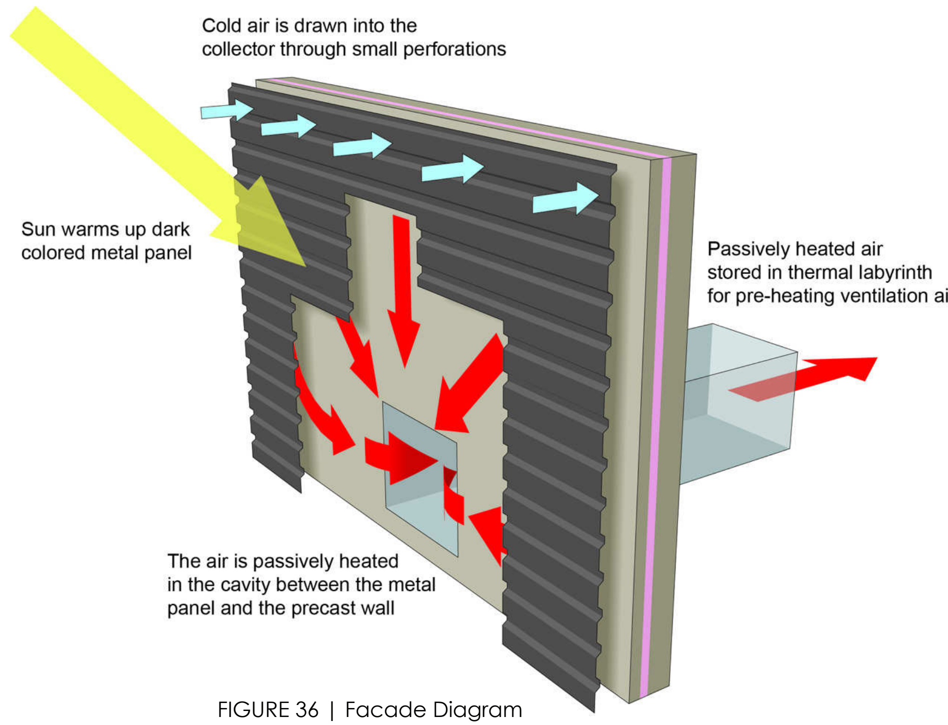
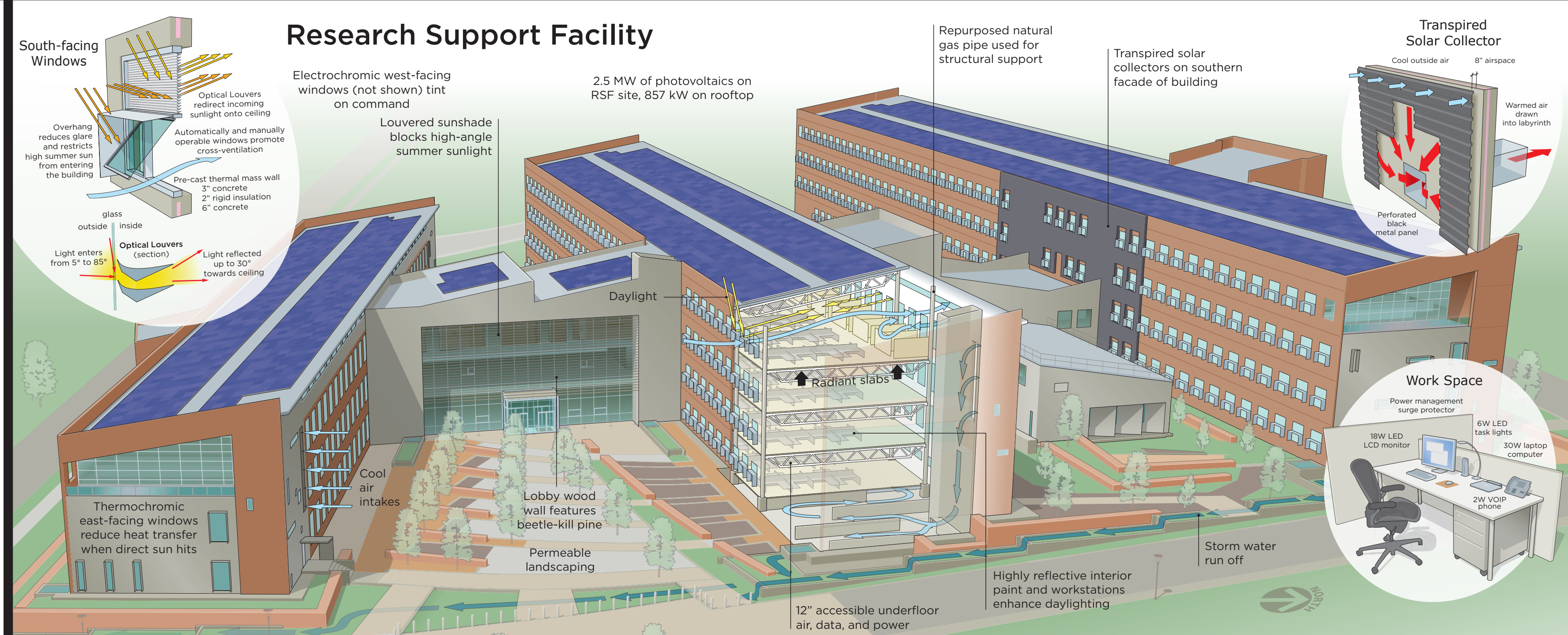


FIGURE 36 | Facade Diagram

Research Support Facility



LEED Platinum

The RSF received a Leadership in Energy and Environmental Design (LEED®) Platinum designation for the southern and middle wings completed in 2010, and the north wing completed in late 2011 will achieve the same rating. Through a whole-building integrated design approach, the building incorporates sustainable features, including ultra-efficient energy practices. LEED points achieved include:

- Daylighting
- Building materials contain recycled content, rapidly renewable products, or are regionally produced
- On-site renewable energy
- Water efficient landscaping
- All ten “reduced energy use” points
- Alternative transportation.

Workplace of the Future

The RSF provides employees with a new type of office space—one that is open and encourages interaction and collaboration. Low profile, modular work stations allow daylight and views for all occupants. Workstations are located within 30 feet of the nearest window, and employees can open windows when conditions permit, allowing for natural ventilation and improved indoor air quality. Highly efficient laptop computers, monitors, and all-in-one print/fax/scan devices contribute to lower energy use. An entire workstation uses about 70W while in use, compared to 300–500W per workstation at a typical office building.

Green Data Center

The RSF data center is highly efficient with many unique features, including:

- Hot aisle containment
- Reuse of data center waste heat to preheat building ventilation
- Hybrid cooling system
- State-of-the-art power systems
- Energy efficient equipment with virtualization.

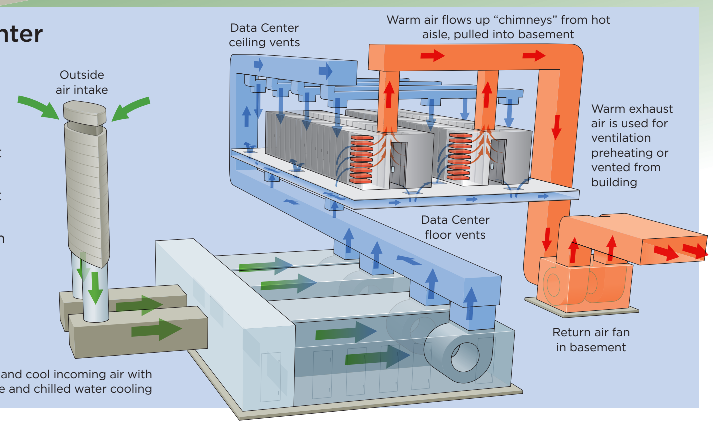


FIGURE 37 | RSF Diagram

1. Permeable Landscaping
2. Thermochromic East facing glazing
3. Fresh air intake
4. Louvred sun shade
5. Low-profile open offices
6. Underfloor air, data, & power
7. Reflective interior paint, flooring, workstations
8. Radiant Floor Slab
9. Transpired solar collector on South facade (not shown)
10. 1.6 MW of photovoltaics
11. Sculptural beetle kill wood wall
12. Electrochromatic West-facing windows (not shown)
13. Open-ceiling offices
14. Repurposed natural gas pipe
15. Basement thermal mass labryinth

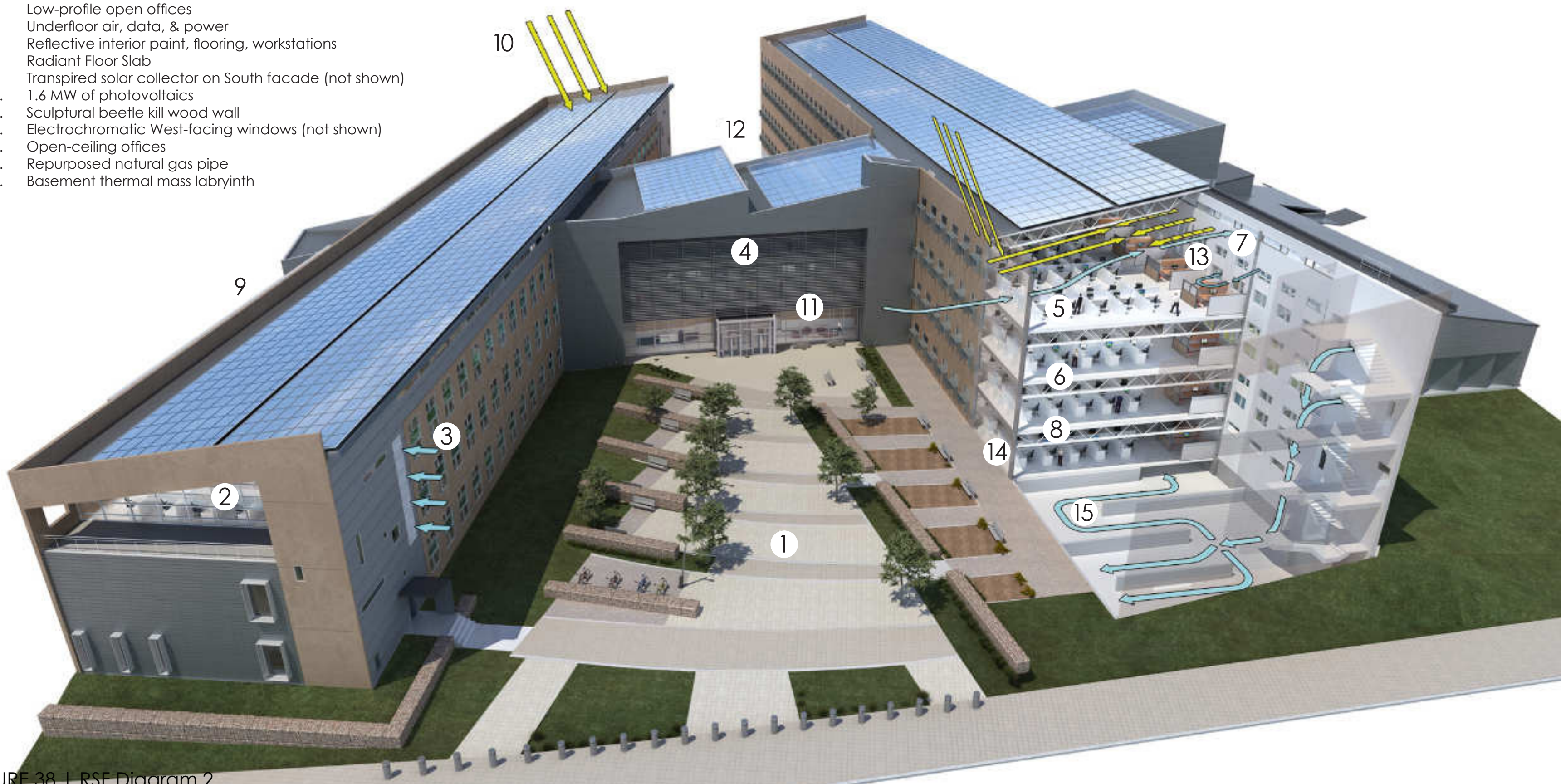


FIGURE 38 | RSF Diagram 2

FIGURE 39 | RSF Front


FIGURE 40 | Open Offices


FIGURE 41 | Hallway

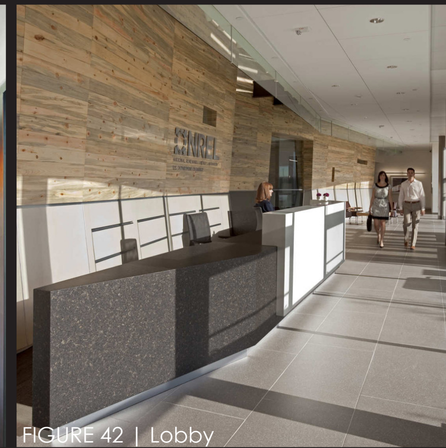


FIGURE 42 | Lobby

PROJECT ELEMENTS:

laboratory
open offices
private offices
library
lunchroom
lobby
conference spaces


FIGURE 43 | Lunchroom


FIGURE 44 | Waiting


FIGURE 45 | Railing


FIGURE 46 | Private Office

ENVIRONMENTAL IMPACT

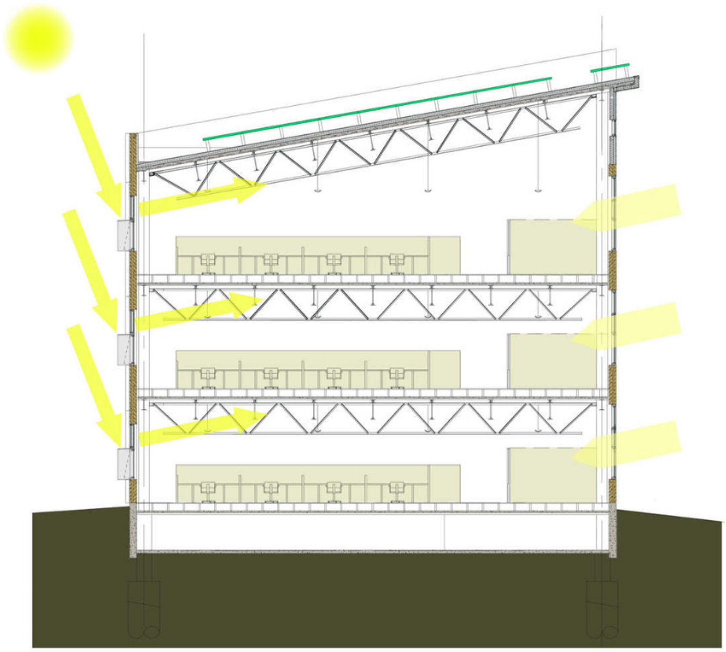
The RSF building's zero energy design and LEED platinum rating has many strong environmental factors. Its' orientation and geometry maximize daylighting while minimizing heat gains and losses. Its' structure consists of a labrynth thermal storage concrete system that allows for passive cooling and heating. Solar energy is installed on the rooftop of the RSF building, visitors parking lot, and staff parking garage. The solar collecters preheat the outside air along the building's South facade before delivering it to the labyrinth. Daylighting from windows on the South facade is reflected to the ceiling and into the spaces with light reflecting devices, allowing all workstations to be daylit. Fresh air is brought into the building through its' triple glazed, operable windows which cool the spaces. Window shades also help to keep the spaces cool by providing shade when needed. The buildling's internal temperature is moderated by precast concrete inisulated panels. Thermal slabs in the ceiling allow the building to be hydronically heated and cooled, while underfloor ventilation and evaporative cooling and energy recovery systems reduce outdoor air cooling and heating loads. The data center's energy use is reduced by using waste heat capture, evaporative cooling, outside air ventilation, and more effecient servers.

SOCIAL IMPACT

The Research Support Facility, home to the NREL and DOE offices, is a prime example of aesthetically pleasing high performance design for the employees that work there. Employees of NREL and DOE all work in the field of energy and energy savings. The building is an inspiring place as it showcases many methods of green design that can inspire their work and encourage productivity throughout the day.

CULTURAL IMPACT

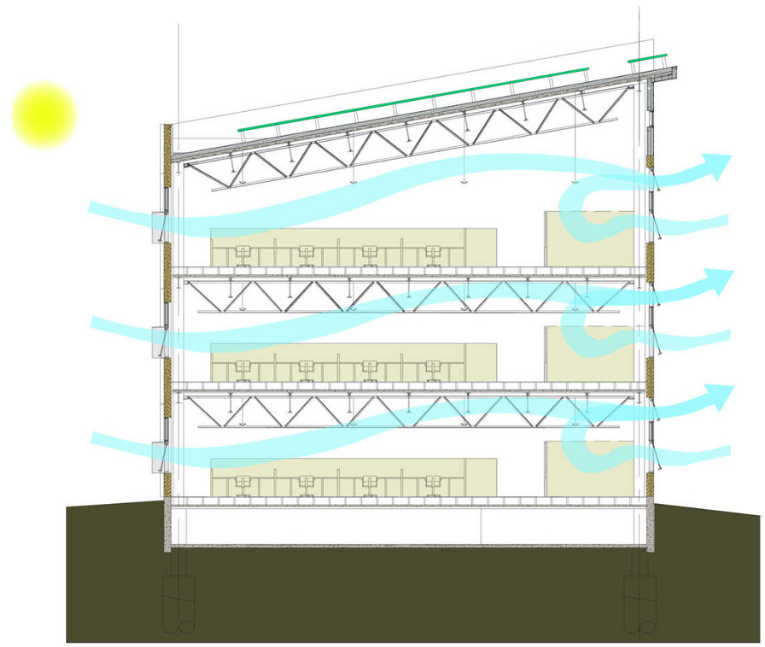
The RSF building gives its' employees as well as the public a look into the future of technological advances in energy efficient and renewable design. The building captures their imagination and gives them a look into the possibilities and benefits of sustainable design.



Daylight enters the upper portions of the south facing windows and is reflected up to the ceiling and deep into the space with a light reflecting LightLouver. Indirect ambient daylight enters from the north facing windows. 100% of the workspaces are daylit.

DAYLIGHTING

FIGURE 47 | Daylighting Diagram



Manual and automatic operable windows provide natural ventilation and comfort during the shoulder seasons and mild summer days.

NATURAL VENTILATION

FIGURE 48 | Natural Ventilation Diagram

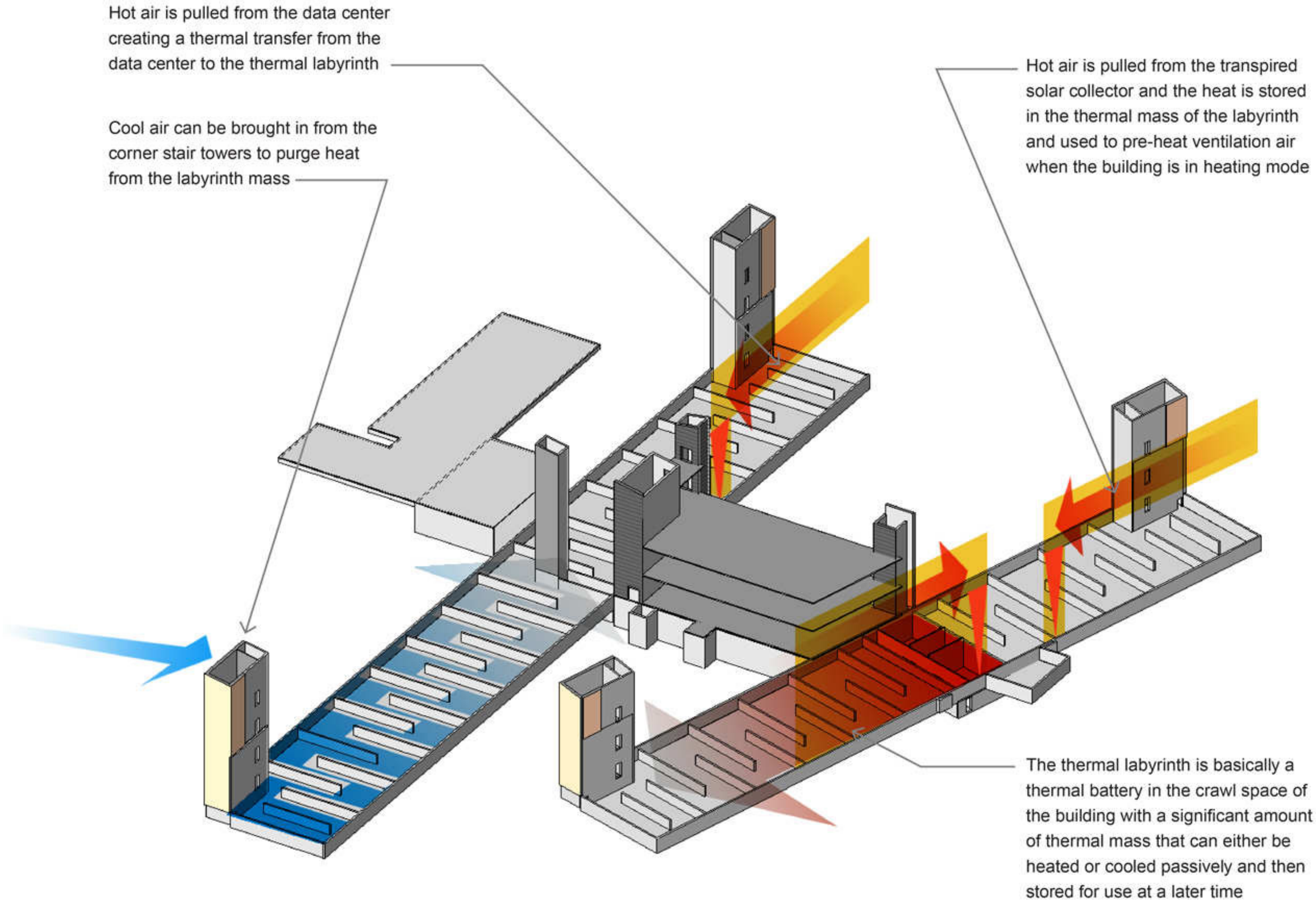


FIGURE 49 | Thermal Labyrinth Diagram

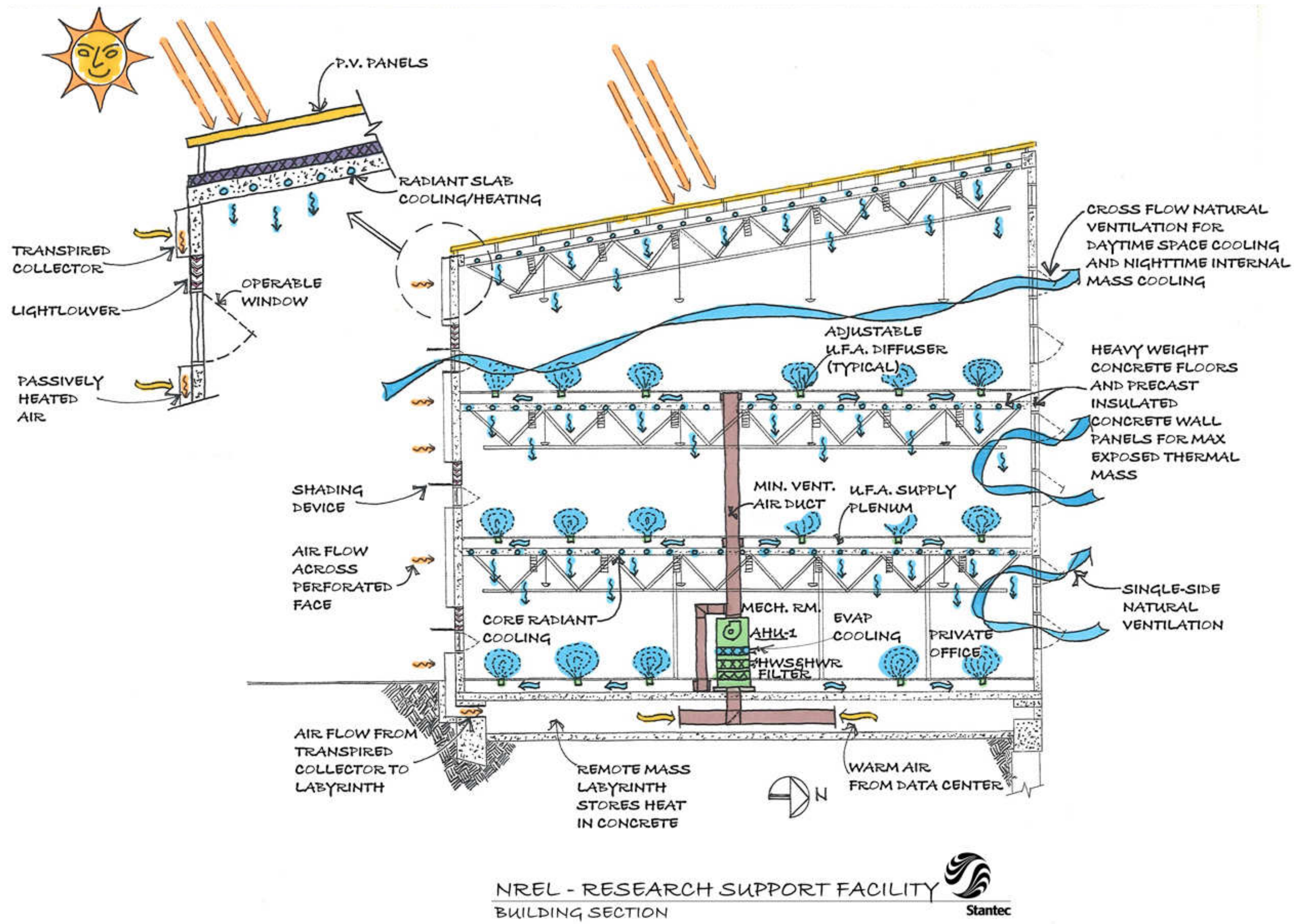


FIGURE 50 | Building Section Diagram

CASE STUDY CONCLUSION

PASONA GROUP HEADQUARTERS can be looked upon for inspiration when designing the urban farm for BiodiverCity. Inspiration can be drawn by further studying the placement of the green spaces incorporated in the project and the planting methods utilized for each one. The building's strategic use of vegetation throughout the spaces creates a pleasant enviornment for guests that is beneficial in many ways. The idea of involving community members in the planting and harvesting of crops is a great interactive learning experience that should be incorporated into the program for BiodiverCity.

JAKOB FACTORY utilizes a creative facade design that is very effective. Its' unique, green porous facade allows for natural ventilation, shading from the sun, and protection from various weather conditions. The factory's efficient spatial oraganization by designing vertically rather than horizontally is a successful way to minimize land development. These ideas are all important considerations that must be accounted for when designing for BiodiverCity.

CASE STUDY CONCLUSION

RESEARCH SUPPORT FACILITY is an ideal case study for BiodiverCity, as it is a zero energy building. From solar collectors on all roofs to under floor ventilation to building orientation, a variety of different methods are employed in the building to make the zero energy design successful. Further studies should be done on these topics as to apply the most effective methods for lighting, heating, cooling, ventilation, waste disposal, and energy storage to BiodiverCity. It is also very important to incorporate and combine all of these methods into a form that is aesthetically pleasing. The RSF is a great example of how many different energy saving components can be combined into an elegant, yet effective form.

MAJOR PROJECT ELEMENTS

The project will consist of two main towers. One tower will include office and living spaces, while the other will hold the vertical urban farm. Major elements required for the urban farm will be proper equipment and systems for in soil planting, hydroponics, aquaponics, and any other methods that may be discoverd during the research phase of the project. The two towers will be connected at the bottom by a base that will be home to various retail spaces. The project should include larger gathering spaces where events can be held in this unique environment, specifically educational events within the vertical farm tower. Although most of the urban farming methods will be applied in this vertical farm tower, an abundance of green space should be designed into the residency tower as well as in the landscape design on the site.

TOWER 1

- urban farm
- research labs
- offices
- event spaces

TOWER 2

- retail space
- office space
- apartments
- apartment amenities (gym, party room, etc.)

BASE

- retail spaces (stores, restaurants, etc.)
- market
- parking

		USER / CLIENT DESCRIPTION
1	TENANTS	those who will occupy the apartment and condo spaces • aesthetically pleasing units with views • parking
2	EMPLOYEES	those who work in the office and retail spaces as well as those who work on the urban farms • provide green spaces for employees to improve their mental health and increase productivity, both indoor and outdoor • parking
3	SCIENTISTS	those who work with and study the urban farming methods as well as sustainable design solutions utilized throughout the building • provide adequate laboratory spaces for scientists to work and study • parking
4	GENERAL PUBLIC	those who visit the site and use the retail spaces, as well as those who will experience the exterior of the site in passing • provide an aesthetically pleasing exterior facade design, that includes vegetation, to give viewers a glimpse of what can be found inside • parking
5	VEGETATION	those who occupy the urban farming areas of the site • provide nourishing, climate controlled areas for vegetation to thrive

FIGURE 51 | US Map

The state of California was chosen as the location for BiodiverCity because of its' warm to moderate year round temperatures. This climate will allow for vegetation to grow on the exterior of the building year round. Los Angeles, specifically, was chosen for the site because it is a very large city where biodiversity is being compromised because of the land development that is, and has taken place due to rapid growth over the years. Creating a zero energy building showcasing urban farming methods can set the standard and encourage green design in a city that has become a concrete jungle.

THE SITE

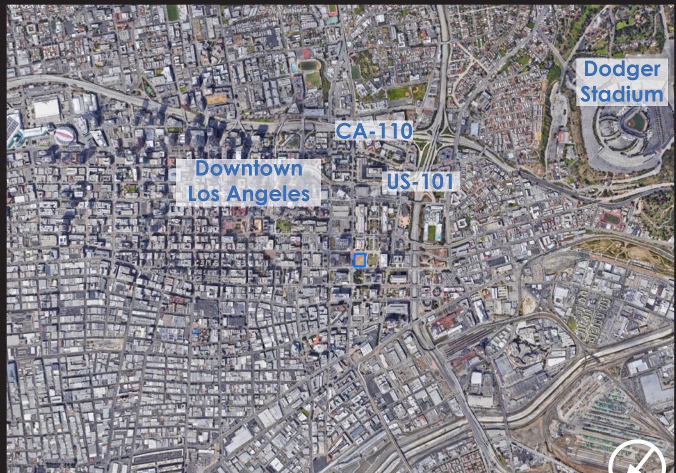


FIGURE 52 | Site Map

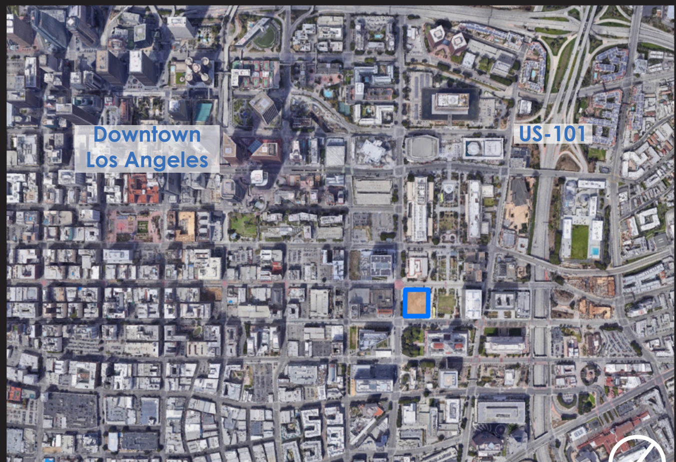


FIGURE 53 | Site Map 2

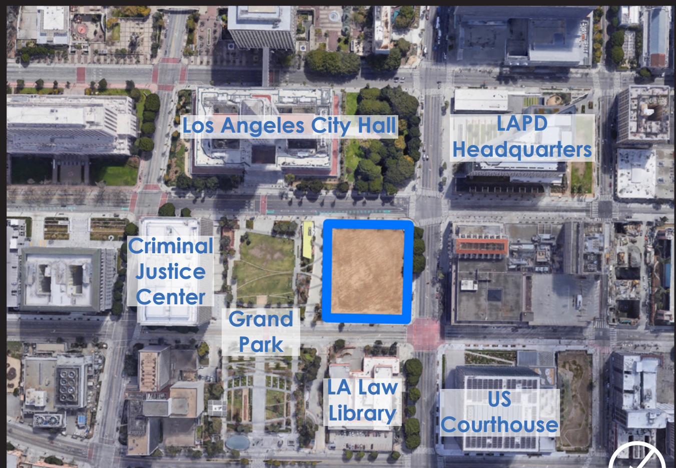


FIGURE 54 | Site Map 3

THE SITE

The location chosen for the site of BiodiverCity is *120 N Broadway, Los Angeles, CA, 90012*. This site was chosen for its' proximity to a local park, transportation, and the Los Angeles City Hall building. Located to the North/Northeast of the site is Grand Park. This park consists of 12 acres of land containing botanical gardens, memorials, a performance lawn, and a community terrace, with paths connecting all of the spaces. The location is a popular spot as it is a gathering area for nearby communities such as Chinatown, El Pueblo, and Little Tokyo. The site is also close to major freeway as well as major transportation hubs, making it an accessible destination for all. Another reason for the site location is its' adjacency to the Los Angeles City Hall. Residents of Los Angeles can look to the building as a symbol of biodiversity within their city. Standing tall and proud next to Los Angeles City Hall, BiodiverCity will be a representation of design that breathes new life into a city where large concrete structures and developments have taken over, all at nature's expense.

PROJECT EMPHASIS

1	URBAN FARMING	focus on urban farming as a way to benefit the occupants environmentally, socially, and culturally • hydroponics • aquaponics • pisciculture
2	ZERO ENERGY DESIGN	combine energy efficient design and renewable energy generation to consume only as much energy as what can be produced on site • solar energy • natural lighting • natural ventilation • rainwater harvesting • green building materials • passive cooling and heating • waste disposal • urban farming
3	CONNECTION TO NATURE	restore human connection to nature and provide an environment where they can coexist simultaneously and don't have to compete with one another • humans nurture the plants, plants nourish the humans
4	HEALTH AND WELLNESS	provide an increased feeling of well-being for occupants through biophilic design • increase sense of creativity • decrease stress levels • improve productivity • promote healthier lifestyle

GOALS OF THE PROJECT

1 enhance and restore the partnership between humans and nature

2 encourage and educate on the ideas of urban farming and create an environment where agriculture is possible within a large city

3 create a zero energy building incorporating elements of biophilic design

4 create an environment that uses elements of nature to provide both physical and mental health benefits to occupants

5 design a project that utilizes urban farming and sustainable design to produce enough energy to power the building without requiring any outside sourcing

PLAN FOR PROCEEDING | RESEARCH DIRECTION

In order to successfully create a zero energy building, extensive research will need to be conducted on topics of zero energy design and sustainable design. Research will need to be done in order to determine the most efficient orientation and location for the building on the site, as well as what materials should be used. Along with zero energy design solutions, it will be vital to research methods of urban farming to determine how it can best be implemented into the project. Studies of different plant species should also be performed to acknowledge which species work best with the different methods. Research on the following topics will be necessary for combining all of these ideas into a successful, cohesive design.

RESEARCH TOPICS TO CONSIDER:

- zero energy design
- sustainable design
- biophilic design
- urban farming
- urban farming methods
- horticulture
- local California building materials

PLAN FOR PROCEEDING | SCHEDULE

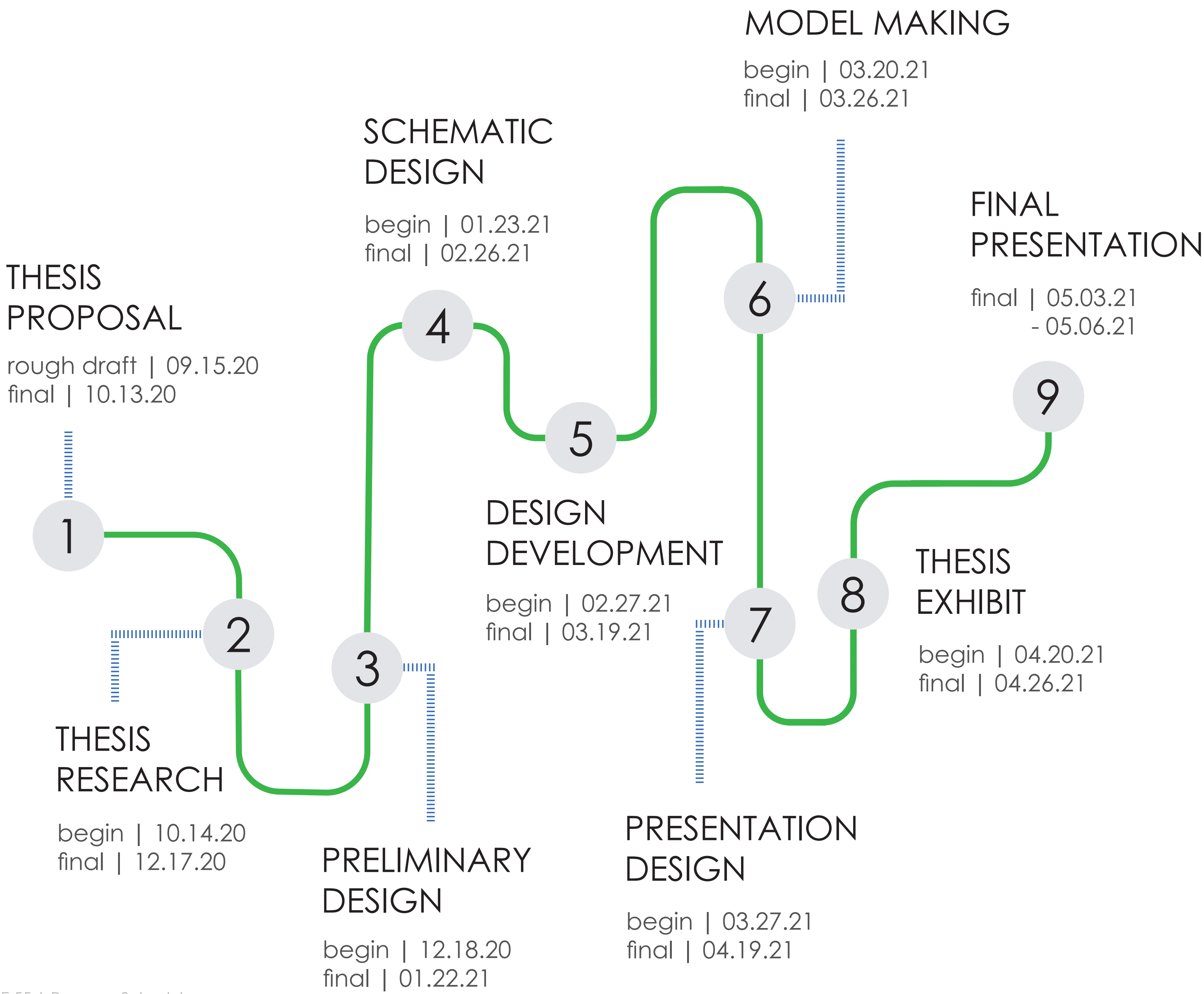


FIGURE 55 | Program Schedule

PLAN FOR PROCEEDING | METHODOLOGY & DOCUMENTATION

After the Thesis Proposal and Thesis Research are completed, design of the building will begin. The first step in the design process will be preliminary design. During the preliminary design phase the design direction for the project will be defined. Concepts for the shape and form of the project will be explored and spaces to be included in the design and their required sizes will be determined. The site will be further explored so that the location of the building on the site will be set. Once this information is established, spatial planning will ensue. For this phase a sketchbook will be the primary method of documentation. Sketch up may also be used to explore different shapes and forms of the building. Following preliminary design will be the schematic design phase. During this phase the building's shape will begin to take place. The form of the building will be determined and floor plans will be created. A large portion of this phase will be directed towards implementing the necessary items required to make the building zero energy. During this phase programs such as Sketch up, Autocad, and most significantly, Revit will be used to represent the design. The schematic design phase will be followed by the design development phase. At this time drawings will be finalized. Incorporating details will be crucial in producing a sophisticated design. Details such as materials and finishes will be determined and modeled using Revit. During the design development phase the digital model in Revit will be finalized and prepared for the rendering software, Lumion. Photoshop may also be used in this phase to produce final drawings.

PLAN FOR PROCEEDING | METHODOLOGY & DOCUMENTATION

Next, once the design is finalized, a physical model of the building and site will be developed to give a visual scale and proportion to the design. Laser cutter and 3D printer technologies will help to hand model the building and the site. Additional models will be made as necessary and physical samples of materials should be obtained for the presentation. Once the design phases are completed and the model made, it will be time to put together the final presentation displaying the project to the viewer. Final drawings will be printed and added to the presentation. Final images will be taken of the Revit model in Lumion and edited using Photoshop. Final drawings will be combined into a cohesive presentation using InDesign, Photoshop, and Illustrator. Diagrams showing the structure, sustainable design solutions, biophilic design solutions, etc. will be created and added to the presentation as necessary. This stage is extremely important as the design must be presented in an artistic, cohesive manner that displays all aspects and portrays the intent of the design.

agriculture [**ag**-ri-kul-cher]

noun

1 the science, art, or occupation concerned with the cultivating land, raising crops, adn feeding, breeding, and raising livestock; farming.

aquaponics [ak-w*uh*-**pon**-iks ah-kw*uh*-]

noun (*used with a singular verb*)

1 a farming system that circulates wastewater from animal aquaculture to hydroponically cultivated plants, whereby the plants draw nutrients from the waste and filter the water, allowing for its recycled use by the aquatic animals.

biodiversity [bahy-oh-di-**vur**-si-tee, -dahy-]

noun

1 diversity among and within plant and animal species in an environment.

biophilia [bahy-oh-**fil**-ee-uh, -**feel**-y*uh*]

noun

1 a hypothetical human tendency to interact or be closely associated with other forms of life in nature: a desire or tendency to commune with nature.

horticulture [**hawr**-ti-kul-cher]

noun (used with a singular verb)

1 the cultivation of a garden, orchard, or nursery; the cultivation of flowers, fruits, vegetables, or ornamental plants

2 the science and art of cultivating such plants.

hydroponics [hahy-dr*uh*-**pon**-iks]

noun (used with a singular verb)

1 the cultivation of plants by placing the roots in liquid nutrient solutions rather than in soil; soilless growth of plants.

vertical farm [**vur**-ti-k*uh*l **fahrm**]

noun Agriculture.

1 a multistory structure in which large-scale, intensive agricultural production takes place, using stacked, inclined surfaces to grow food crops, and sometimes to raise livestock and fish:

Vertical farms and other urban agricultural initiatives can reduce our dependence on imported food.

zero energy building [**zeer**-oh **en**-er-jee **bil**-ding]

noun

1 any building or construction characterized by zero net energy consumption and zer carbon emissions calculated over a period of time.

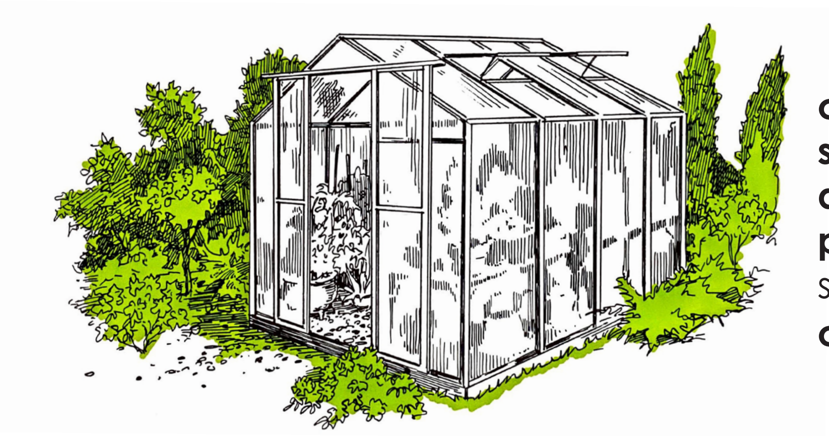


FIGURE 56 | Conventional Greenhouse

CONVENTIONAL

cost: engineered trusses can be costly
structure: very sturdy, good long term, simple
align: axis east-west
pros: simple design, maximum use of space along side walls, efficient air circulation
cons: requires more materials than other methods

FIGURE 57 | Gothic Arch Greenhouse

GOTHIC ARCH

cost: more expensive than hoop house
structure: simple structure, cross bars may be added in center for additional support
align: axis east-west
pros: shape allows for simple water runoff
cons: curved side walls restrict storage space and headroom

FIGURE 58 | Hoop House Greenhouse

HOOP HOUSE

cost: relatively inexpensive
structure: simple structure
align: axis east-west
pros: shape allows for simple water runoff, relatively easy to build
cons: curved side walls restrict storage space and headroom, frame is not as sturdy as other methods

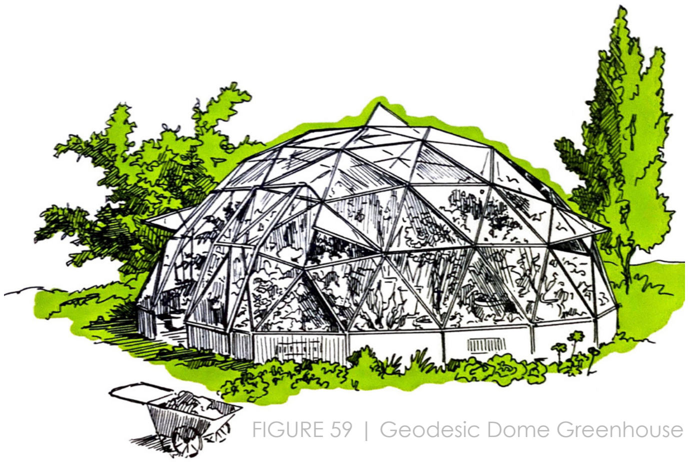


FIGURE 59 | Geodesic Dome Greenhouse

GEODESIC DOME

cost: moderately expensive
structure: simple, no trusses
align: door facing east or west
pros: offer large, open floor space, efficient cooling, good lighting
cons: more expensive than other methods, odd wall angles may affect layout of growing beds

FIGURE 60 | Gambrel Roof Greenhouse

GAMBREL ROOF

cost: engineered trusses can be costly
structure: sturdy, fairly simple
align: axis east-west
pros: gambrel roof shape provides more headroom, maximum use of space along side walls, efficient air circulation
cons: requires more materials than other methods

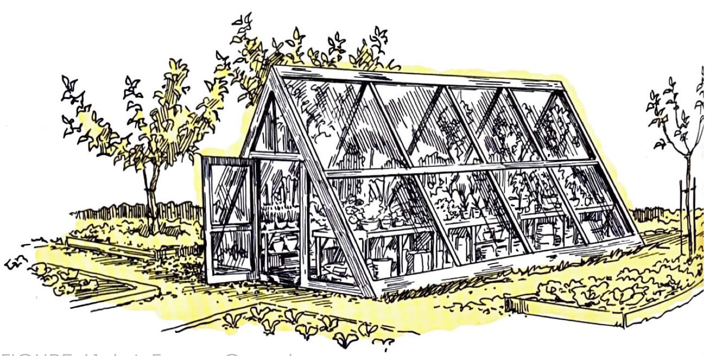


FIGURE 61 | A-Frame Greenhouse

A-FRAME

cost: fairly inexpensive
structure: simple structure, minimal materials
align: facing south, axis east-west
pros: simple, energy efficient design, requires less materials than other methods
cons: narrowing side walls limit use of footprint, air circulation can be prolematic, heat tends to collect in corners and at top, away from plants

DEEP WATER CULTURE (DWC)

- plant roots are suspended in a nutrient solution
- aeration stones oxygenate the solution to prevent the roots from drowning

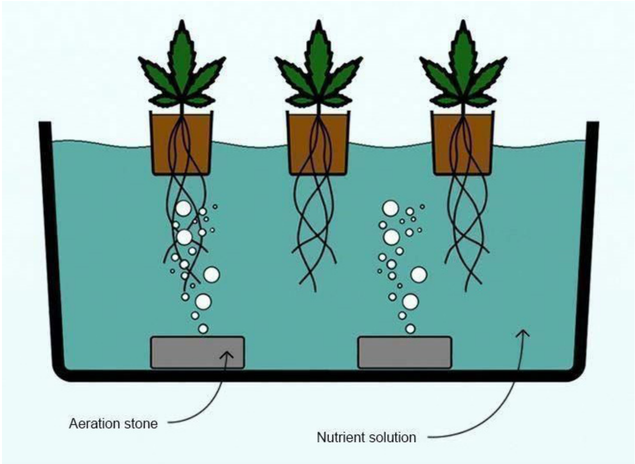


FIGURE 62 | Deep Water Culture

EBB & FLOW (FLOOD & DRAIN)

- a water pump on a timer periodically floods the plants with water from the nutrient solution
- the water slowly drains back into the nutrient solution

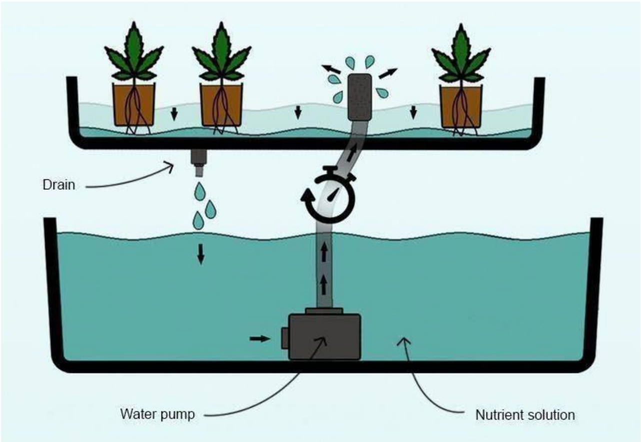


FIGURE 63 | Ebb & Flow

DRIP SYSTEM

- a water pump draws water from a nutrient solution and drips it continuously onto the plants
- the drain returns the water to the nutrient solution (or discards it in some systems)

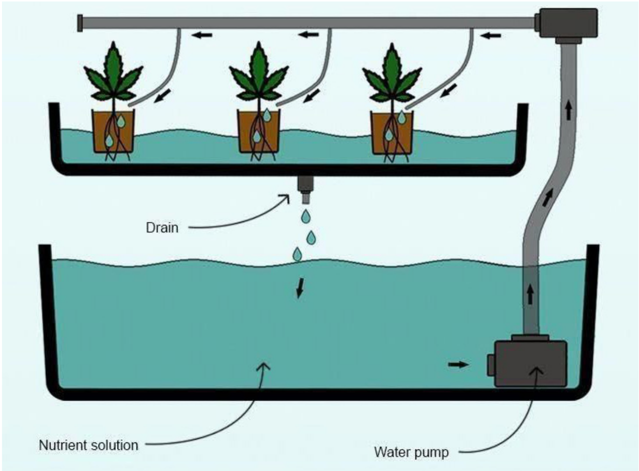


FIGURE 64 | Drip System

BUBBLEPONICS (TOP-FED DWC)

- plant roots are suspended in a nutrient solution
- aeration stones oxygenate the solution to prevent the roots from drowning
- a water pump supplies water directly to the roots via the top-feed

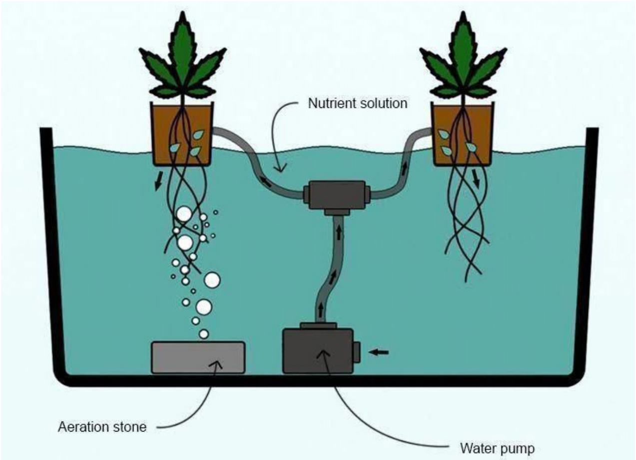


FIGURE 65 | Bubbleponics

AEROPONICS

- a water pump draws water out of a nutrient solution and sprays mist directly onto the roots of the plants

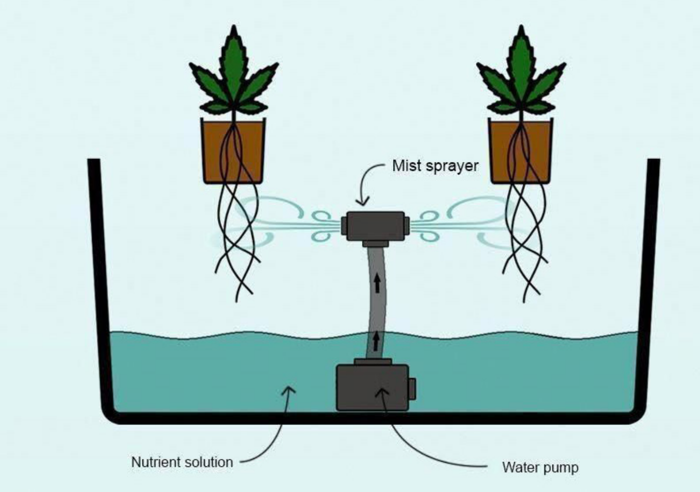


FIGURE 66 | Aeroponics

AQUAPONICS

- nutrients in the fish waste is converted from ammonia to nitrogen and provides food for the plants
- the plants filter the water to keep the fish healthy

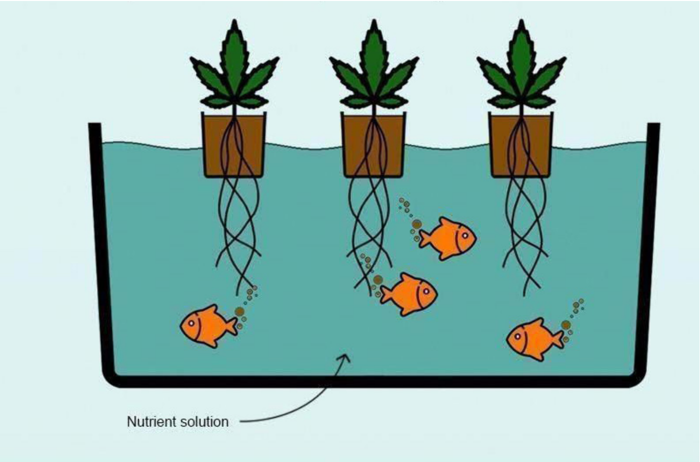


FIGURE 67 | Aquaponics

NUTRIENT FILM TECHNIQUE (NFT)

- plants are secured on a shallow ramp and water is pumped onto the ramp from a nutrient solution
- the water flows down the ramp and back into the nutrient solution via a drain, continuously bathing the roots in the nutrient rich water

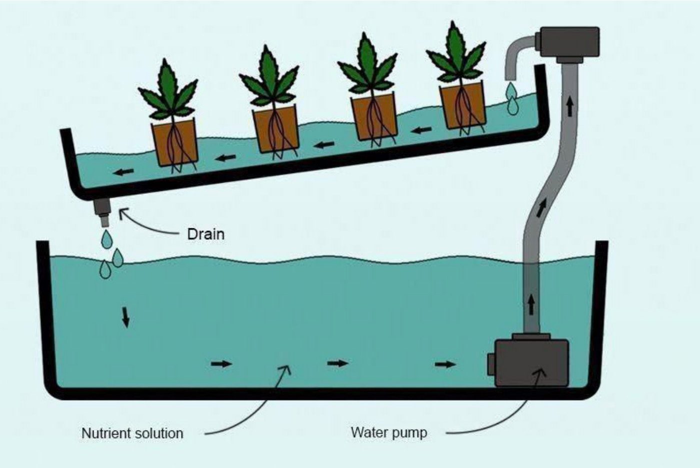


FIGURE 68 | Nutrient Film Technique

HAND WATERED HYDROPONICS

- plants are grown in an inert growth medium
- nutrients are added to the water supply and plants are hand watered

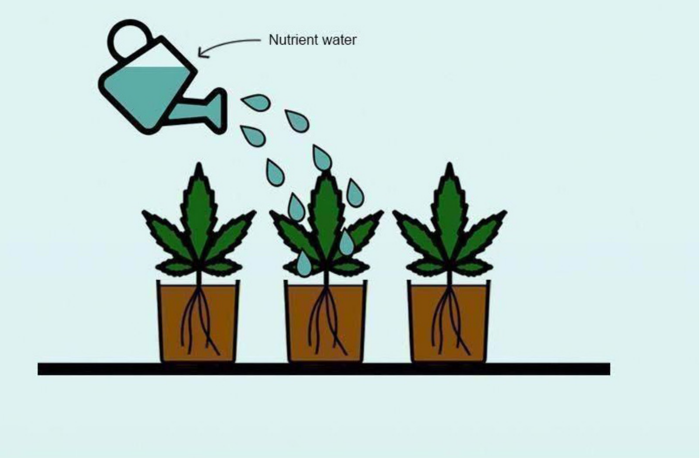


FIGURE 69 | Hand Watered Hydroponics

In his book, “The Veritcal Farm:Feeding the World in the 21st Century”, Dickson Despommier displays vertical farming as a world changing innovation in working towards securing the world’s food supply.

Chapter 5 of Despommier’s book iterates the many advantages of vertical farming. In today’s society, biodiversity is being lost due to modern farming practices. Agrochemicals are being used to reduce, or completely eliminate, competition for the crop that is being grown, resulting in the killing of other organisms such as insects and weeds. Along with the loss of biodiversity, the land itself is being pushed to its limits. The world population is growing tremendously, resulting in more and more mouths to feed, but the earth is not getting any bigger. Farming on soil is not a long term sustainable solution to meeting our growing population’s energy needs. We are locked in an outdated system of food production that requires the use of more and more land to meet the demands of the growing human population. Therefore, alternative methods to traditional farming are needed. Although this can be an expensive venture, there can be no dollar amount put on the natural processes that keep life on earth alive. Creating a city-based agricultural system, as Despommier calls it, would allow us to continue producing food without further damaging the environment. In his book Despommier lists the 11 advantages of the vertical farm. These advantages are as follows:

1. Year-round crop production
2. No weather-related crop failures
3. No agricultural runoff
4. Allowance for ecosystem restoration
5. No use of pesticides, herbicides, or fertilizers
6. Use of 70-95 percent less water
7. Greatly reduced food miles
8. More control of food safety and security
9. New employment opportunities
10. Purification of grey water to drinking water
11. Animal feed from post harvest plant material

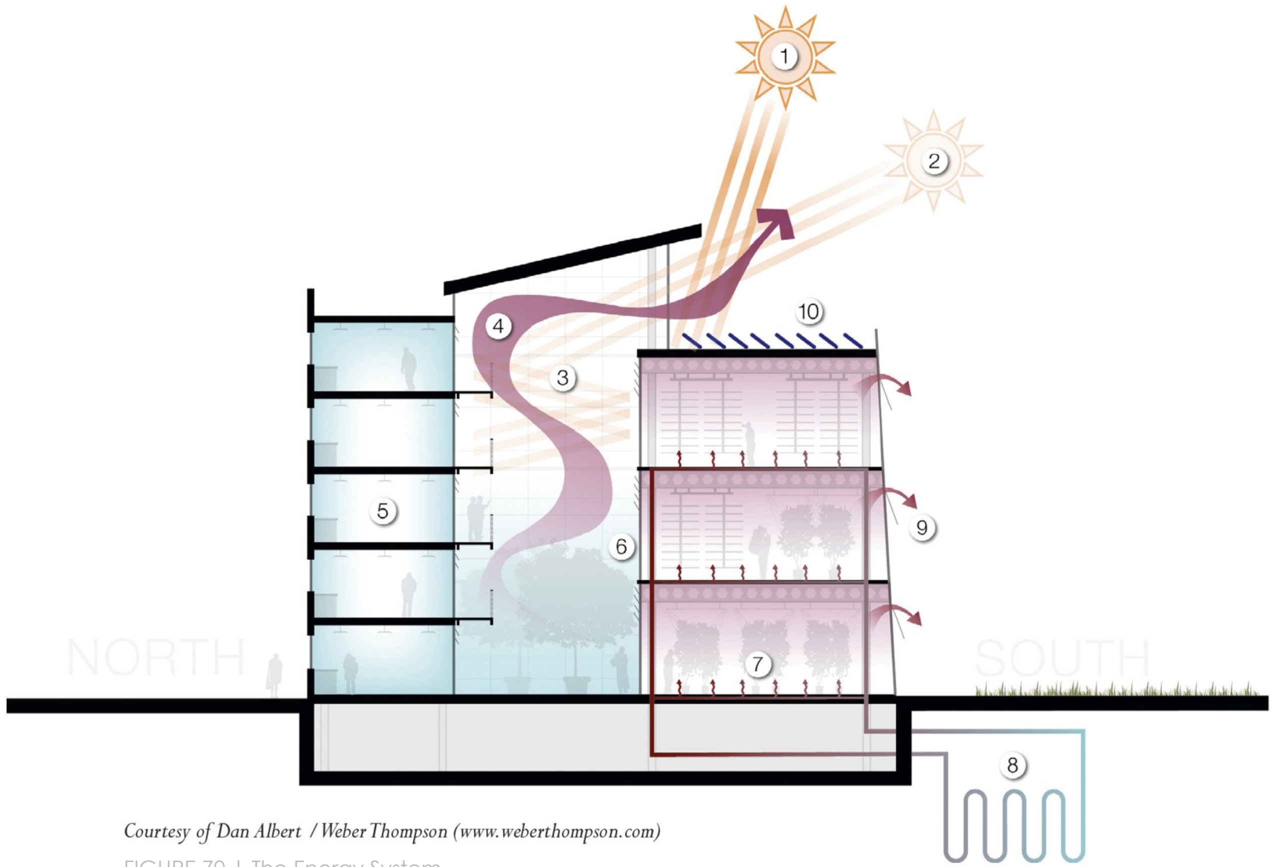
(Despommier, 2011)

In chapter 6 of the book Despommier discusses the configuration for a vertical farm. The building should include an area for growing food, offices for management, a separate control center for monitoring the performance and overall running of the facility, a nursery for selecting and germinating seeds, a quality control laboratory for the monitoring of food safety, documentation of the nutritional facts for each crop, and for the monitoring plant diseases. An important idea to keep in mind while designing the vertical farm building is the concept that the design must be driven by the plants and the needs they have rather than specifically just for humans. Despommier has included four major themes to consider when designing a vertical farm that will be critical for the design of Biodiver“City“. Listed below are these four themes:

1. Capture sunlight and disperse it evenly among the crops
2. Capture passive energy for supplying a reliable source of electricity
3. Employ good barrier design for plant protection
4. Maximize the amount of space devoted to growing crops

There is a clear need in the world for urban vertical farming that Despommier has portrayed throughout his book. When designing the vertical farm for Biodiver“City“ I will consider all advantages listed in the book as well as the critical design themes. It will be crucial to design an environment that is best suited for the plants’ needs so that maximum crop production can take place. The components of a vertical farm go far beyond just the planters and plants themselves. There are many supporting spaces that should be included as well. Each of the components discussed throughout the literature review will be crucial when designing my project in order to produce a building that provides maximum comfort for all of its occupants; both plants and humans equally.

(Despommier, 2011)

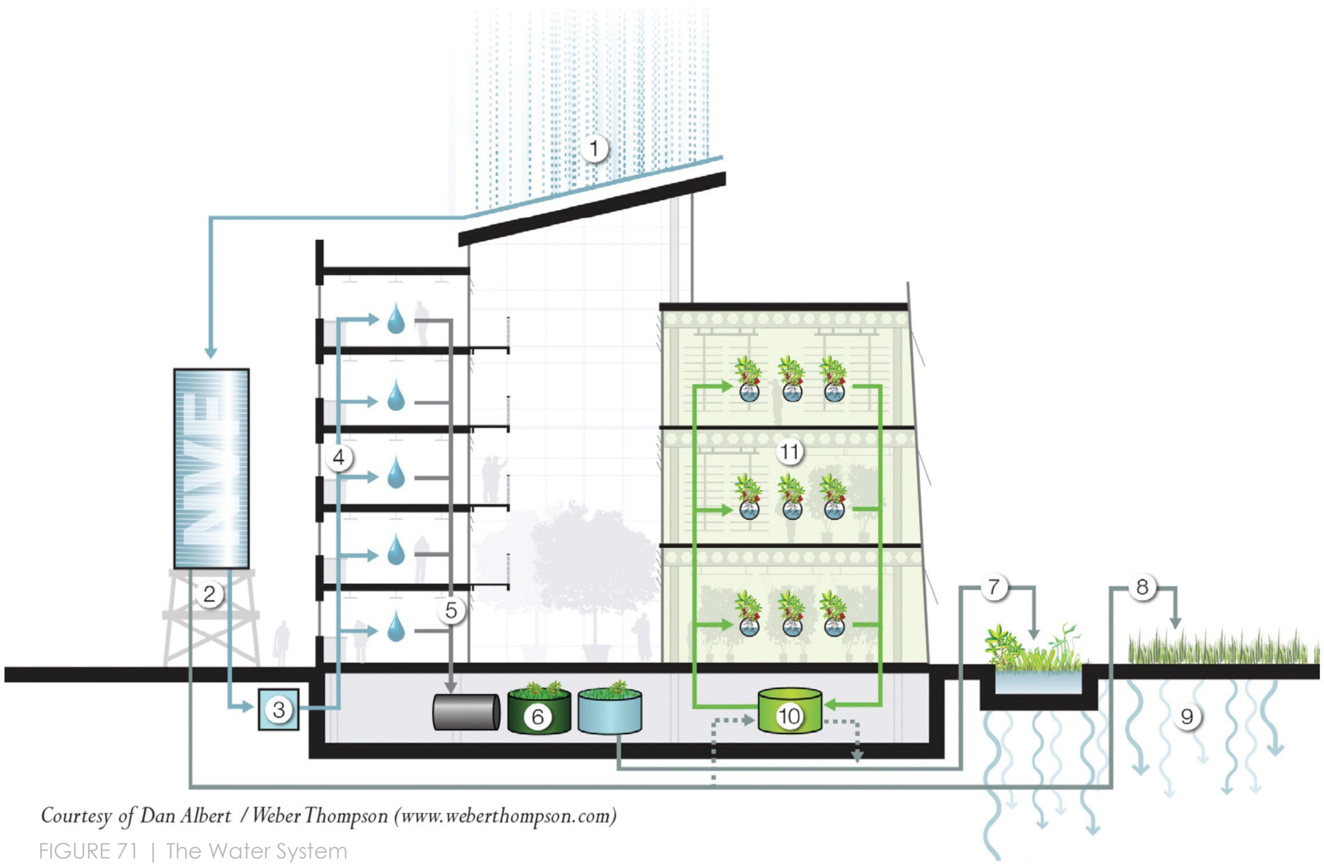


Courtesy of Dan Albert / Weber Thompson (www.weberthompson.com)

FIGURE 70 | The Energy System

THE ENERGY SYSTEM

1. summer sun
2. winter sun
3. reflected light
4. thermal stack
5. north side - cool thermal mass
6. warm air vented from greenhouse
7. radiant floor
8. ground source loop
9. operable vents
10. photovoltaic panels



Courtesy of Dan Albert / Weber Thompson (www.weberthompson.com)

FIGURE 71 | The Water System

THE WATER SYSTEM

1. rain water collection
2. cistern
3. purification
4. potable water
5. grey/black water
6. on-site wastematter treatment
7. output water to wetland system
8. rain water for urban farm
9. on-site infiltration
10. nutrient supply for growing systems
11. hydroponic, aeroponic growing facility

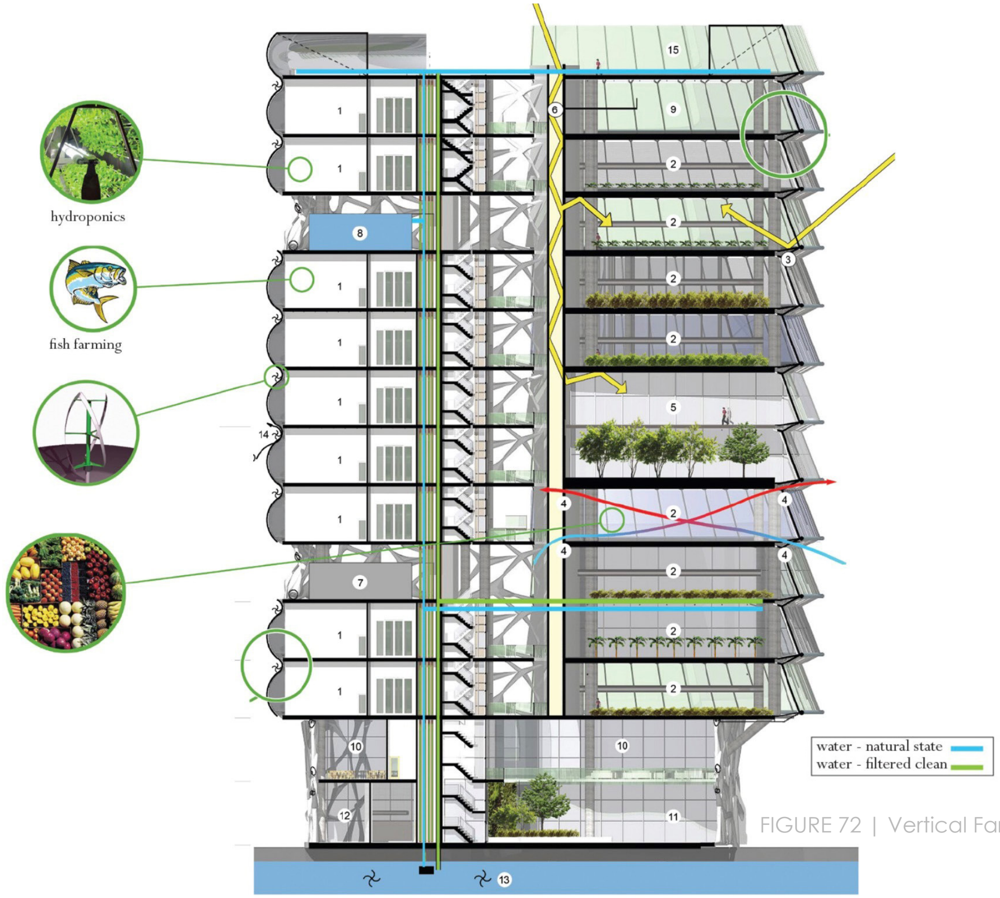


FIGURE 72 | Vertical Farm Section 1

1. hydroponics, aquaponics, processing or accommodation (mixture)
2. crop sections (larger crop type farming)
3. reflective edge or light shelf
4. strategically placed vents provide multiple ventilation scenarios (to further cater for each planting variety)
5. orchard section (more intensive farming)
6. light tube - maximizing the natural light
7. plant level - location is flexible
8. water storage level
9. restaurant
10. cafe/restaurant
11. entry
12. storage
13. water turbines (dependent upon location)
14. wind turbines
15. rooftop farming

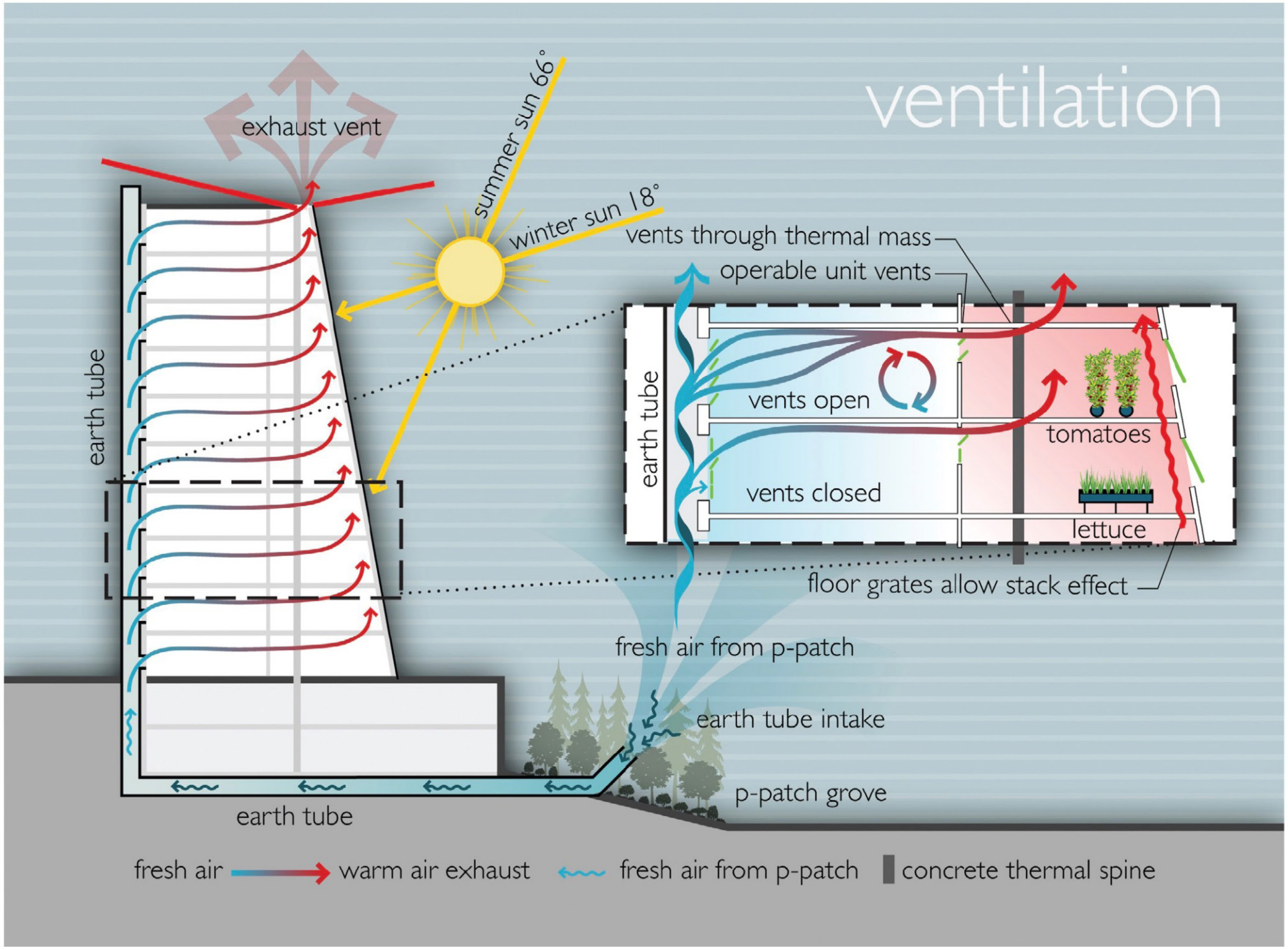


FIGURE 73 | Vertical Farm Ventilation

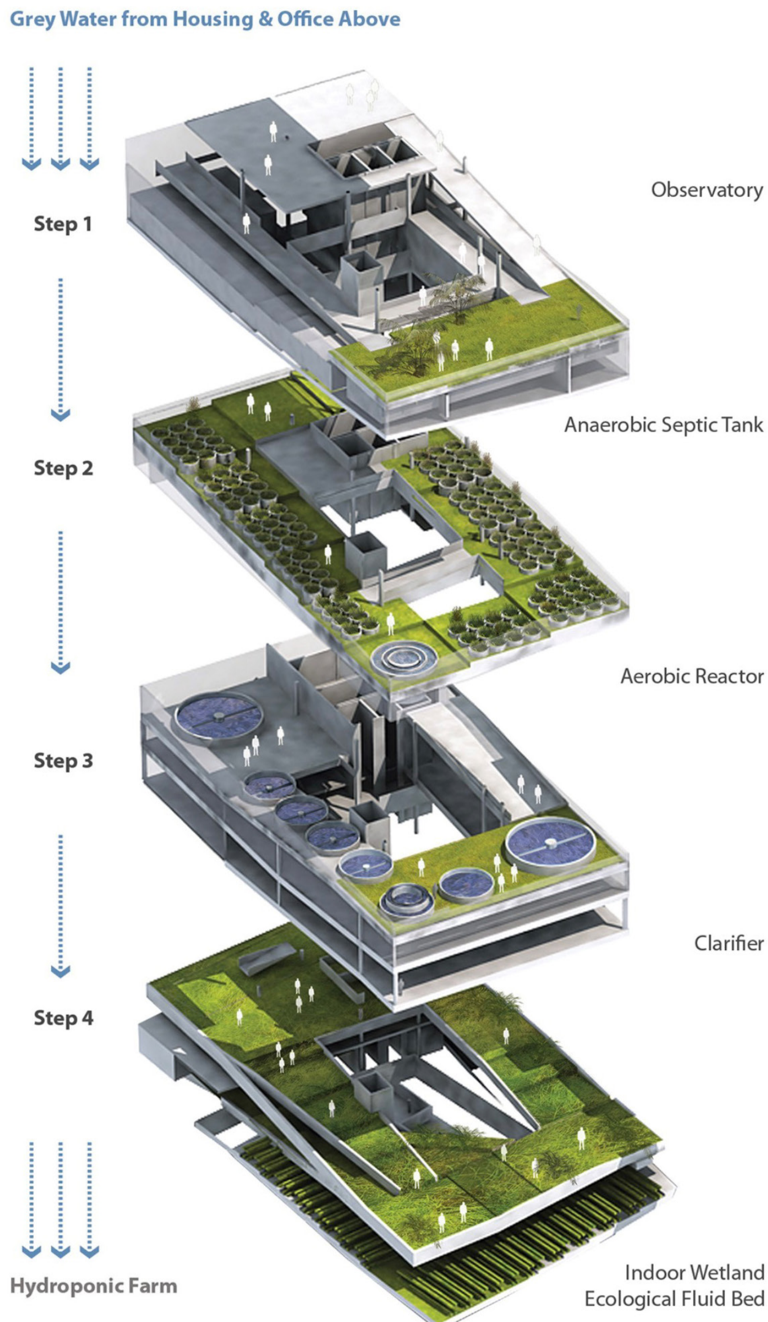


FIGURE 74 | Grey Water System

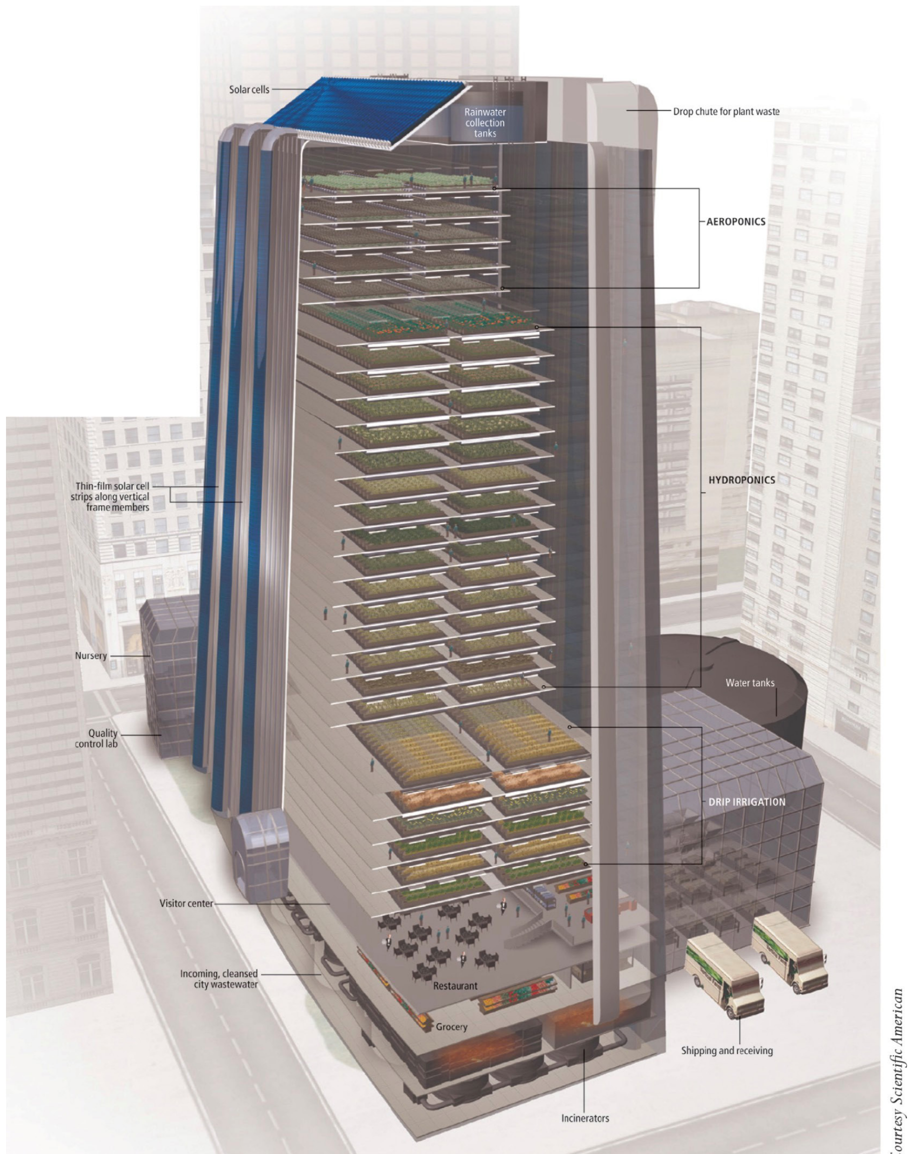
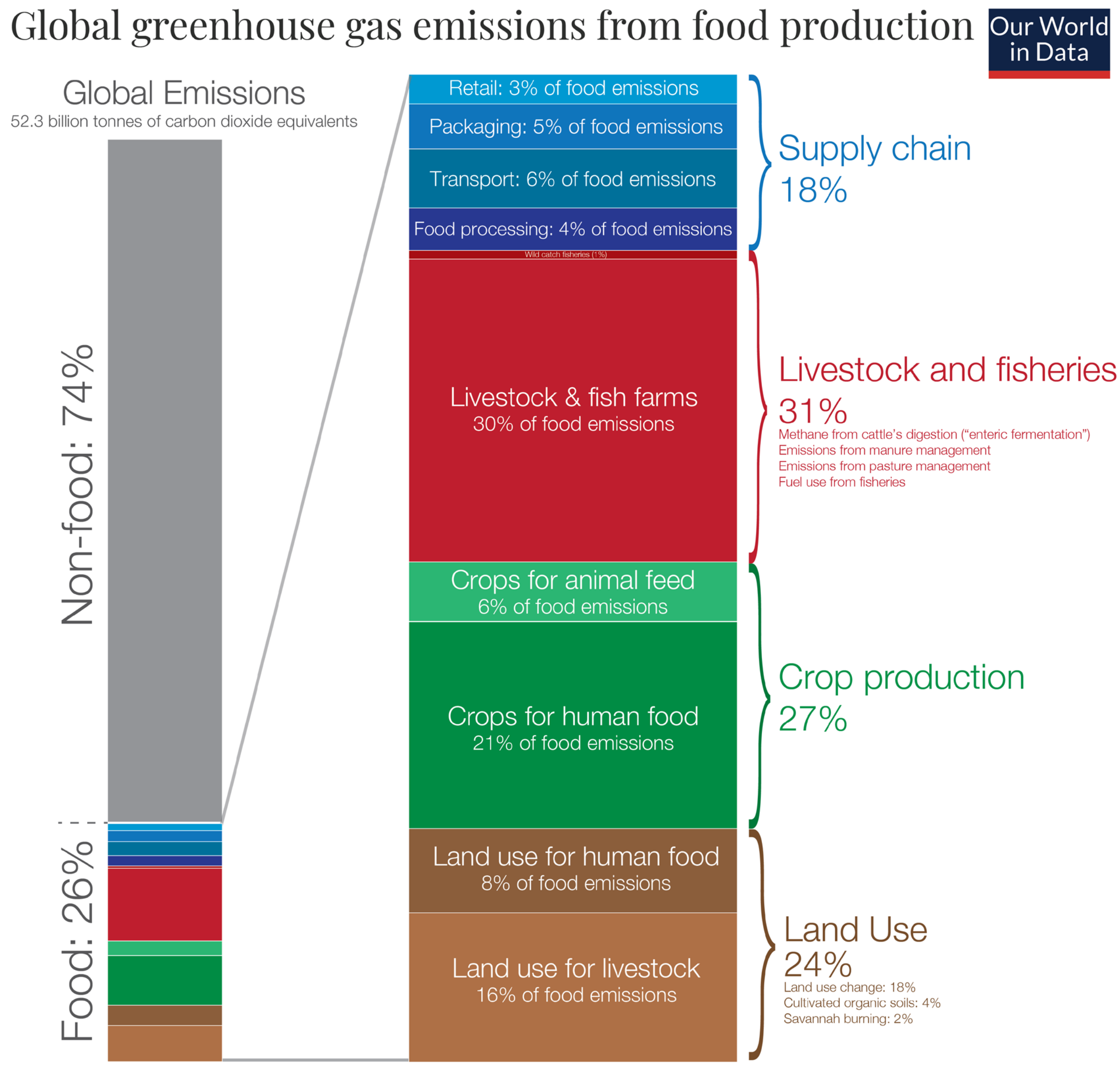


FIGURE 75 | Vertical Farm Section 2

Global greenhouse gas emissions are the main cause for global warming. A large percentage of greenhouse gas emissions today are generated through the food production process. The processes involved in food production and their percentage of the global greenhouse gas emissions can be seen in the chart on the following page. Food's GHG emissions can be quantified into four different categories: land use, crop production, livestock and fisheries, and supply chain. Vertical farms could greatly reduce these numbers. In a vertical farm everything is controlled due to its location indoors. This means that weather conditions aren't a factor in production, and any unwanted pests can be kept out. This eliminates the need for herbicides, pesticides, and fertilizers, which all contribute tremendously to greenhouse gas emissions. If vertical farming becomes more common among larger cities, the amount of fossil fuels burned in the storage and transportation of fresh produce can be greatly reduced as well. Another befit of this aside from the reduction of GHG emissions is that local growing allows for people to know exactly where their food is being sourced from. Food that is sourced locally will not have to endure the processes that transported food does such as refrigeration, freezing, packaging, and the application chemical preservatives. Land use emissions could be reuduced greatly as well, due to the verticality aspect of the vertical farm. Overall, the compactability and environmentally sound methods of vertical farms could contribute highly to reducing the amount of greenhouse gas emissions created from the food production industry (Ritchie, 2019).



Data source: Joseph Poore & Thomas Nemecek (2018). Reducing food's environmental impacts through producers and consumers. Published in *Science*.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

FIGURE 76 | GHG Emissions

Agriculture is the cultivation and exploitation of animals, plants, and other forms of organic life for human use including food, fiber, medicines, fuel, and anything else. Agriculture developed autonomously in various regions of the world. For this reason, a variety of plants and animals have been domesticated at various times and places. Therefore, agriculture has no single, simple origin. The first signs of agriculture seem to have taken place towards the end of the Ice Age, about 11,700 years ago. During that time period temperatures warmed causing glaciers to melt and sea levels to rise, which led to the reorganization of ecosystems throughout the world (Crawford n.d.). The new plant life and patterns of growing that emerged as a result of the Ice Age made the need to move so often less essential for hunters and gatherers. Over time, settlements developed in these areas and agriculture had begun (Mason, 2020).

FIGURE 77 | Ancient Hieroglyphic

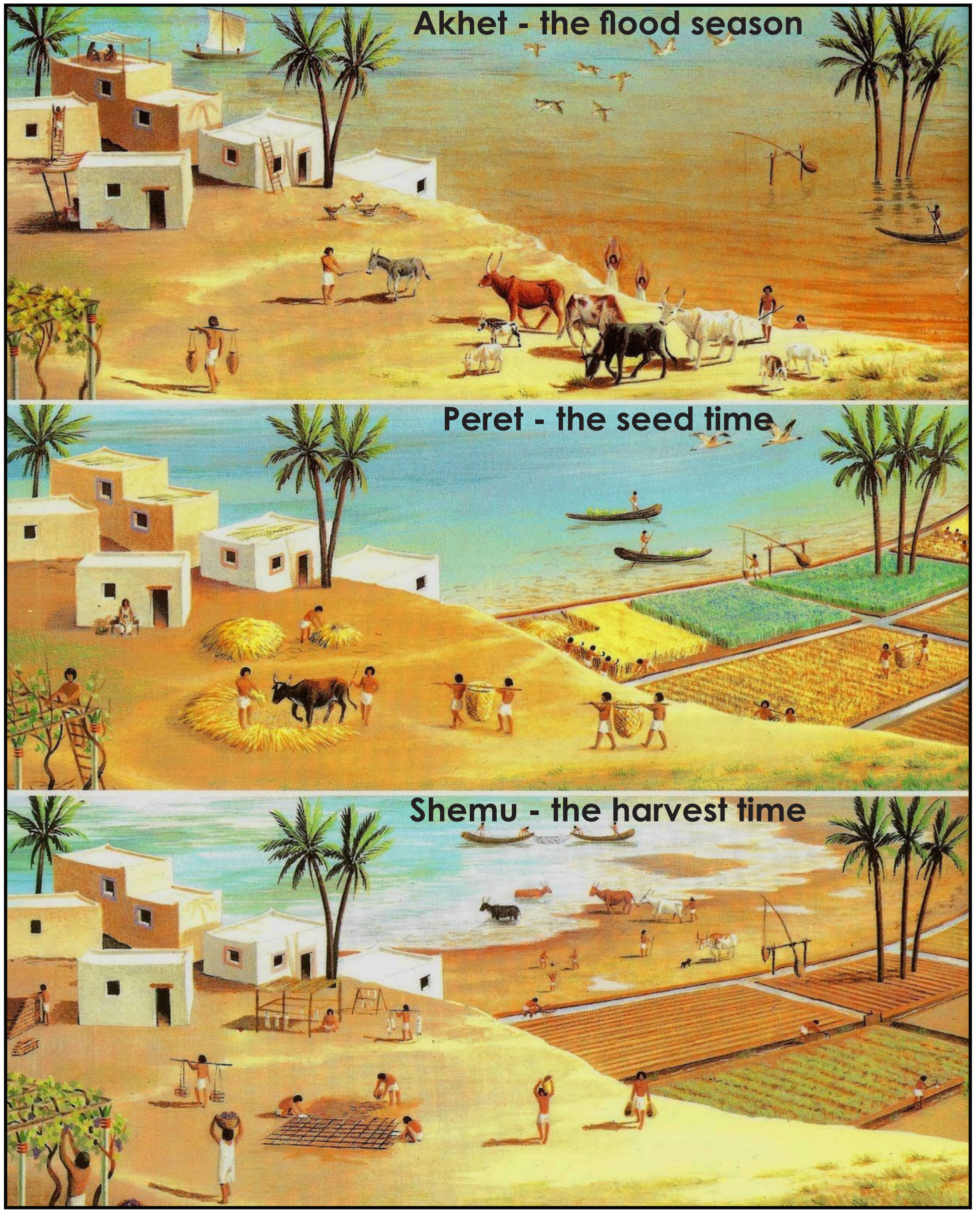


FIGURE 78 | Nile Seasons

Early civilizations grew many crops that still exist today: wheat, barley, flax, plums, grapes, and apples to name a few. Along with food they also grew materials such as cotton and hemp for clothing and coffee and coca for medicines. As a result of these permanent settlements, ancient people were able to domesticate animals such as dogs, sheep, goats, horses, and cows.

These early civilizations made huge advancements in agricultural science and technology. During the time period, around 5500 B.C., Sumerian civilizations understood the need for specialized agricultural work in order for their society to prosper, which led to the invention of the irrigation system. Domesticated horses were used as draft animals for plowing and digging the irrigation canals. This invention along with other technological advancements led to the development of the first cities.

Ancient Egypt had one of the world's most complex agricultural systems of the ancient world. The River Nile contributed greatly to the success of this system. Each year the river would flood its banks and part of the surrounding countryside leaving behind deposits of nutrient-rich soil, allowing for the cultivation of crops such as chickpeas and lentils, lettuce, onions, garlic, corn, barley, papyrus, and flax.

FIGURE 79 | Hieroglyphics

FIGURE 80 | Ancient Civilization

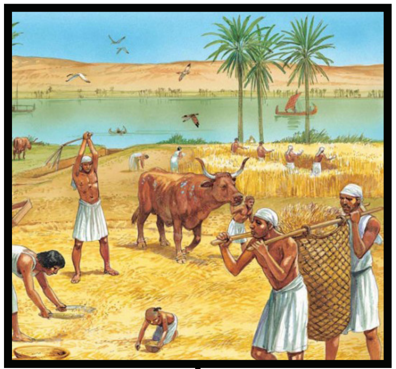


FIGURE 81 | Ancient Farming

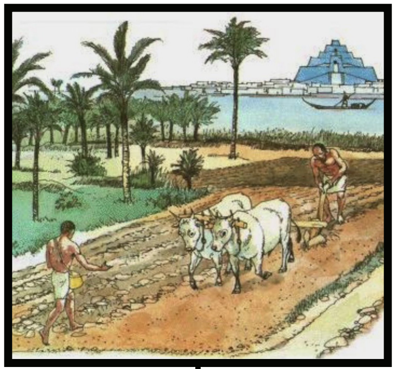


FIGURE 82 | Domestic Animals

about **11,700 YA**

THE BEGINNING

The end of the Ice Age reveals new plant life and patterns of growing. The need to move around so often becomes less essential for hunters and gatherers. Agriculture begins.

about **8,000 YA**

CIVILIZATIONS

People are able to rely more heavily on the ability to grow food rather than hunting and gathering. This leads to the development of permanent settlements and communities. In these settlements animals are domesticated and provide materials such as meat, wool, or milk. Crops are not only grown for food, but for clothing and medicine as well.

about **5,500 YA**

NEW ADVANCEMENTS

Sumerian civilizations make new advancements in agricultural technology such as the irrigation system. Domesticated horses are used for plowing and digging the irrigation canals. The workforce is transformed as humans and animals are assigned with specific tasks.

312 BCE - 226 CE

ANCIENT ROME

An aqueduct system is created in Ancient Rome to bring water to the city for irrigation of crops. Further establishment of farming and domestic animals provided an abundance of food and allowed people to pursue topics of philosophy, art, and science.

FIGURE 83 | Medieval Farming

FIGURE 84 | First Tractor

FIGURE 85 | Present Day Farming

600 CE - 1600 CE

MEDIEVAL PERIOD

Farmers developed systematic ways of dividing land into acres. Crop rotation was introduced. More farmland was created from forests and marshes to meet the food demands of the rising population. Tools became more advanced and improved with the use of metals.

1900-1999

THE 20TH CENTURY

Agricultural technologies were developing faster than ever before. The invention of the internal-combustion engine revolutionized the agriculture industry and became the main power source for most farms. The invention and evolution of the tractor during this time would dramatically increase the productivity of agricultural labor.

Today

PRESENT DAY

Crops are grown with the goals of producing the highest yields possible and obtaining the highest profit possible. Synthetic fertilizers, intensive tillage, chemical pest control, and genetic manipulation of crops are all widely utilized in today's highly mechanized agricultural system.

FIGURE 86 | Ancient Mesopotamia

Urban agriculture has been dated back to about 3,500 B.C. in ancient Mesopotamia where farmers began setting aside plots for growing within their cities. Around 1,500 years later, in the same part of the world, aqueducts have been found to be some of the earliest pieces of archeological evidence of urban food production. The aqueducts are believed to have been used to bring mountain water to certain areas of the cities for producing food.

FIGURE 87 | Machu Picchu

Another early example of urban farming, perhaps even early vertical farming, took place during the 1,400's B.C. in the city of Machu Picchu, Peru. This nutritionally self-reliant city reused its scarce water supply over and over as it travelled step-by-step down the beds of the terraced hillside. Biointensive vegetable beds were integrated into these terraced hillsides that were cut progressively steeper, from the valleys up the slopes. The beds were designed to catch the afternoon sun and to elongate the growing season.

FIGURE 88 | Gardens of Babylon

FIGURE 89 | Ancient Egypt Garden

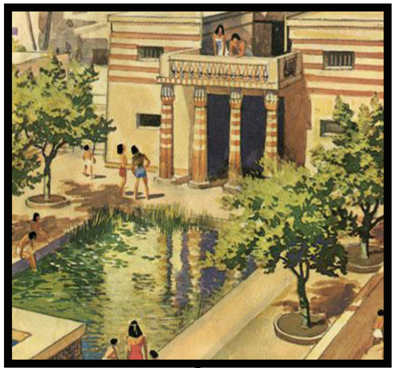


FIGURE 90 | Aztec Gardens

FIGURE 91 | London Park

3500 BC

MESOPOTAMIA

Urban agriculture has been dated back to about 3,500 B.C. where Mesopotamian farmers set aside small plots of land within the city's walls for farming.

2500 BC

ANCIENT EGYPT

Ancient Egyptians utilized fruit and nut trees throughout their growing cities. The trees were not only planted for food, but to provide shade and greenery to the cities as well. These trees were also placed into tombs and holy spaces.

1100 CE

AZTEC FARMING

The Aztecs built a complex garden and canal system for food production. The garden plots, called chinampas, were tied to their irrigation waterways. The chinampas began as small "floating gardens" that were maintained by farmers, but eventually grew to larger scales and were implemented throughout urban areas.

19TH CENTURY

LONDON

Following a long period of industrialization in London, the city had become a global hub of poverty, slums, and inequality. During this time allotments and public parks were introduced in order to maintain certain amounts of land within the city for residents to use.

FIGURE 92 | Germany Gardens

FIGURE 93 | Victory Garden

FIGURE 94 | Indoor Garden

19TH CENTURY

GERMANY

The "Schreber Movement" in Leipzig, Germany was the introduction to organized allotment gardening. The goal of this movement was to maintain green spaces within the city so that children could play in nature. Eventually the movement became more oriented towards growing edible gardens in urbanized areas. The importance of this concept of allotment gardens grew significantly during World Wars I and II, as well as out of plain necessity for fresh food within the city.

1910'S - 1940'S

VICTORY GARDENS

As World Wars I and II took place, food was prioritized for the war effort, resulting in scarcity for those at home. In order to increase food supplies, many countries developed "Victory Gardens" or "War Gardens". These gardens were cultivated by citizens on both private and public land. Victory gardens contributed to a large portion of vegetable produce during these times. Along with the relief to the public food supply, victory gardens were perceived as a way to boost morale and patriotism during these times of war.

2010'S

JAPAN

Japan experienced tremendous growth in urban farming throughout the 2010's. Unique designs from this time period include rooftop paddy fields and bee farms, vegetable gardens under the Tokyo metro, and even farms with animals taking up an entire floor of a skyscraper.

FIGURE 95 | 120 N Broadway Site Map

The chosen site for BiodiverCity is located at 120 N Broadway, Los Angeles, CA 90012. This site was chosen for its' proximity to a local park, transportation, and the Los Angeles City Hall building. Located to the North/Northeast of the site is Grand Park. This beautiful park consists of 12 acres of land containing botanical gardens, memorials, a performance lawn, and a community terrace, with pedestrian paths connecting the spaces. The site's proximity to major transportation hubs allows it to be an accessible destination for all. Another reason for the site location is its' adjacency to the Los Angeles City Hall. Residents of Los Angeles can look to the building as a symbol of the rebirth of biodiversity within their city. Standing tall and proud next to Los Angeles City Hall, BiodiverCity will be a representation of design that breathes new life into a city where large concrete structures and developments have taken over, all at nature's expense.

FIGURE 96 | Downtown L.A. Districts

The site is located in the Civic Center district of Downtown Los Angeles. Its' location in the Civic Center is a popular spot as it is a central gathering area for nearby communities: Chinatown, El Pueblo, and Little Tokyo to the North and East, and the Wholesale District, Fashion District, Historic Core, South Park, and New Downtown to the South and West. The Civic Center is known as the administrative core of the city. This area contains many government buildings including City Hall, courthouses, and federal governt offices.

Average Monthly Temperature in Los Angeles, California

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F	67	67	67	69	70	73
Average low in °F	51	51	51	53	56	58

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in °F	77	79	78	75	71	67
Average low in °F	62	62	62	59	55	51

FIGURE 97 | Average Temperatures

The site for BiodiverCity is located in Los Angeles, California. The city of Los Angeles has a year round mild-to-hot climate. It is located within a Mediterranean type of climate zone, which means the area experiences wet and mild winters followed by hot and dry summers. Its proximity to the ocean allows for cool breezes to be brought in during the summer months and warm breezes in the winter. Mountain ranges surrounding the area allow protection to the city from cooler Northern winds, as well as retaining the warm winds brought up from Mexico. The chart, shown above, displays the average high and low monthly temperatures in the city for each month.

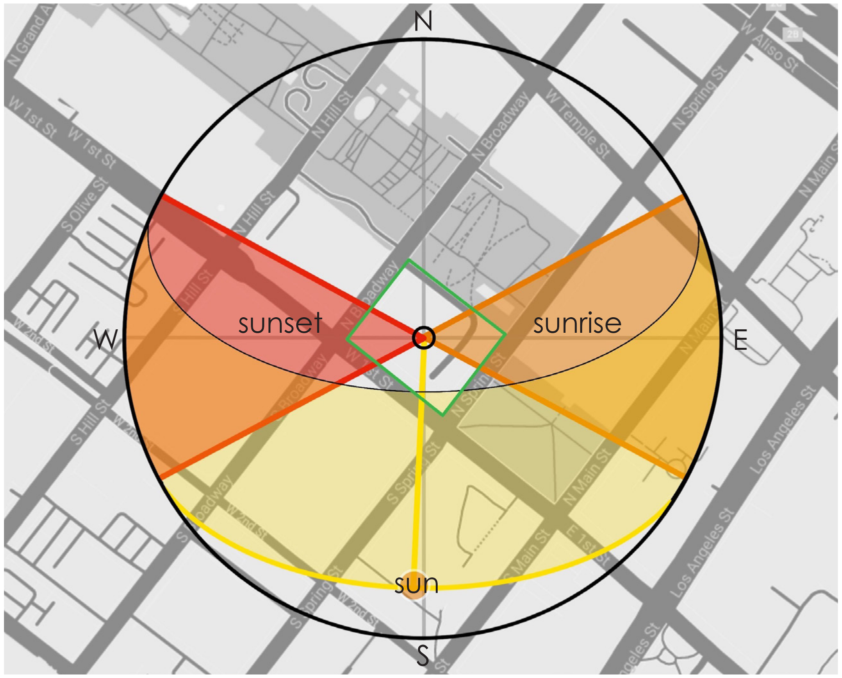


FIGURE 98 | Sun Chart

The image shown to the left represents the yearly sun patterns on the site. In the diagram the sun is shown at its noon position. The yellow shaded region represents the path that the sun travels over the site on average throughout the year. The orange shaded slice represents the direction in which the sun has risen over the course of the last year, while the red slice represents the direction in which the sun has set within the same time frame.

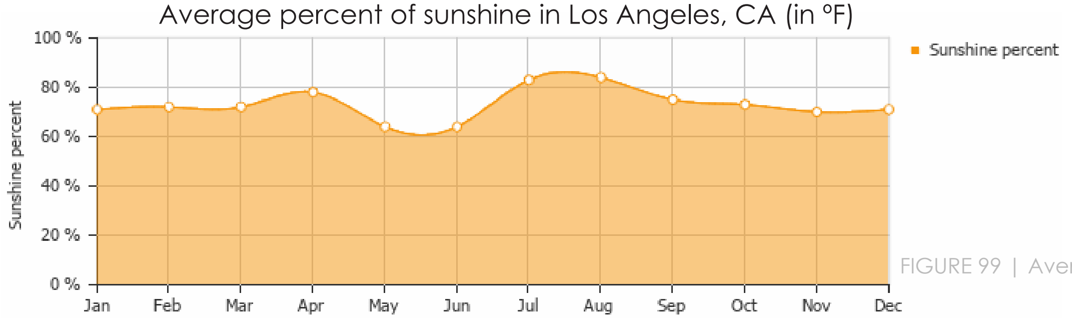


FIGURE 99 | Average Sunshine

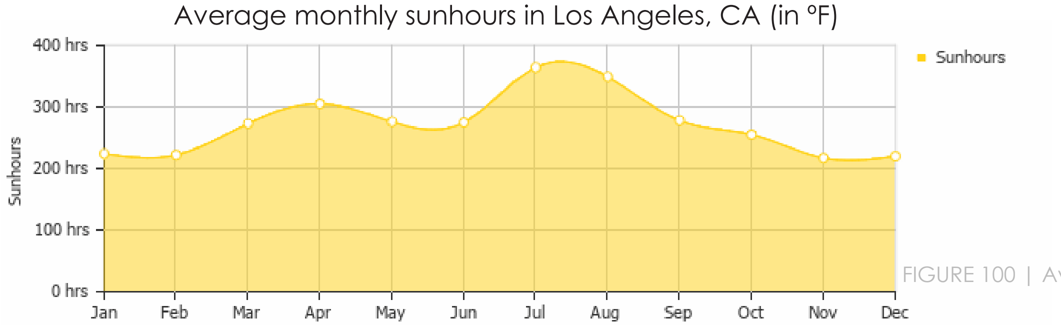


FIGURE 100 | Average Monthly Sunhours

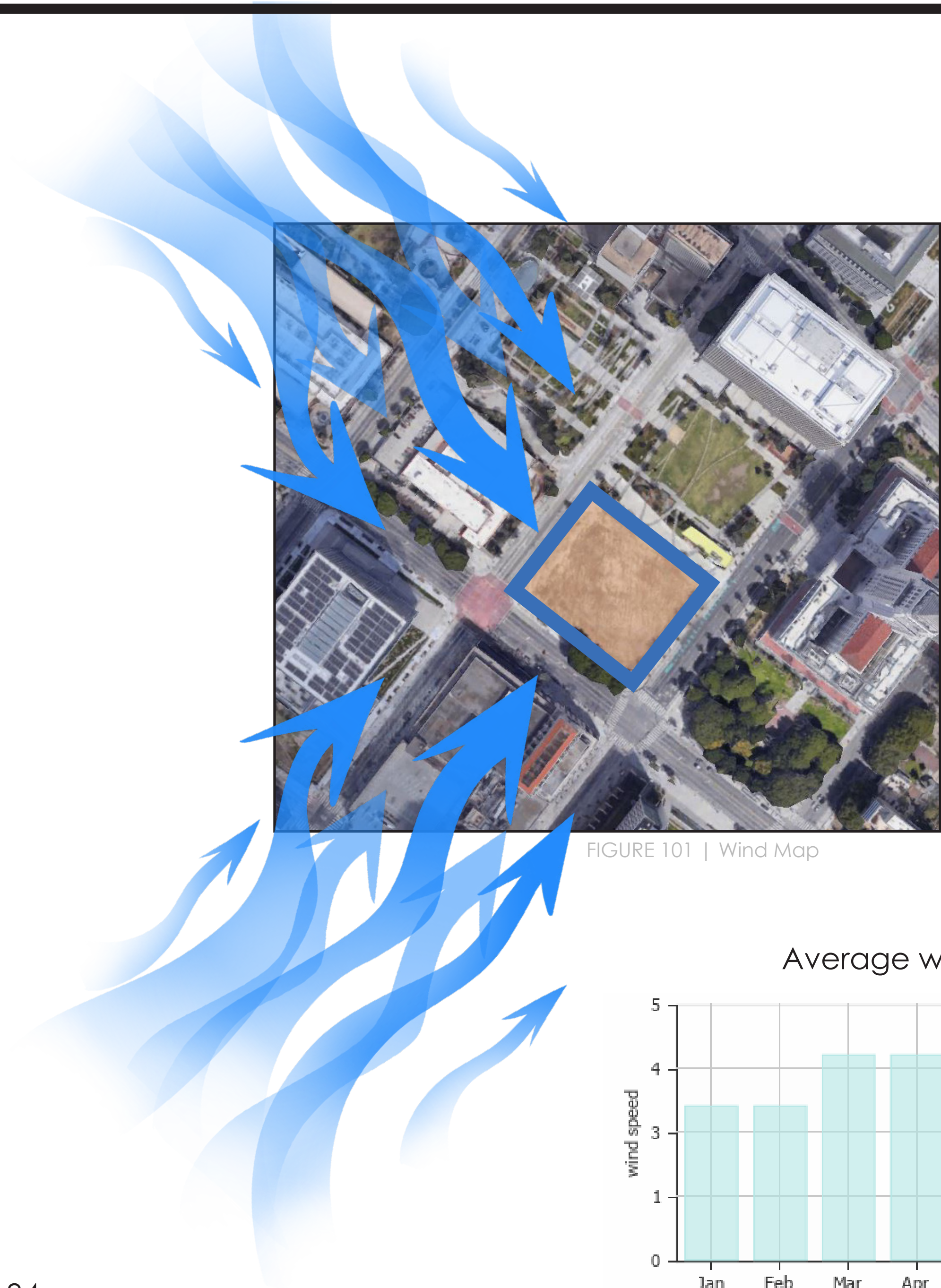


FIGURE 101 | Wind Map

On the site, the majority of summer breezes come from the South or Southwest. During the winter months, most wind comes from the North or Northwest. On average, the site experiences the most wind in July and the least amount of wind in January.

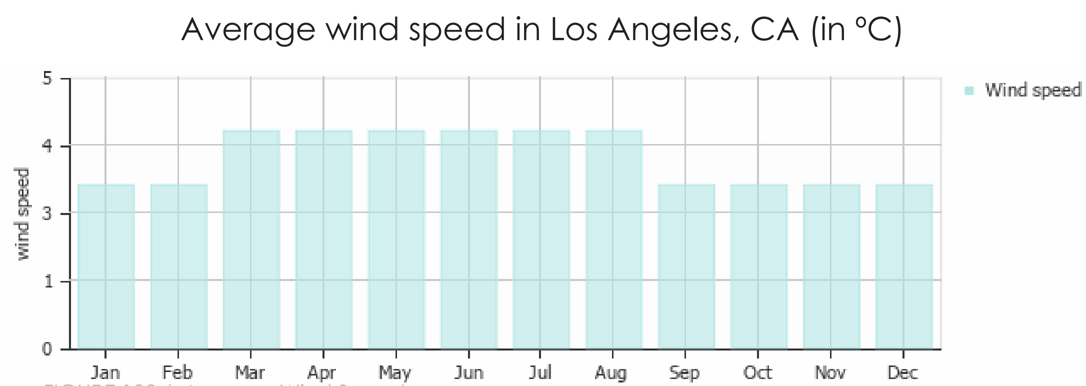


FIGURE 102 | Average Wind Speed

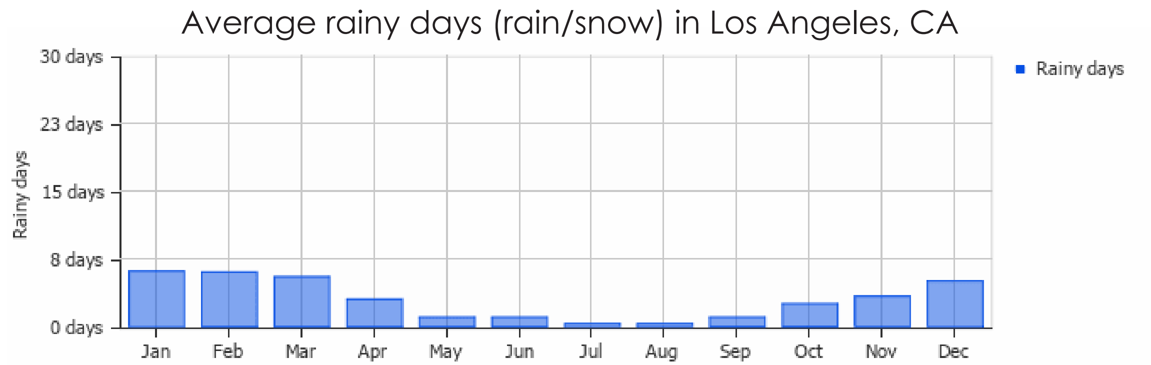


FIGURE 103 | Average Rainy Days

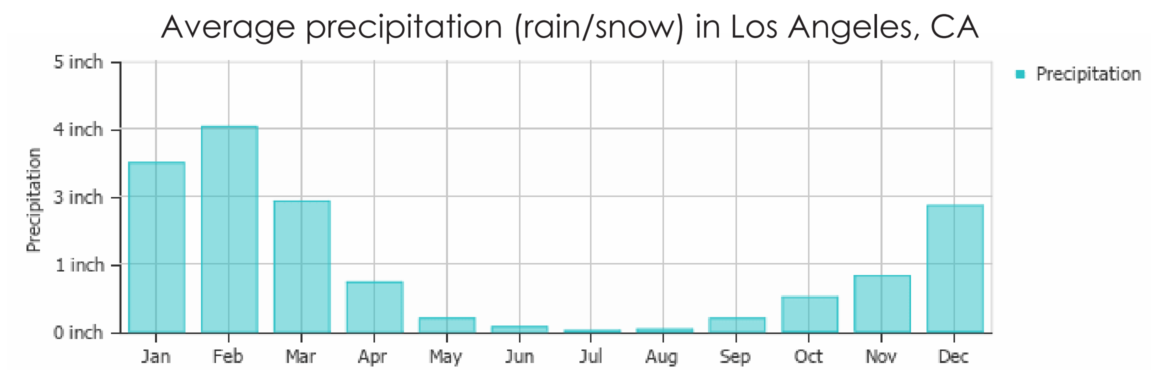


FIGURE 104 | Average Precipitation

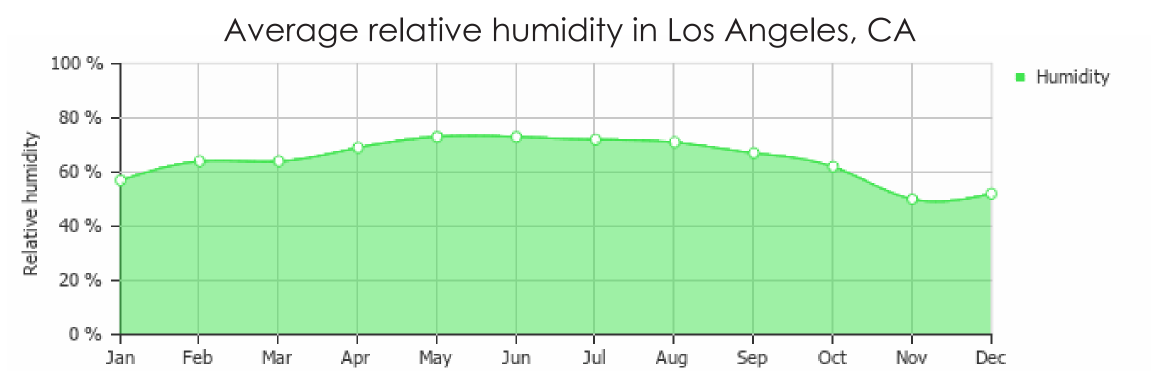


FIGURE 105 | Average Relative Humidity

The charts to the left depict the yearly averages in precipitation and humidity in Los Angeles, California. The city receives the most precipitation in the winter months (Dec.-Mar.) and is driest during the summer and fall seasons. On the contrary, the most humidity takes place in the city during the summer months, and it is least humid in the early winter (Nov.-Jan.).

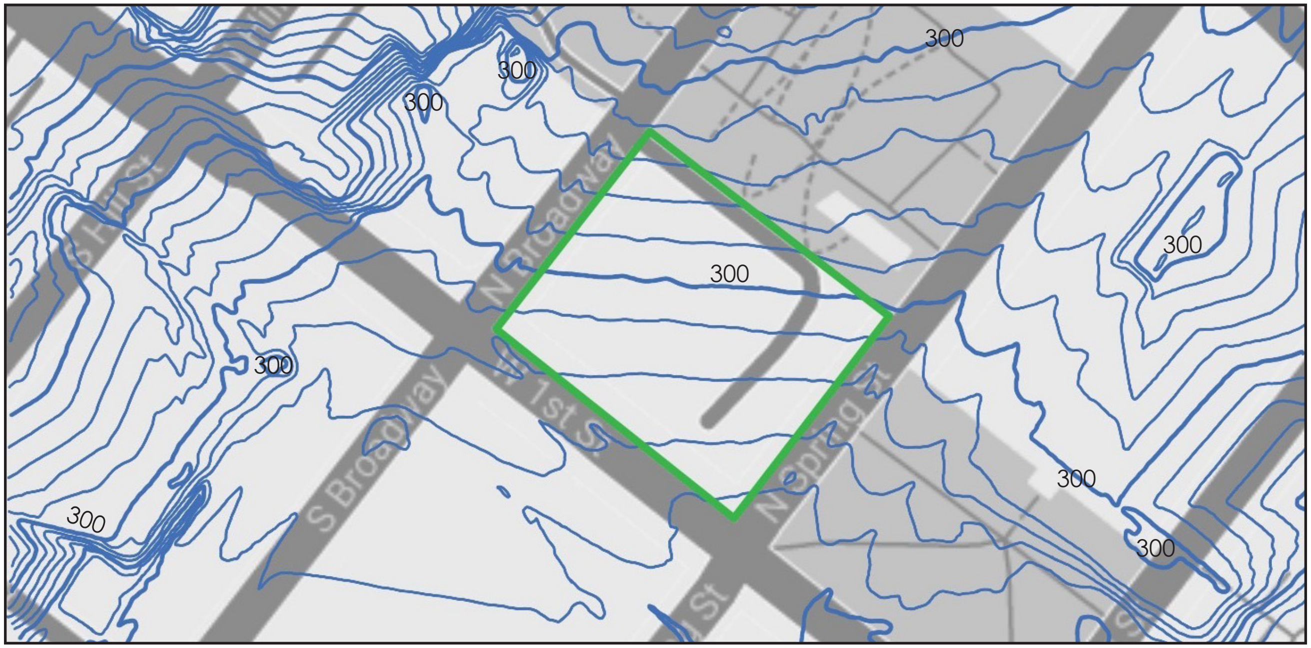


FIGURE 106 | Topography Map

The site is fairly flat, but has a slight slope down towards its Southern corner. This elevation change will create variations in each facade of the design. Due to its slope, water will run off the Southern edge of the site. For this reason, drainage will need to be accounted for when designing at this location. The building will sit towards the center of the site so it will be critcal to design with water drainage in mind, especially on the Northern side of the building to avoid pooling.

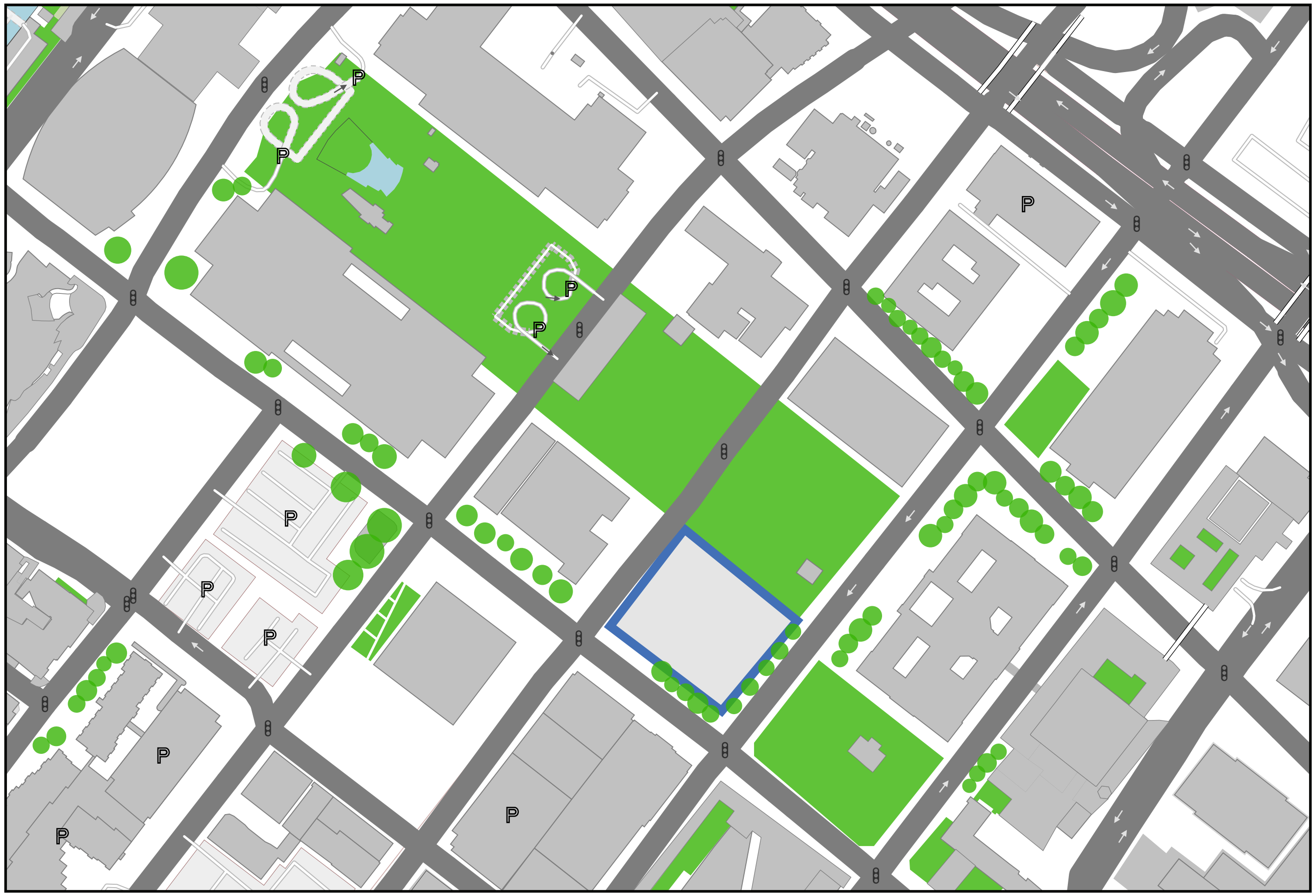


FIGURE 107 | Vegetation Map

The diagram above shows the vegetation on and around 120 N Broadway. Grand Park to the North provides for great views of greenery from the site. There are also beautiful views of greenery around City Hall to the East. The site itself is barren of vegetation aside from several trees along its' Southern borders.

FIGURE 108 | Soils Map

The site is situated upon two different soil types. Both types have high concentrations of urban land soils, meaning that the soil is located in an area of high population density where the native soil has been altered by human materials. The soils on the site are considered high desert soils. They consist of mainly loamy sand with deep and well-drained Entisols. This type of soil is formed in alluvium fans from mainly granitic rocks. There is very low organic material in this kind of soil. The slope ranges from 0-5% in the 1200 zone, to 5-35% in the 1201 zone. Above is a map showing the soil types and their location on the site.

FIGURE 109 | Circulation Map

The site has various transportation hubs allowing for it to be easily accessible to visitors. There are two bus stops on the site: one along the Northwest boundary and one on the Southwest side. The site and surrounding areas offer many opportunities for pedestrian circulation to and around the site. The site is close to a major freeway as well as various transportation hubs, making it an accessible destination for all.

SITE ANALYSIS | SITE CHARACTER

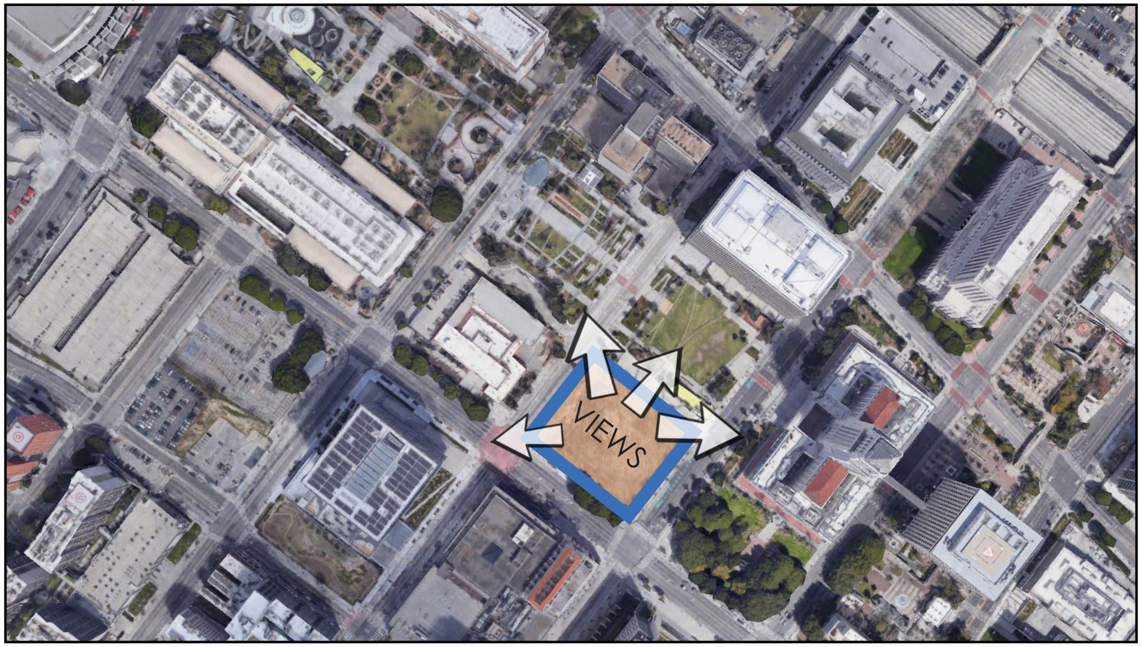
FIGURE 110 | Homeless Tents

The site itself has already been cleared and leveled. This will be an advantage when designing BiodiverCity because there are no existing buldings or obstructions that will need to be cleared. The sidewalks surrounding the site, however, will require some improvements. There is currently a fence around the site that appears to be a gathering place for garbage and weeds. There is also an accumulation of homeless tents that have been set up in the shade of the trees along the Southwestern peremiter of the site.

FIGURE 111 | Site View

FIGURE 112 | Site Fence

FIGURE 113 | Site Views



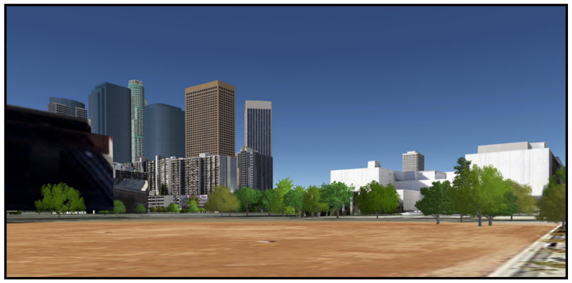


FIGURE 114 | Site Render 1

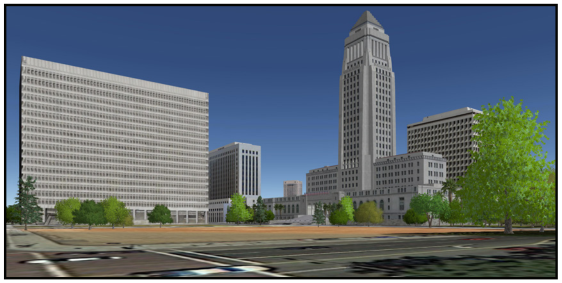


FIGURE 115 | Site Render 2

The best views from the site are towards the adjacent properties to the North and East of the lot. Located directly to the North of the site is Grand Park. The site offers visitors beautiful views into the park's 12 acres of land containing botanical gardens, memorials, a performance lawn, and a community terrace. Following the eye from Grand Park to the East, visitors will see the beautiful Los Angeles City Hall building. Another good view from the site is to the West. This direction gives a nice view into the downtown Los Angeles area.

FIGURE 116 | White Population

WHITE POPULATION

- very high (more than 88%)
- high (79.1 to 88%)
- average (66.1 to 79%)
- low (42.1 to 66%)
- very low (42% or less)

FIGURE 117 | Black Population

BLACK POPULATION

- very high (more than 30%)
- high (19.1 to 30%)
- average (7.1 to 19%)
- low (7% or less)

FIGURE 118 | Hispanic Population

HISPANIC POPULATION

- very high (more than 30%)
- high (20.1 to 30%)
- average (10.1 to 20%)
- low (10% or less)
- none

FIGURE 119 | Am. Indian Population

AMERICAN INDIAN POPULATION

- very high (more than 4%)
- high (2.1 to 4%)
- average (2% or less)
- none

FIGURE 120 | Asian Population

ASIAN POPULATION

- very high (more than 4%)
- high (2.1 to 4%)
- average (2% or less)
- none

FIGURE 121 | Pacific Isl. Population

PACIFIC ISLANDER POPULATION

- very high (more than 4%)
- high (2.1 to 4%)
- average (2% or less)
- none

TWO OR MORE RACES POPULATION

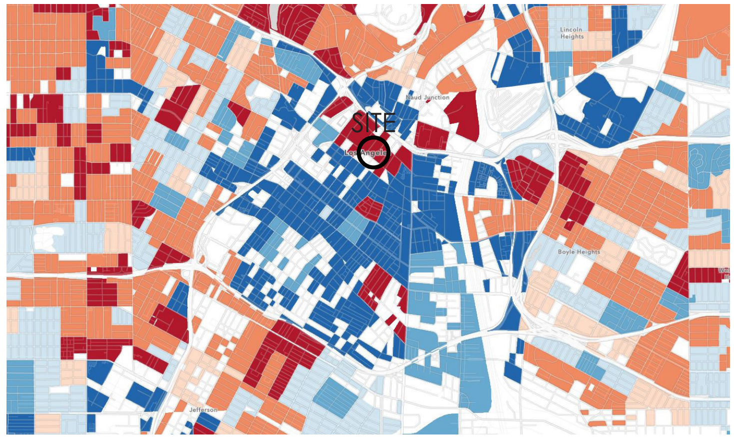
- very high (more than 4%)
- high (2.1 to 4%)
- average (2% or less)
- none

FIGURE 122 | Multiple Race Population

DIVERSITY INDEX

- very high (more than 60%)
- high (47.1 to 60%)
- average (34.1 to 47%)
- low (21.1 to 34%)
- very low (21% or less)

FIGURE 123 | Diversity Index



POPULATION CHANGE
2000-2010

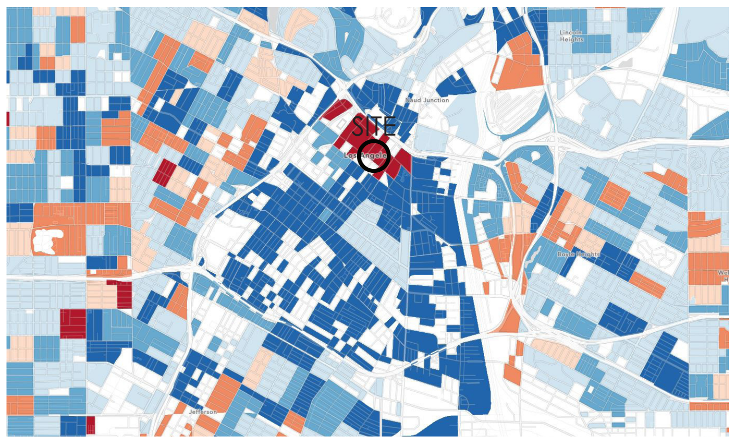
Percent Population Change

GROWTH

Great		More than 1.5
Moderate		0.75 to 1.5
Slight		0 to 0.75
Slight		-0.25 to 0
Moderate		-1.5 to -0.25
Great		Less to -1.5

DECLINE

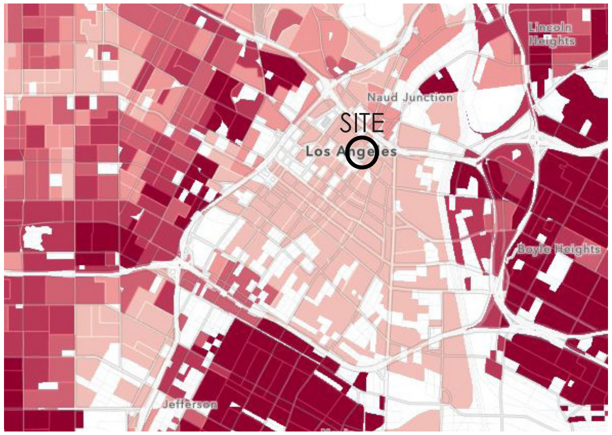
FIGURE 124 | Population Change



POPULATION CHANGE
2010-2017

PROJECTED
POPULATION CHANGE
2017-2022

FIGURE 125 | Age Demographics

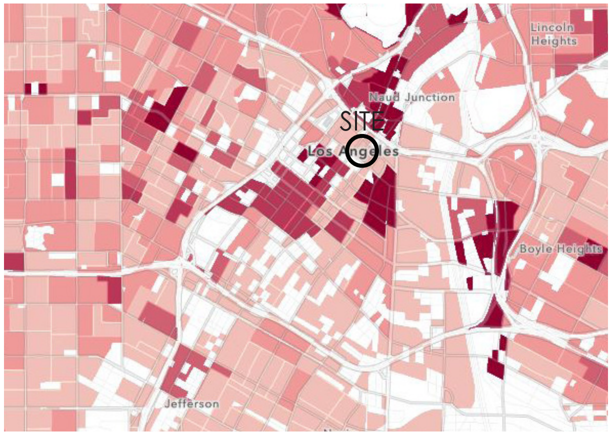


UNDER 18
POPULATION

- very high (more than 28.6%)
- high (25.1 to 28.6%)
- average (21.6 to 25%)
- low (18.1% to 21.5%)
- very low (less than 18.1%)

AGE 18 TO 64
POPULATION

- very high (more than 68.7%)
- high (64.7 to 68.7%)
- average (60.6 to 64.6%)
- low (56.5% to 60.5%)
- very low (less than 56.5%)



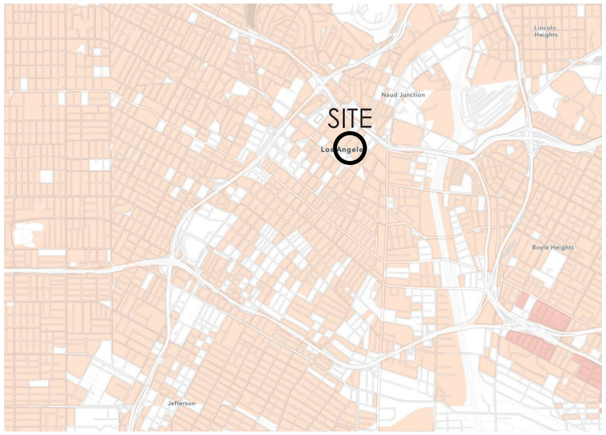
65 AND OVER
POPULATION

- very high (more than 20.2%)
- high (16.1 to 20.2%)
- average (11.9 to 16%)
- low (7.6% to 11.8%)
- very low (less than 7.6%)

FIGURE 126 | Housing Demographics

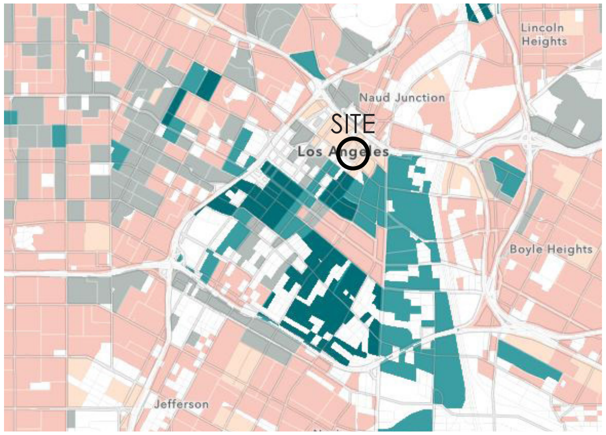
RENTER OCCUPIED HOUSING

- very high (more than 47.3%)
- high (36.3 to 47.3%)
- average (25.3 to 36.2%)
- low (14.3% to 25.2%)
- very low (less than 14.3%)



OWNER OCCUPIED HOUSING

- very high (more than 76.3%)
- high (64.4 to 76.3%)
- average (52.4 to 64.3%)
- low (40.5% to 52.3%)
- very low (less than 40.5%)



VACANT HOUSING

- very high (more than 18%)
- high (13.1 to 18%)
- average (8.1 to 13%)
- low (3.2% to 8%)
- very low (less than 3.2%)

PROJECT JUSTIFICATION

The project that I have delineated is of great importance because it is imperative that biodiversity be restored within environments where land developments have taken over and the landscape has been long forgotten. Farming culture has been left behind as many rely on a trip to the grocery store to get their food with no interest or concern in where this food came from and how it got there.

As climate change becomes more and more apparent in today's society, it is vital that the architecture profession adapts to provide designs that combat the effects of these greenhouse gasses. It is important to find ways for design to become an advocate for the environment in order to create a better future. It is also important to return cultures of farming to a city where this once crucial skill has been long disregarded. New technologies and ways of growing food must be employed as traditional farming methods cannot be performed due to lack of land space resulting from extensive land development over time.

BiodiverCity aims to restore these broken bonds while standing as a landmark for what is possible in the future of architecture for the environment. The environmental and economic benefits of the project will far exceed the justification of the monetary investment made to create the structure. The site's location adjacent ton the Los Angeles City Hall as well as an up and coming city park serves as a gateway for nearby communities to join together to experience the one of a kind design.

PERFORMANCE CRITERIA | ZERO-ENERGY DESIGN

As a building that aims to reestablish biodiversity within the city of Los Angeles, it will be imperative that the building program implements all necessary means of sustainable design in order to produce a zero energy building. Energy efficiency and renewable energy, thermal performance, water efficiency, waste reduction, and indoor air quality are components that can be measured in order to analyze the building's energy use and environmental impact. The EnergyPlus modeling program will be used to analyze the energy use throughout the building. Materiality is another key factor of the building's energy use, but for the purpose of the project's typology and location, I will be allocating it its' own respective category of performance criteria.

FIGURE 127 | Solar and Wind Energy

PERFORMANCE CRITERIA | MATERIALITY

FIGURE 128 | Local Materials

As the framework of the project, material choice will be an integral part of the design. Selection of the most environmentally friendly and energy efficient materials will be an important component when measuring the overall performance of the building. When selecting materials, I will be taking into consideration several factors. The materials' impact on the environment, longevity, and sourcing will be the key components in determining the final material selections as well as, of course, the cost of each product. The materials' direct and indirect impacts on the environment will be examined, as well as the typical life-cycle of the products. Locally sourced materials from the Los Angeles area will be implemented throughout the project as much as possible.

The amount of food produced by the design will be measured (in bushels) along with the required space to grow each crop (measured in square feet). Growing space on each of the floor plans will need to be measured and a sum (in square feet or acres) of feasible planting space will need to be determined. This number will give a basis for how much food can be planted throughout the building. By installing growing trays with product specifications, an accurate measurement of total food production can be gathered. It will be important to determine a realistic production goal for the building. Research into existing urban vertical farms will help to justify an appropriate goal for production. When the design is completed, I will be able to compare the project's total food production with other similar facilities to determine whether the project has reached new vertical farming standards for urban crop production.

FIGURE 129 | Lettuce

FIGURE 130 | Gotham Greens Brooklyn

Gotham Greens
Greenpoint, Brooklyn, NY
15,000 sq.ft.

Built in 2011, this greenhouse was the first commercial building of its' kind. The state-of-the-art facility was designed with a focus on recycling its water supply to greatly reduce energy use. Insects are used to naturally keep produce disease free, rather than harmful chemicals.

FIGURE 131 | AeroFarms Newark

AeroFarms Newark Farm
400 Ferry Street, Newark, NJ
Size: 30,000 sq. ft.

This greenhouse was designed in a former paintball and laser tag arena in 2015. The farm was designed to meet the intense marked demand in the area. It feeds the citizens of Newark and the surrounding areas.

FIGURE 132 | Gotham Greens Queens

Gotham Greens
Jamaica, Queens, NY
60,000 sq.ft.

This greenhouse is located on the roof of the Ideal Toy Company factory. Its' climate-controlled, automated design was completed in 2015 and produces millions of heads of fresh leafy greens each year for the local area.

FIGURE 133 | AeroFarms HQ

AeroFarms Global Headquarters
212 Rome Street, Newark, NJ
Size: 70,000 sq.ft.

This facility was transformed from a steel mill in 2015. Its modular design is very adaptable to fit the space and can be moved around easily if necessary. Based upon the building's annual growing capacity of up to 2 million pounds per year, this greenhouse is the largest indoor vertical farm in the world.

FIGURE 134| Plenty Unlimited

Plenty Unlimited Inc.
San Francisco, CA
Size: 100,000 sq.ft.

Building fits 1,500 acres worth of growing space inside the 100,000 sq.ft. building, and produces up to 350 times more crop than a typical farm of that size.

FIGURE 135 | Gotham Greens R.I.

Gotham Greens
Providence, Rhode Island
Size: 100,000 sq. ft.

This greenhouse, opened in 2019, partners with local companies and community programs to provide fresh produce all year round to the New England region of the U.S. Millions of heads of leafy greens are grown in the facility each year.

BiodiverCity will consist of a vertical farming greenhouse structure connected at its base to a multiuse highrise building. The vertical farm greenhouse will consist of various growing techninques and processes among different floors of the buildling. Along with the vertical farm aspect of this tower will be the offices that are necessary for those who work in the buildling, classrooms for educational purposes, and mechanical spaces to control the building. The base will consist of rentable tennant spaces along with a restaurant and market where the crops grown in the vertical garden can be used and sold. The second tower will consist of apartments. Apartment units will occupy most of the floor space in this tower accompanied by a community room, fitness room, conference room, and other amenities. Biophilic design will be implemented throughout the entire project to create a more seamless connection to nature. Green spaces will be an important part of the biophilic design and will occupy most public spaces throughout the project. The greenhouse project examples on the previous pages were used as studies when determining spatial interactions, as well as the size of spaces in the space allocation table. Various sizes of greenhouses were studied so that a space allocation table could be accurately made for small, average, and large buildings.

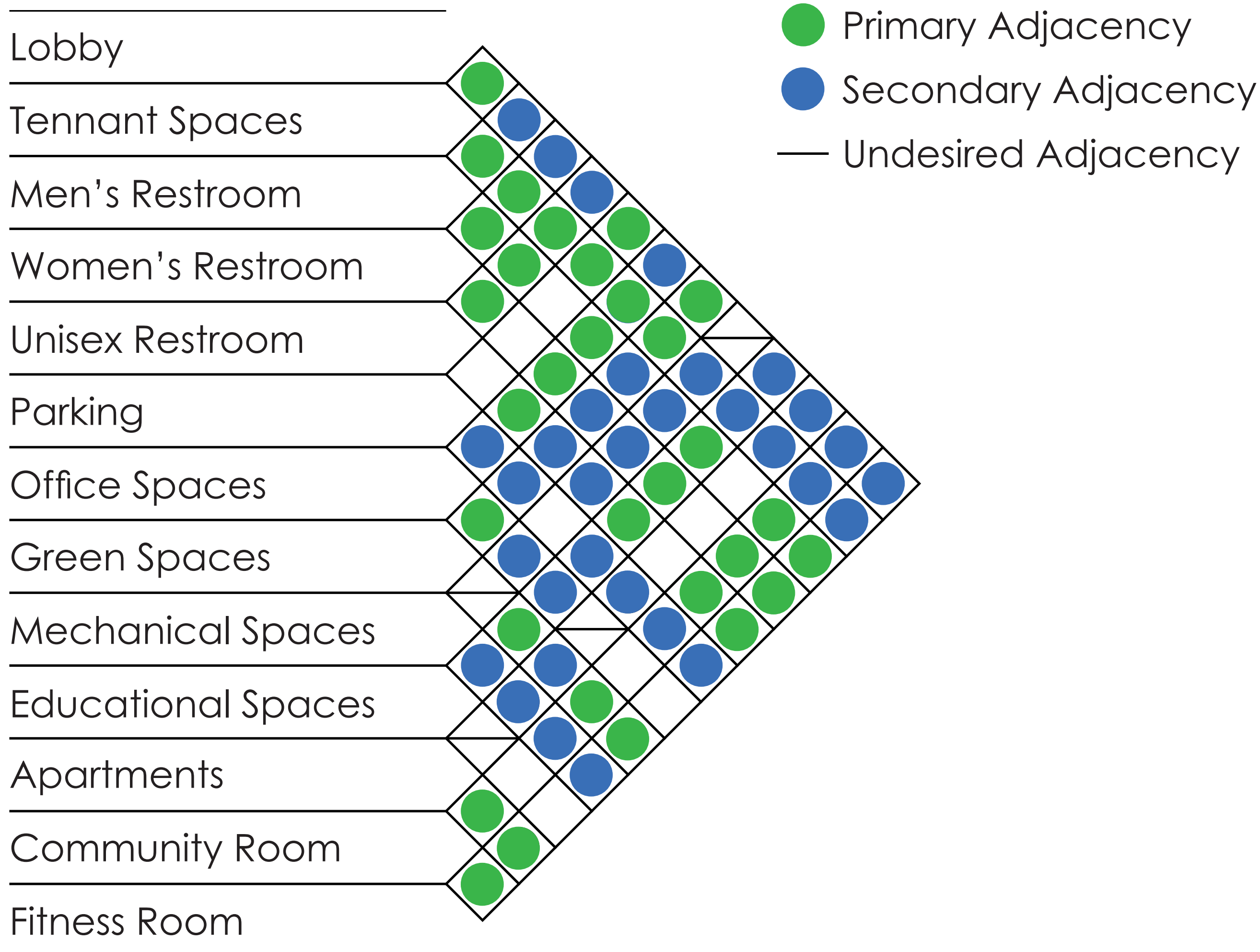


FIGURE 136 | Space Interaction Matrix

PERFORMANCE CRITERIA | SPACE INTERACTION NET

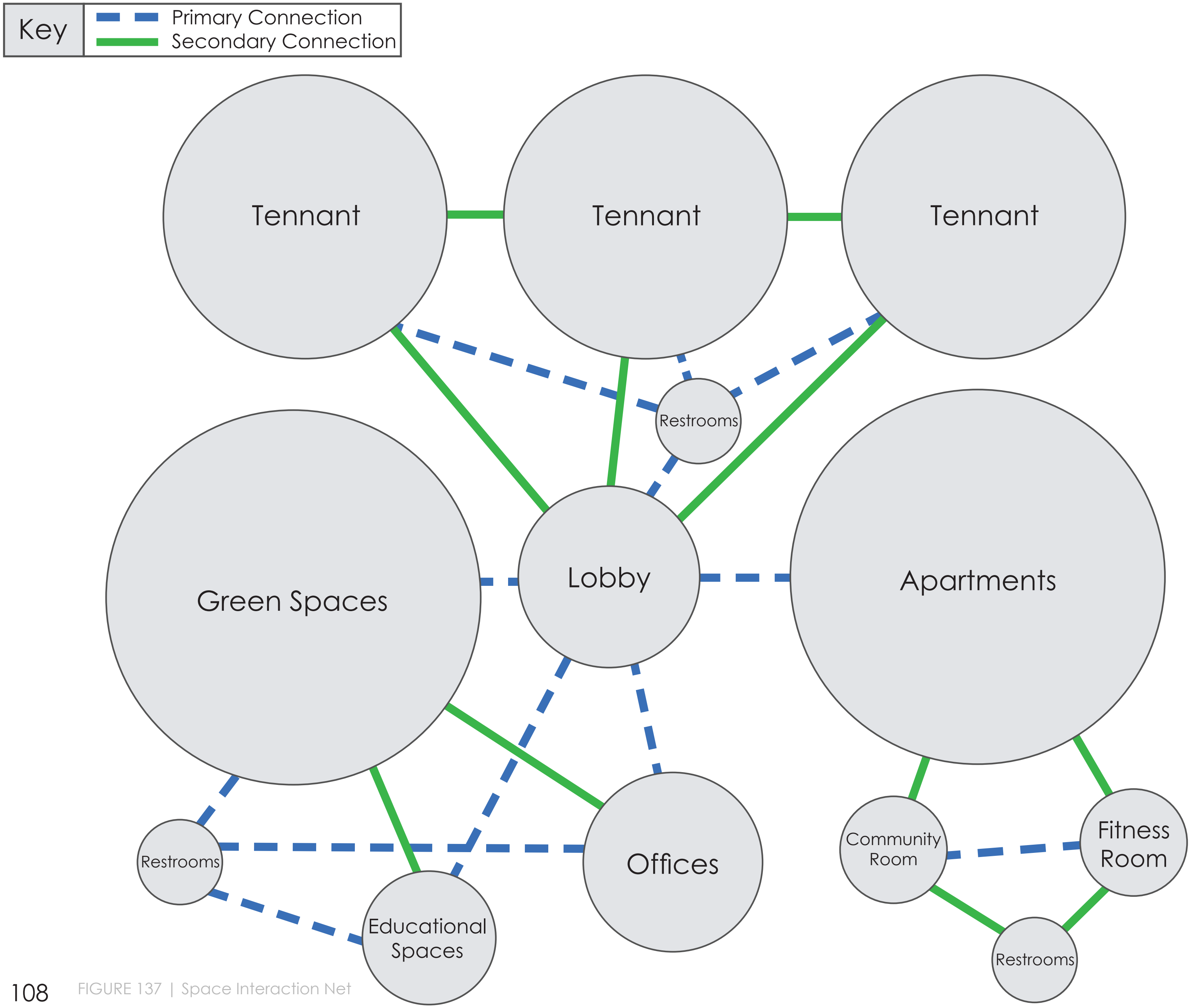


FIGURE 137 | Space Interaction Net

ALLOCATION OF SPACE IN MULTIUSE COMPLEX (in sq.ft.)				
	SMALL	**AVERAGE**	**LARGE**	
Base				
Parking	site	site	site	
Lobby	500	2,000	8,000	1.4%
Tennant Spaces	1,250	2,500	10,000	1.7%
Mechanical Spaces	125	500	2,000	0.3%
	1,875	**5,000**	**20,000**	
Tower 1				
Apartments	25,000	50,000	200,000	34.2%
Fitness Room	250	1,000	2,000	0.3%
Community Room	375	1,500	6,000	1.0%
Mechanical Spaces	1,000	4,000	16,000	2.7%
	26,625	**56,500**	**224,000**	
Tower 2				
Office Spaces	2,500	10,000	40,000	6.8%
Educational Spaces	1,250	5,000	20,000	3.4%
Green Spaces	12,500	50,000	200,000	34.2%
Mechanical Spaces	5,000	20,000	80,000	13.7%
	21,250	**85,000**	**340,000**	
TOTAL	**49,750**	**146,500**	**584,000**	**100%**

FIGURE 138 | Space Allocation Table

Design Solution...

BIODIVERCITY

By the year 2050...

...the world population is expected to exceed 9 billion people.

...two out of every three people are expected to live in urban areas.

...demand for food will
rise by 70 to 100 percent.

... the per capita arable land worldwide will be just .47 acres per person.

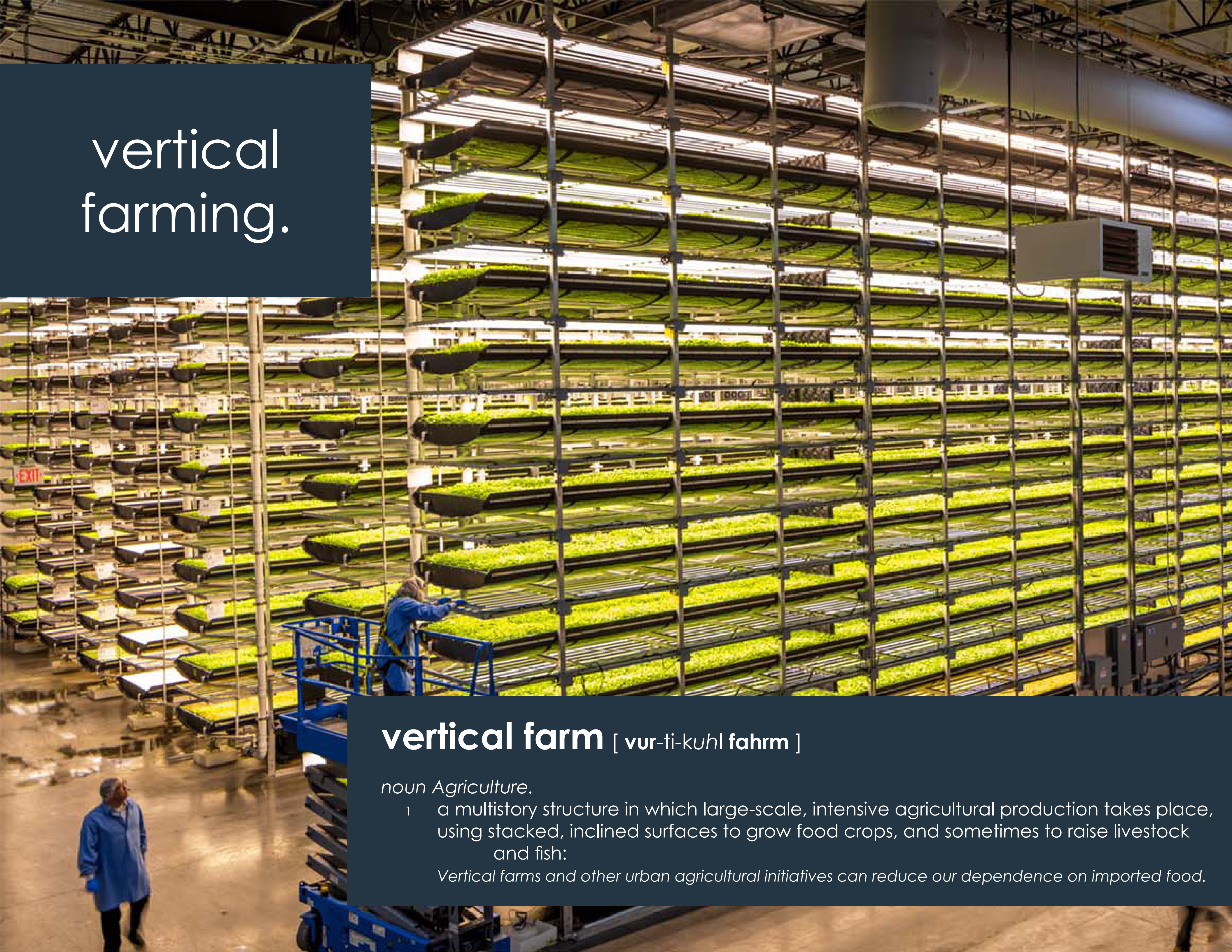
... it takes around 3 acres to feed a single person.

... climate change will decrease the amount of food able to be produced around the world by 2%.

This is equal to about 4.4 million tons, or about 9,768,000,000 lbs. of food.

the solution...

vertical farming.



vertical farm [**vur**-ti-*kuh*l **fahrm**]

noun Agriculture.

1 a multistory structure in which large-scale, intensive agricultural production takes place, using stacked, inclined surfaces to grow food crops, and sometimes to raise livestock and fish:

Vertical farms and other urban agricultural initiatives can reduce our dependence on imported food.

benefits of vertical farming...

indoor, controlled environment allows for year-round production of crops

virtually no need for pesticides or herbicides

reduce greenhouse gas emmisions from food production and transportation

provides fresh, locally sourced produce

benefits of vertical farming...

can use up to 99% less land than traditional farms

can grow up to 400 times more crops per square foot

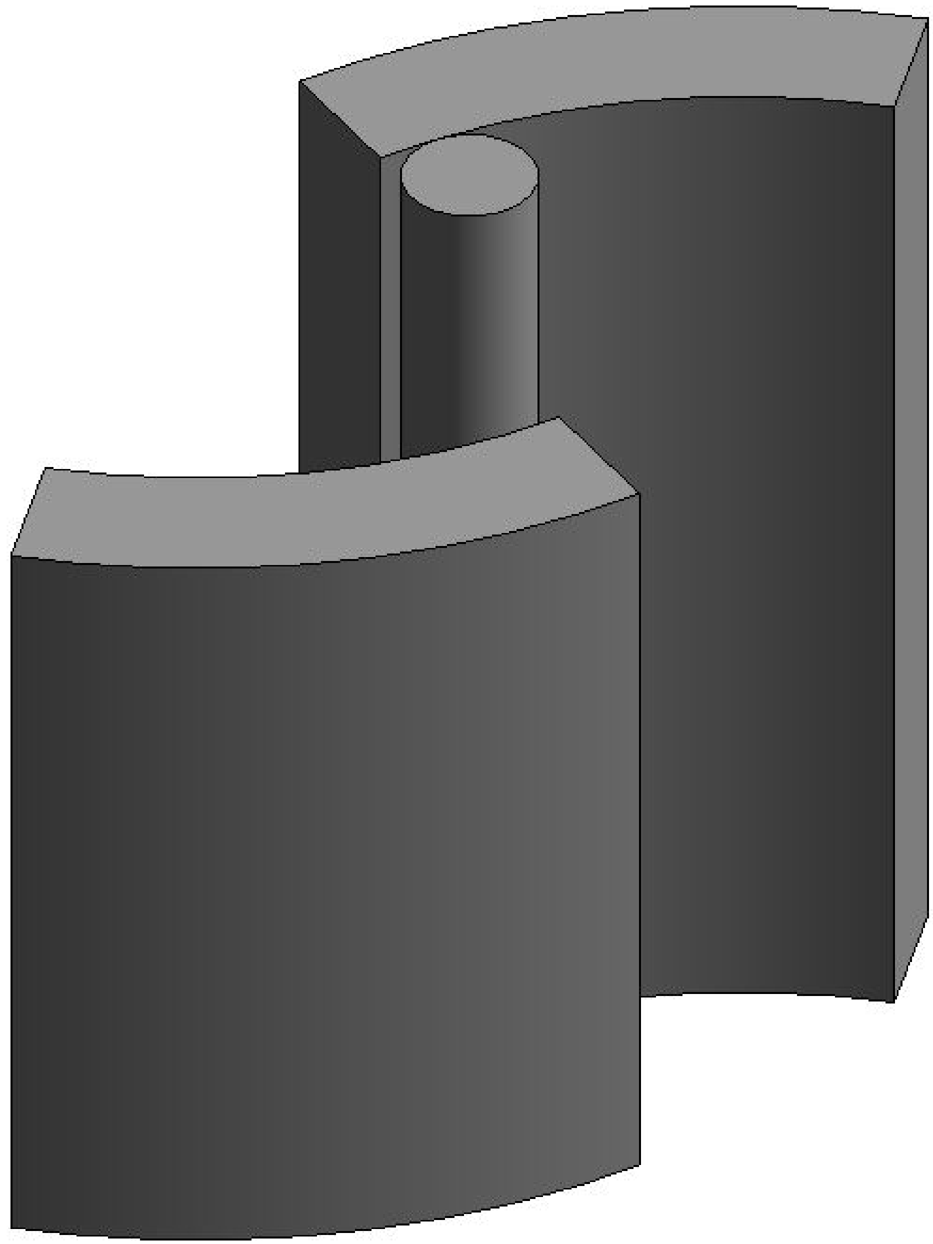
uses up to 95% less water than traditional farms

provides new employment opportunities

site...

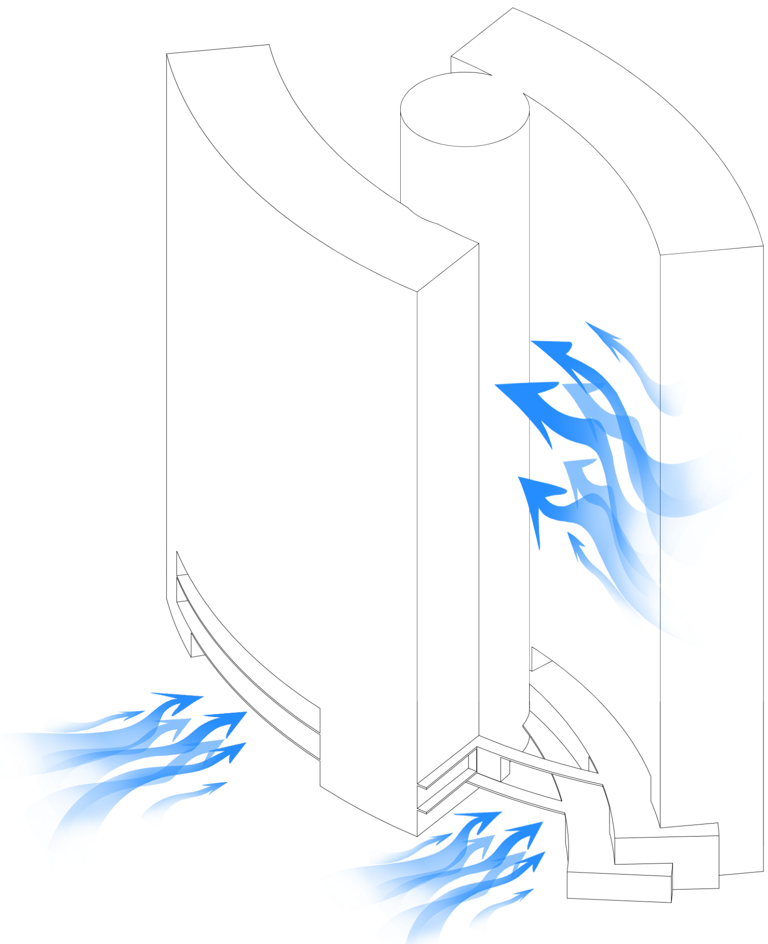
120 N Broadway, Los Angeles, CA

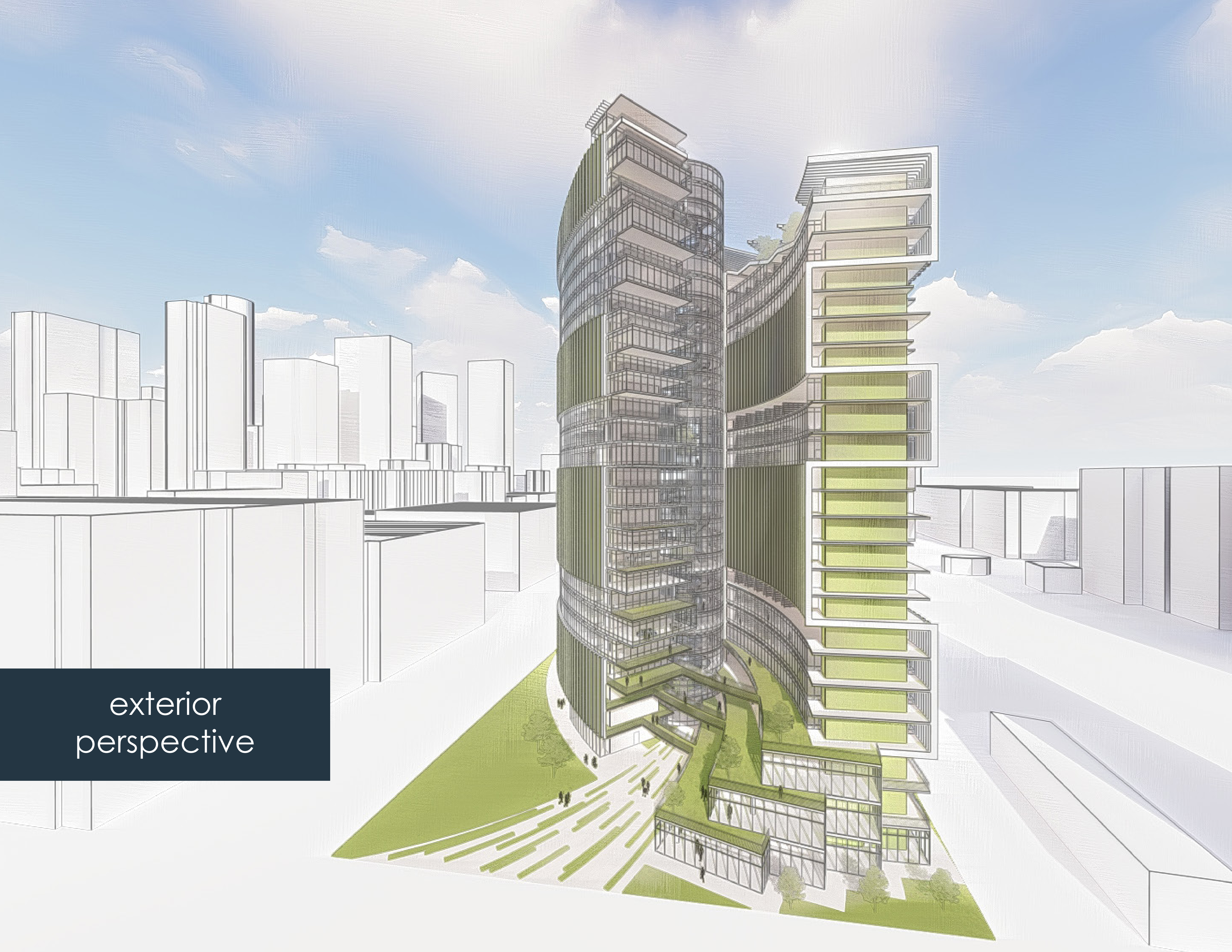
form...



solar...

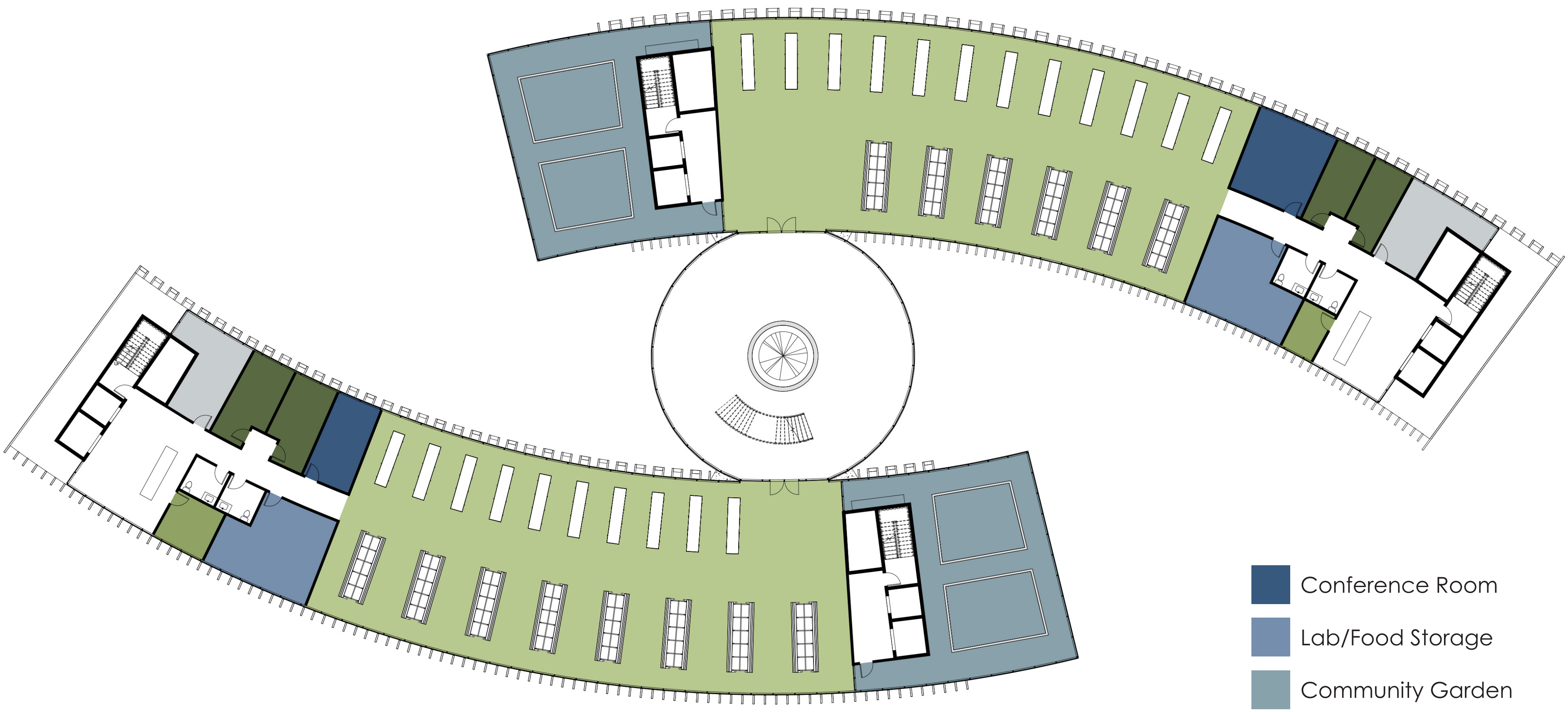
ventilation...



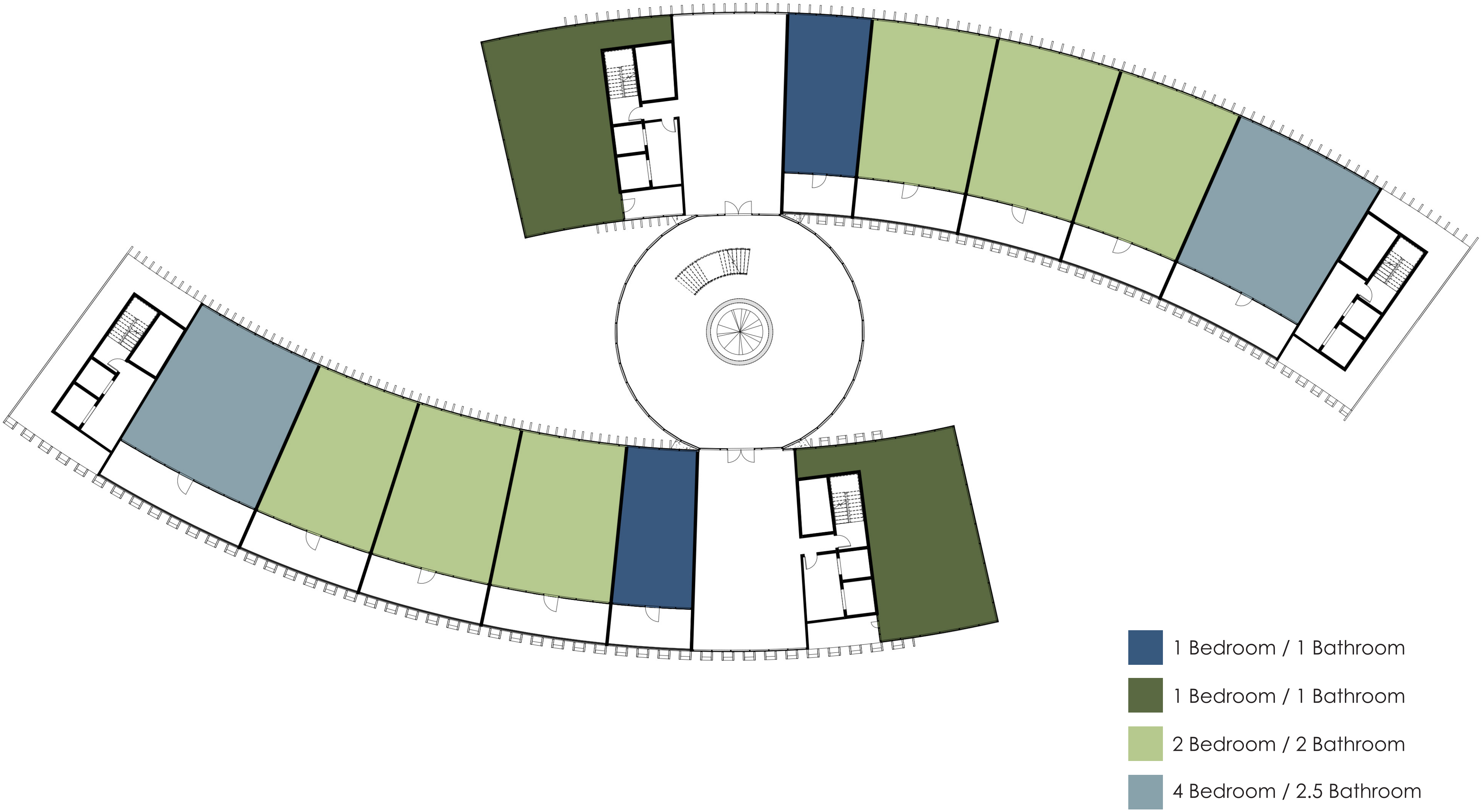


exterior perspective

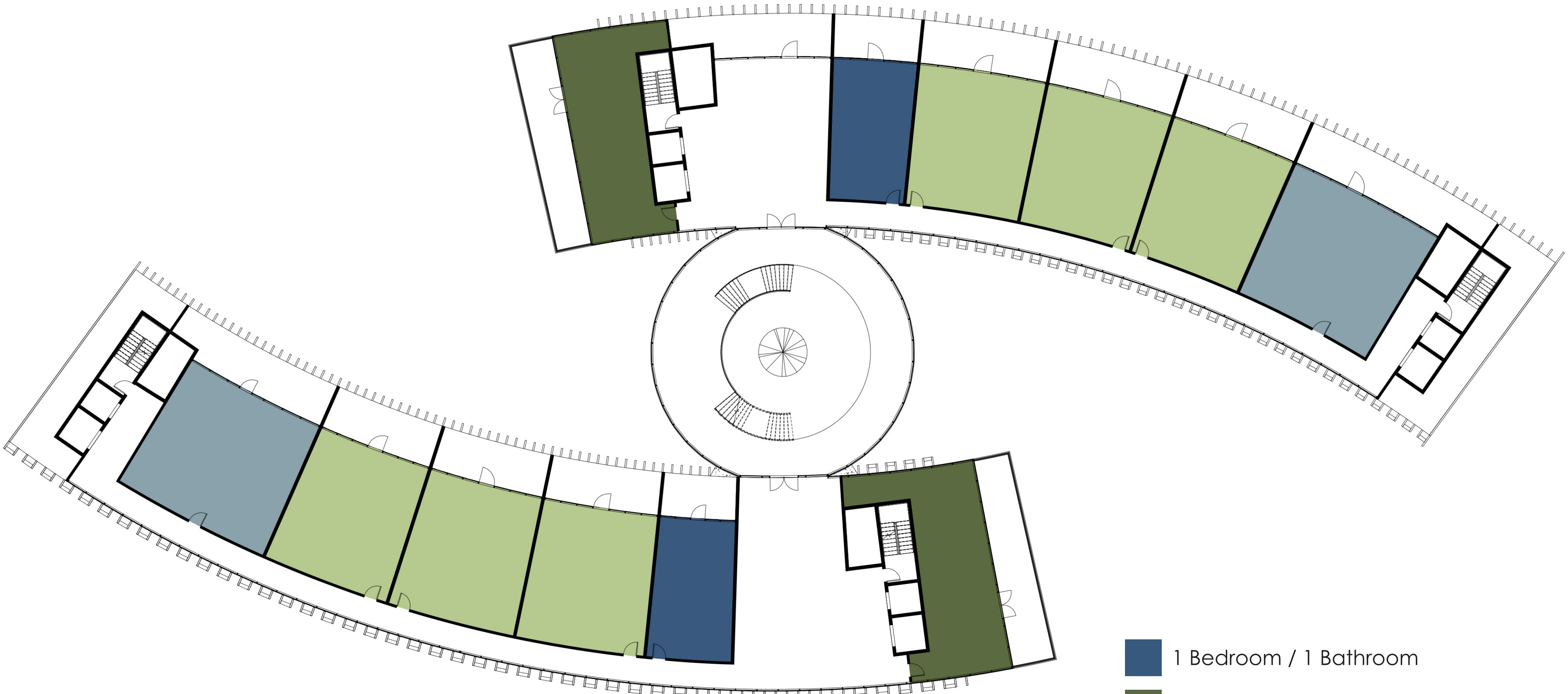
typical farm floor plan



typical lower level apartment floor plan

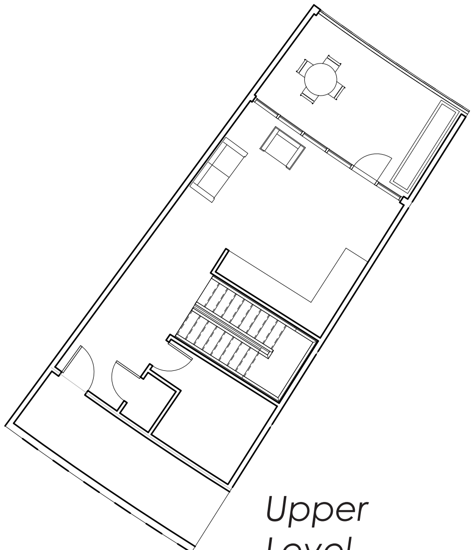


typical upper level apartment floor plan

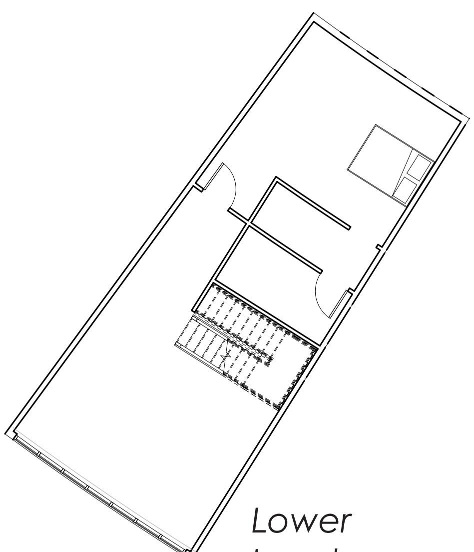


(dark blue)	1 Bedroom / 1 Bathroom
(dark green)	1 Bedroom / 1 Bathroom
(light green)	2 Bedroom / 2 Bathroom
(grey-blue)	4 Bedroom / 2.5 Bathroom

Typical 1 Bedroom Apartment

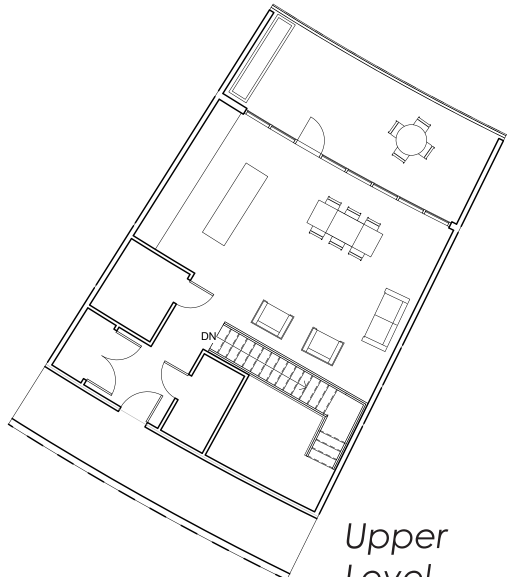


Upper Level

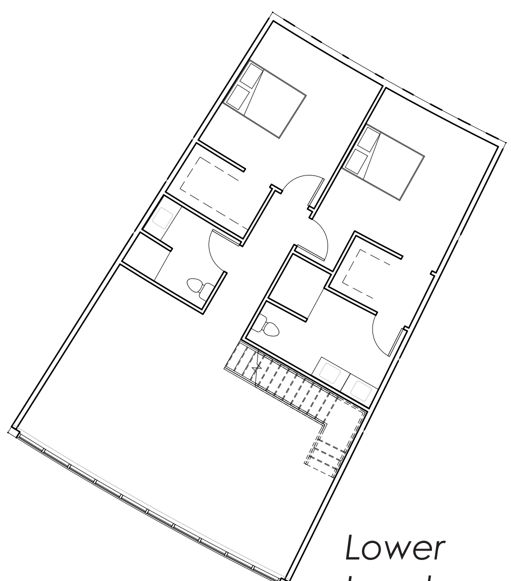


Lower Level

Typical 2 Bedroom Apartment

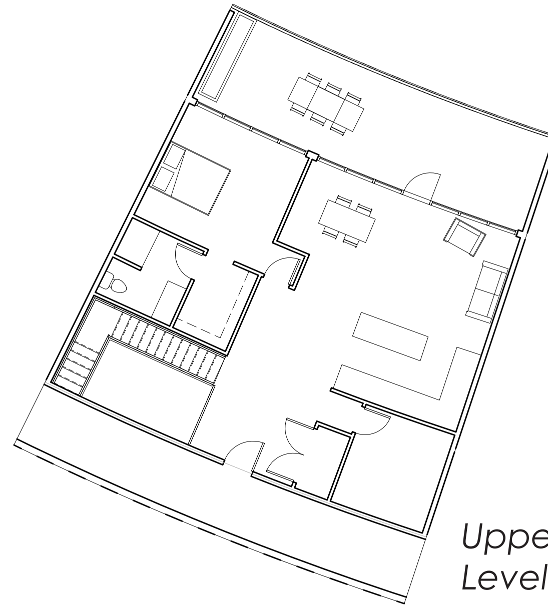


Upper Level

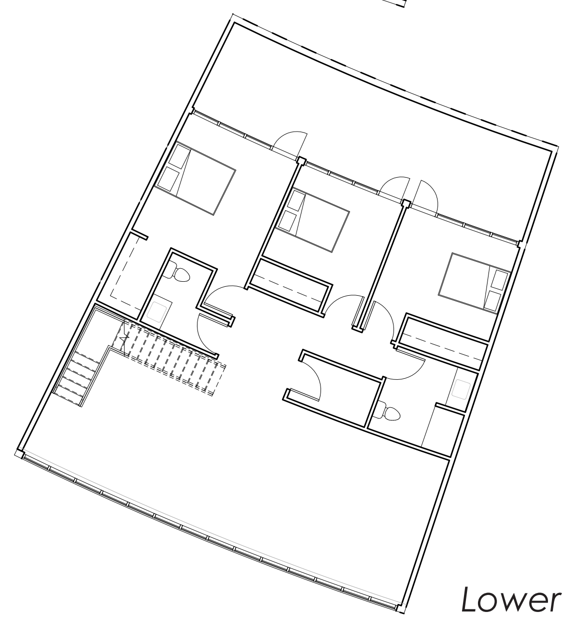


Lower Level

Typical 4 Bedroom Apartment



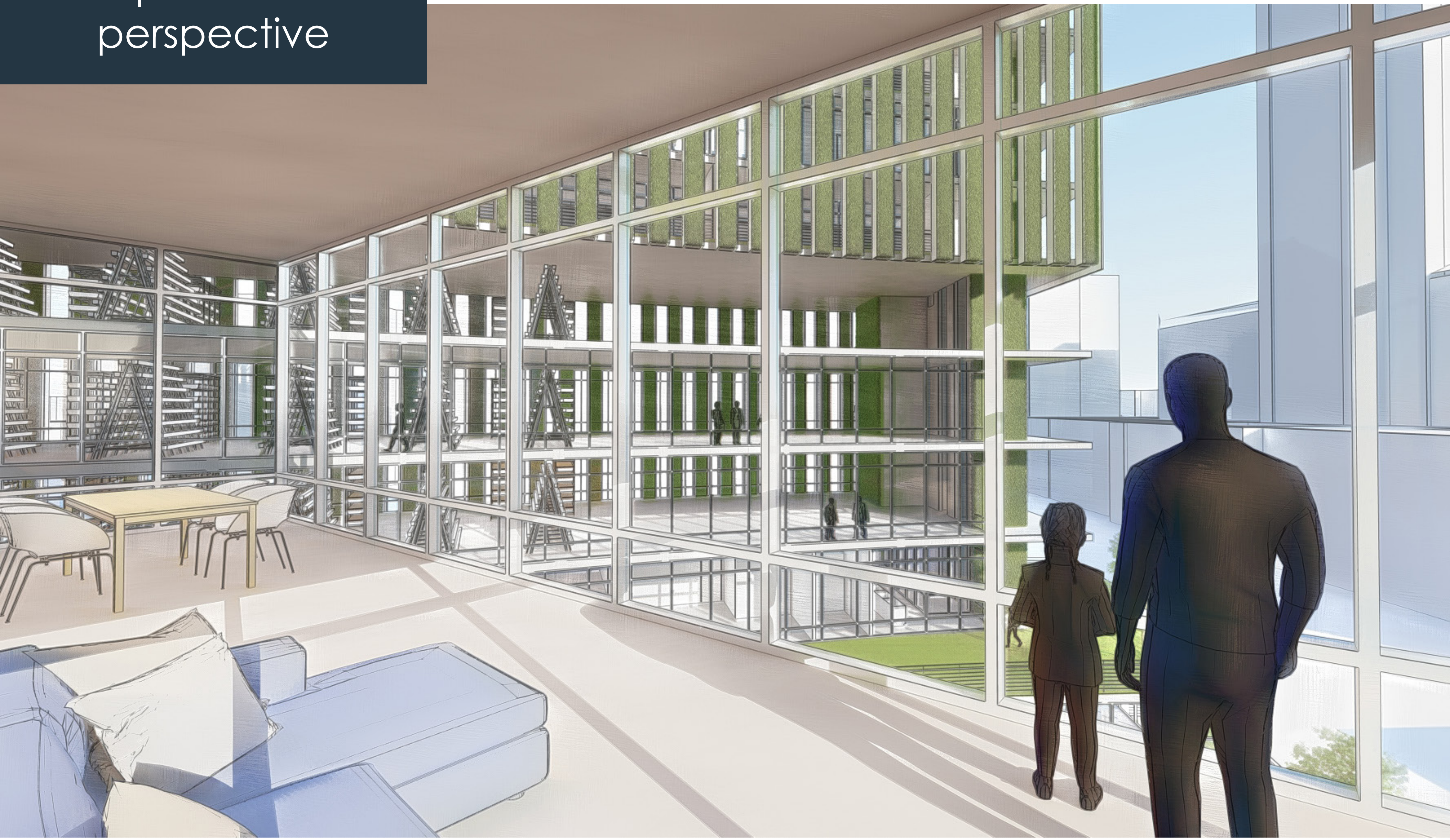
Upper Level



Lower Level

exterior perspective

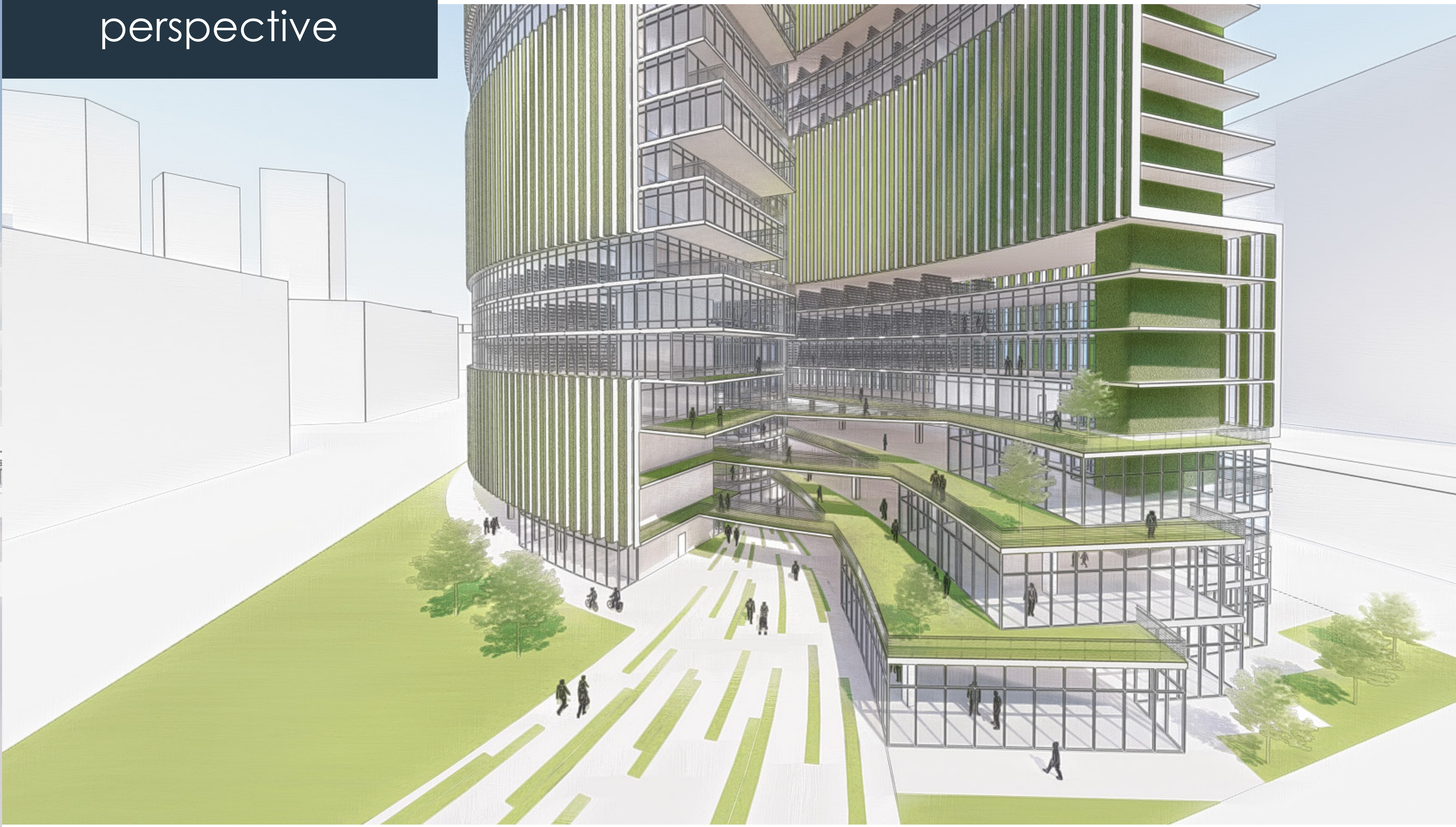
apartment perspective



vertical farm perspective

exterior perspective

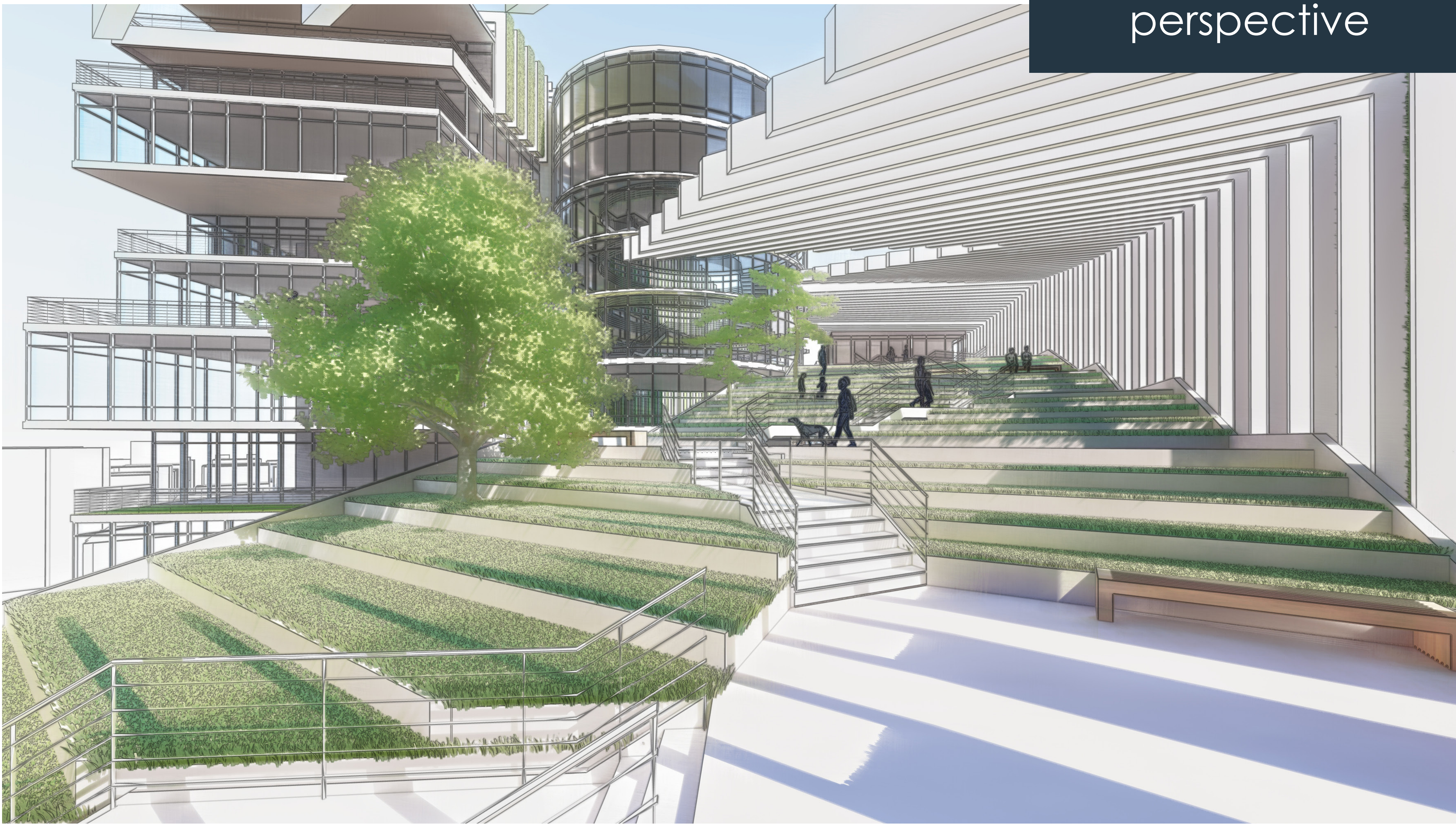
exterior perspective



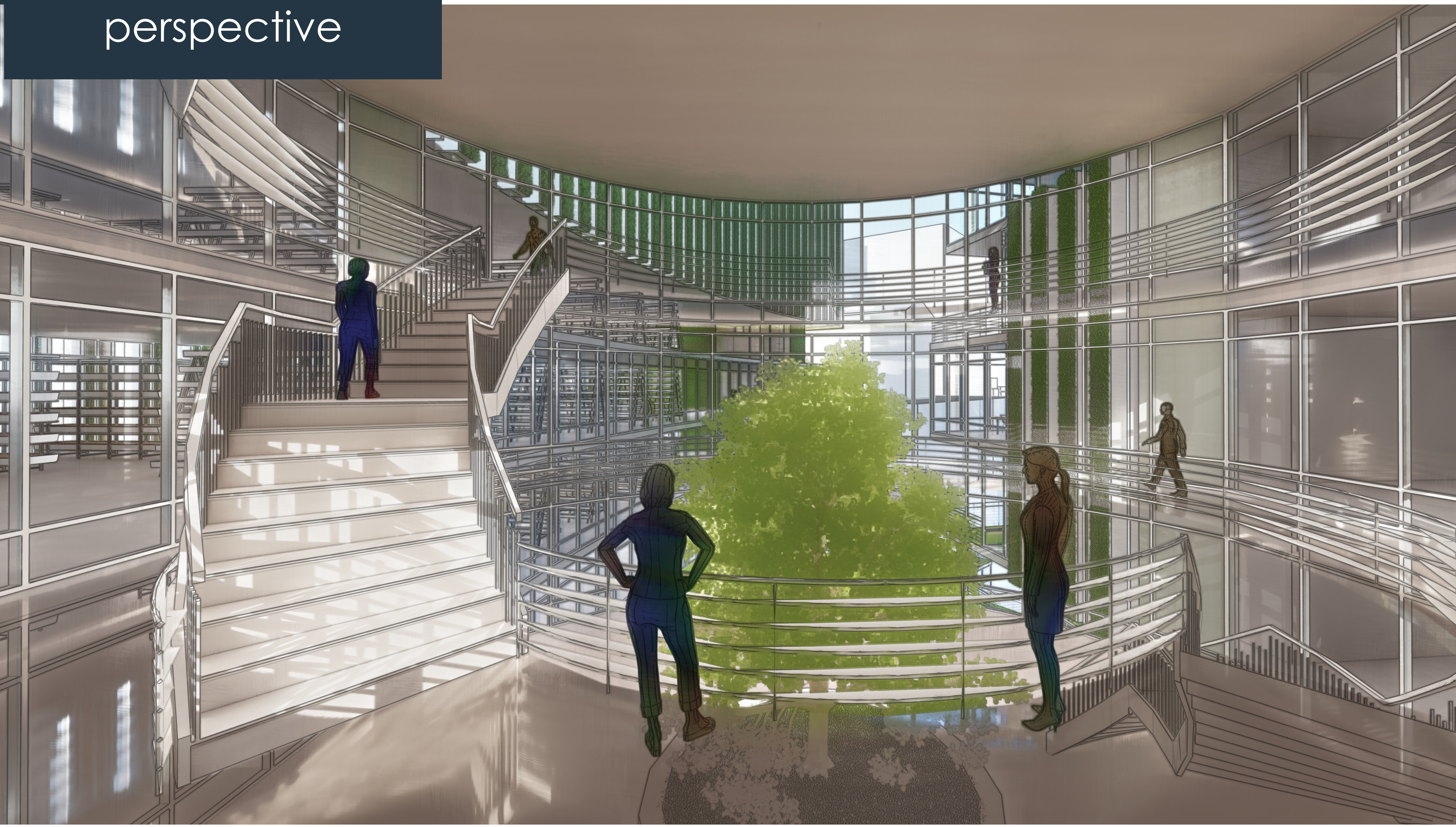
third level terrace perspective

entrance perspective

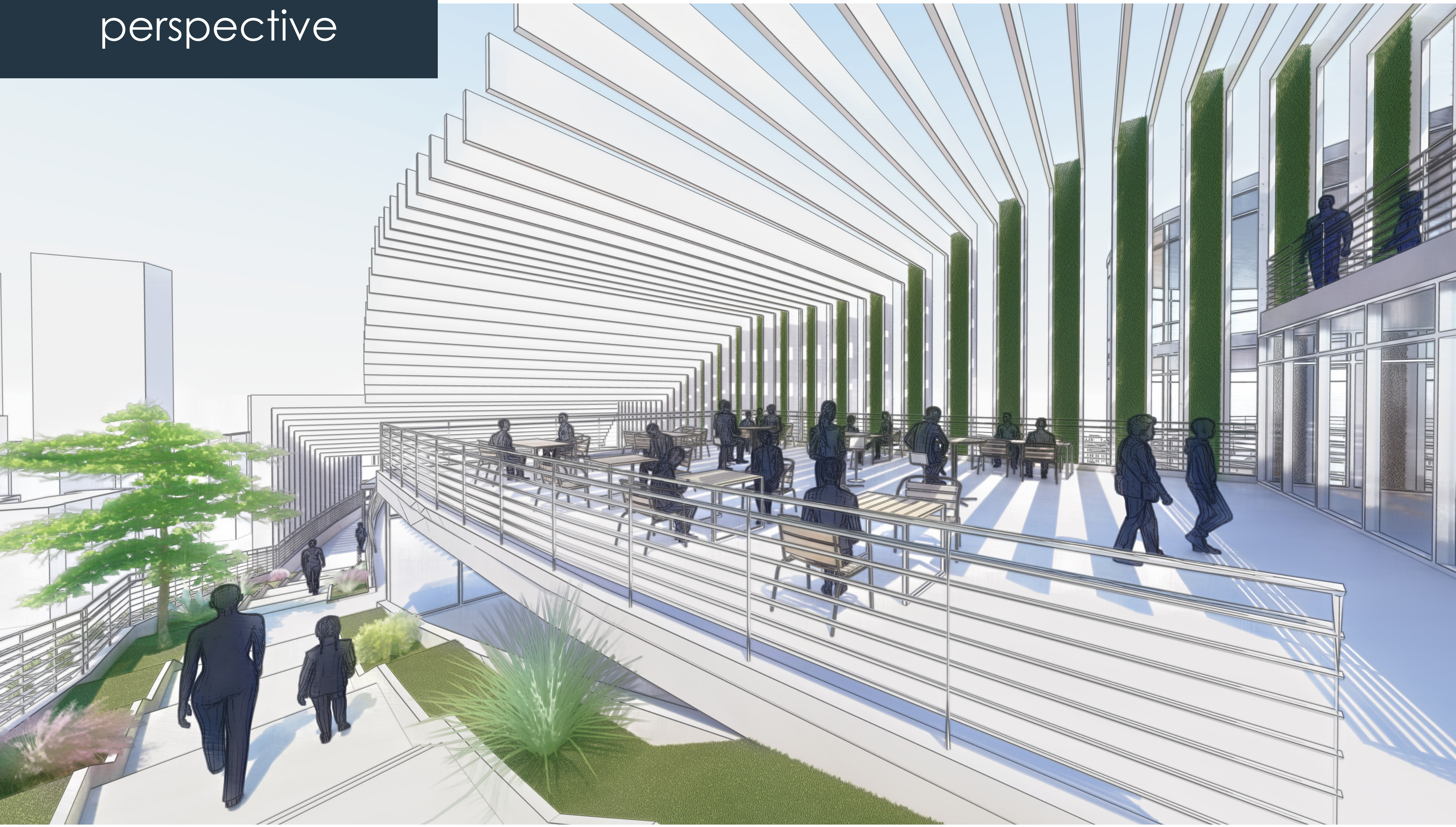
roof top perspective



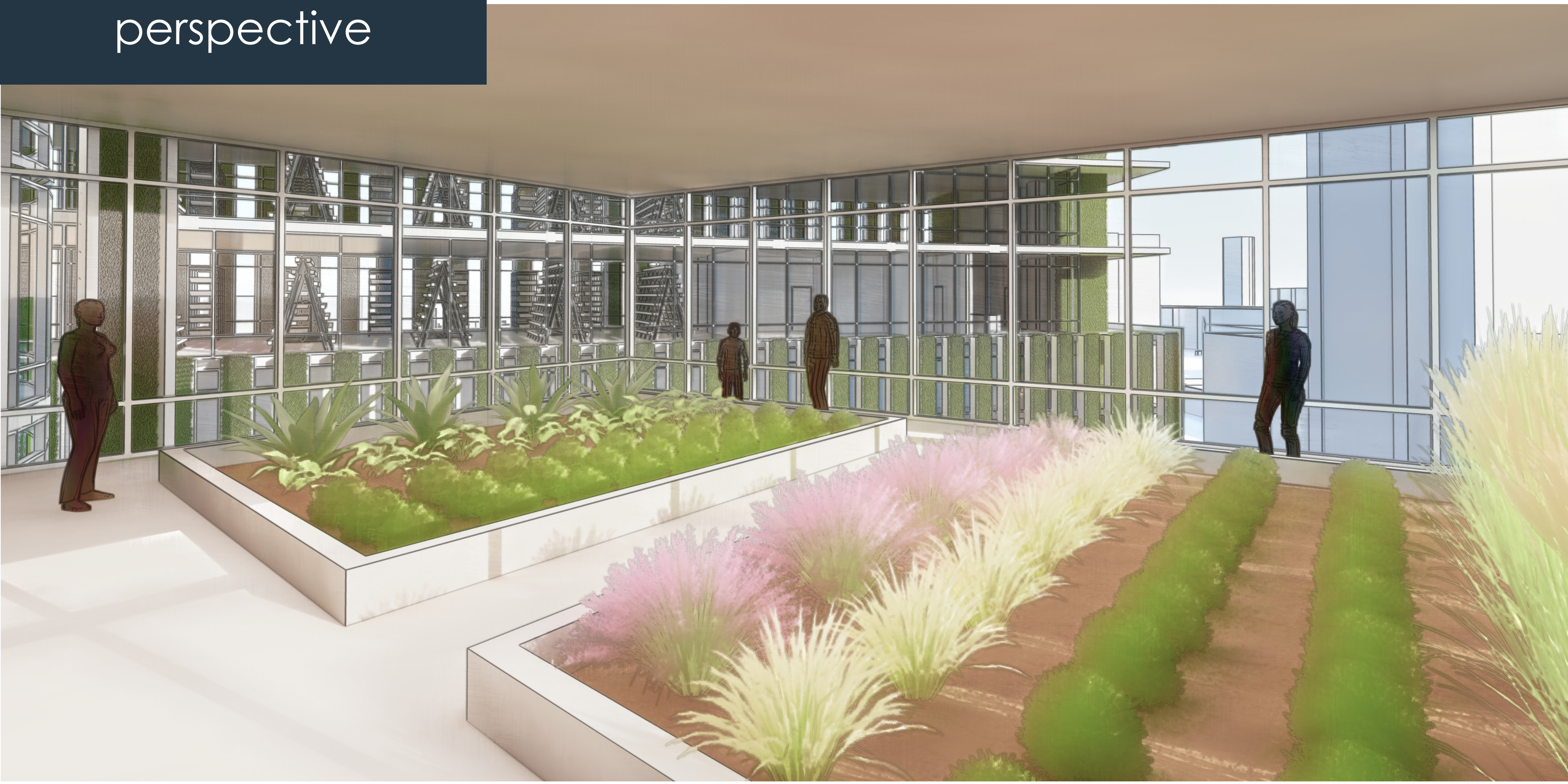
atrium perspective



roof top perspective



community garden perspective



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2ND YEAR	**FALL 2017** Charlotte Greub	Tea House | Moorhead, MN Boat House | Minneapolis, MN
	SPRING 2018 Cindy Urness	Multiuse Apartment Complex | Fargo, ND Dwelling | Cripple Creek, CO
3RD YEAR	**FALL 2018** Mark Barnhouse	Entomology Lab | Rochert, MN Office Building | Fargo, ND
	SPRING 2019 Emily Guo	Assisted Living Facility | China Museum | Moorhead, MN
4TH YEAR	**FALL 2019** Cindy Urness	High Rise | Miami, FL
	SPRING 2020 Amar Hussein	Marvin Window House Competition | Fargo, ND Thesis Preparation Project | Minneapolis, MN
5TH YEAR	**FALL 2020** Lance Josal	Fenway Park Hotel + Surge Healthcare | Boston, MA
	SPRING 2020 Bakr Aly Ahmed	BiodiverCITY | Los Angeles, CA