LIVE | WORK | GROW

Integrating Food Production into a Cooperative Housing Project

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Abstract

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Integrating Food Production into a Cooperative Housing Project

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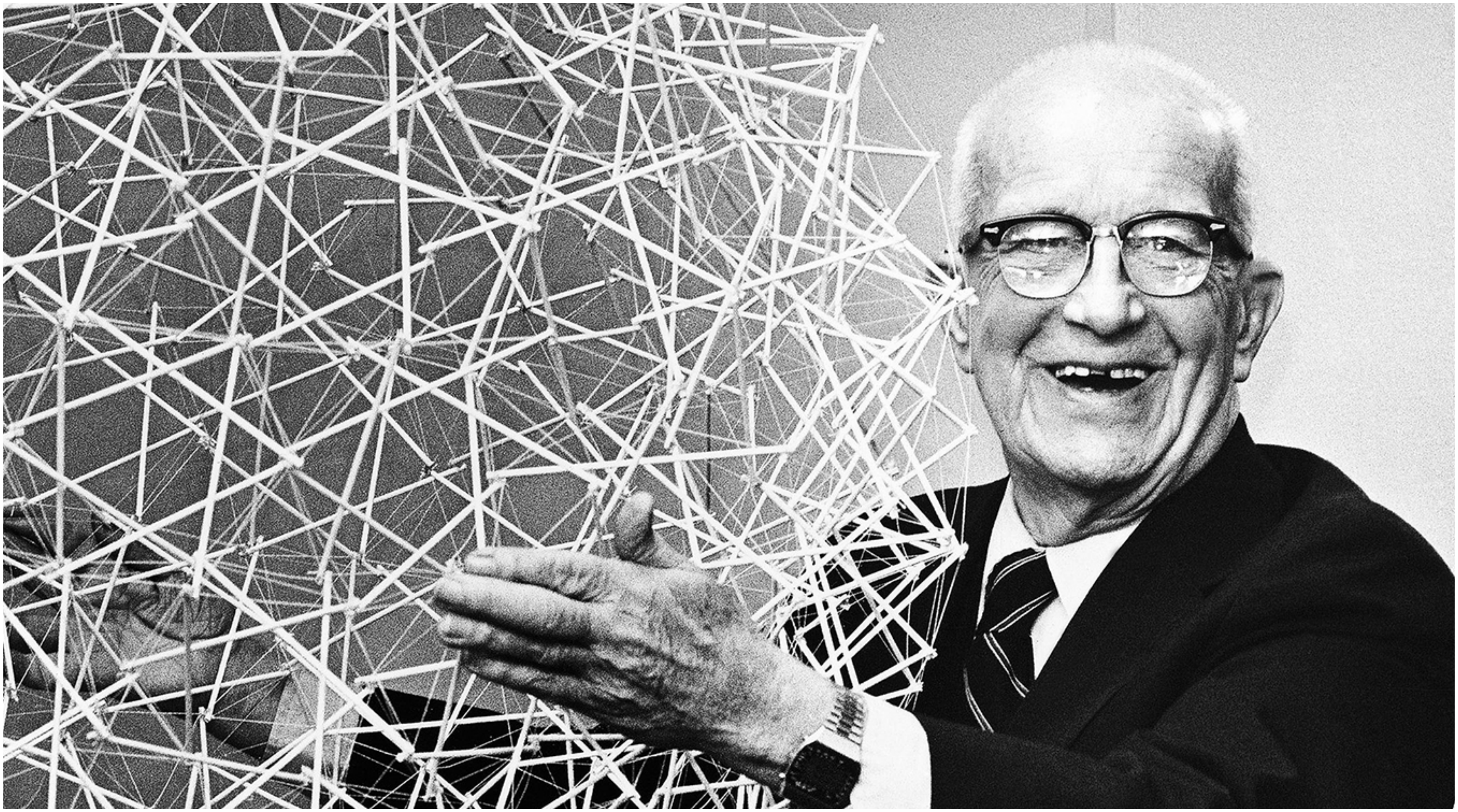
With the continued growth of the world's urban population, the demand for accessible food sources increases significantly. Over half of the global population now lives in urban areas, and projected to increase exponentially. This urban expansion not only increases demand for food production, but also influences rising costs of living as housing demand outmatches supply. Being one of America's fastest growing cities, housing security and affordability in Seattle is being tested while extending the separation between where people live and where their food is grown. Considering the threat of housing inequity and agriculture's ecological impacts, an integrated model is needed to supply fresh food and affordable living to urban communities.

This thesis posits that an entrepreneurial group of urban farmers can work together to address food and housing insecurity by integrating agriculture with a cooperative housing project in a rapidly growing Seattle. The thesis will explore how integrating the two can aggregate the impacts into a shared infrastructure and act as a responsible model for housing in Seattle. The innovative and environmentally conscious community in Seattle make it an ideal location to become a progressive leader in building integrated agriculture (BIA) and cooperative housing, potentially influencing the shift into a new paradigm for a sustainable food system and housing type.



“YOU NEVER CHANGE THINGS BY FIGHTING AN EXISTING REALITY.
TO CHANGE SOMETHING, BUILD A NEW MODEL THAT MAKES THE EXISTING MODEL OBSOLETE.”

- R. Buckminster Fuller

Fig. 1 | *R. Buckminster Fuller holds up a Tensegrity sphere*

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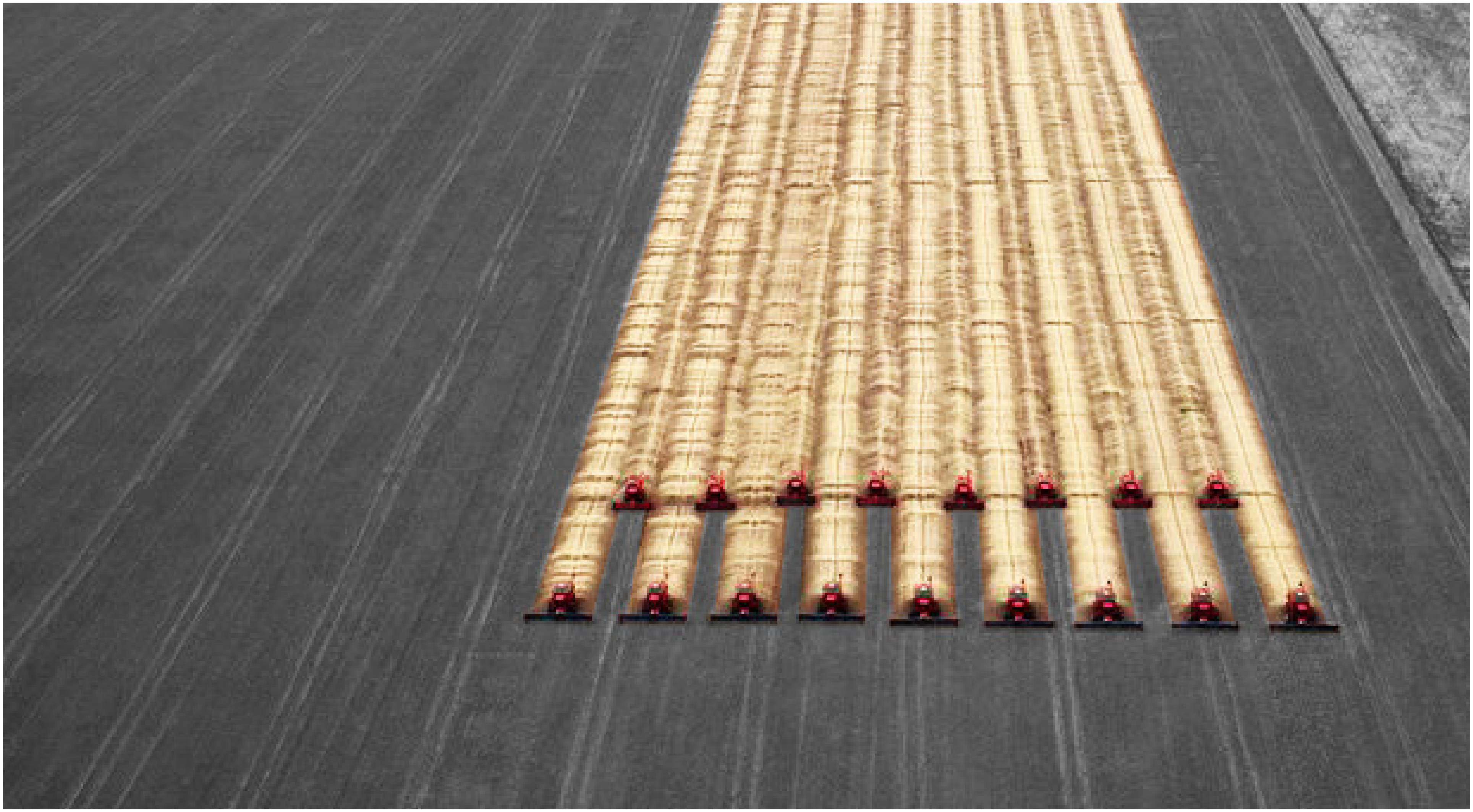

1: [INTRODUCTION]

Fig. 2 | *Combines Harvesting Soybeans*

Problem Statement

With the continued growth of the world's urban population, the demand for accessible food sources increases significantly. Over half of the global population now lives in urban areas, with a projected urbanization growth rate of 1.84 percent per year for the next 5 years.[1] This urban expansion not only increases demand for food production, but also extends the separation between where people live and where their food is grown—influencing the current food system to become more and more industrialized. Conventional field-farming agriculture currently uses 40 percent of the world's arable land surface and 60 percent of the world's water usage, while transporting the product an average of 1500 miles to the consumer[2]

1 United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352)

2 D. Gould and T. Caplow, "Building Integrated Agriculture: A New Approach to Food Production" (*Metropolitan Sustainability: Understanding and Improving the Urban Environment*, edited by Frank Zeman. Cambridge/Philadelphia: Woodhead Publishing, 2012) p. 148.

Fig. 3 | *Exponential Growth*

Fig. 4 | *40% of Earth's Arable Land Surface used as Farmland*

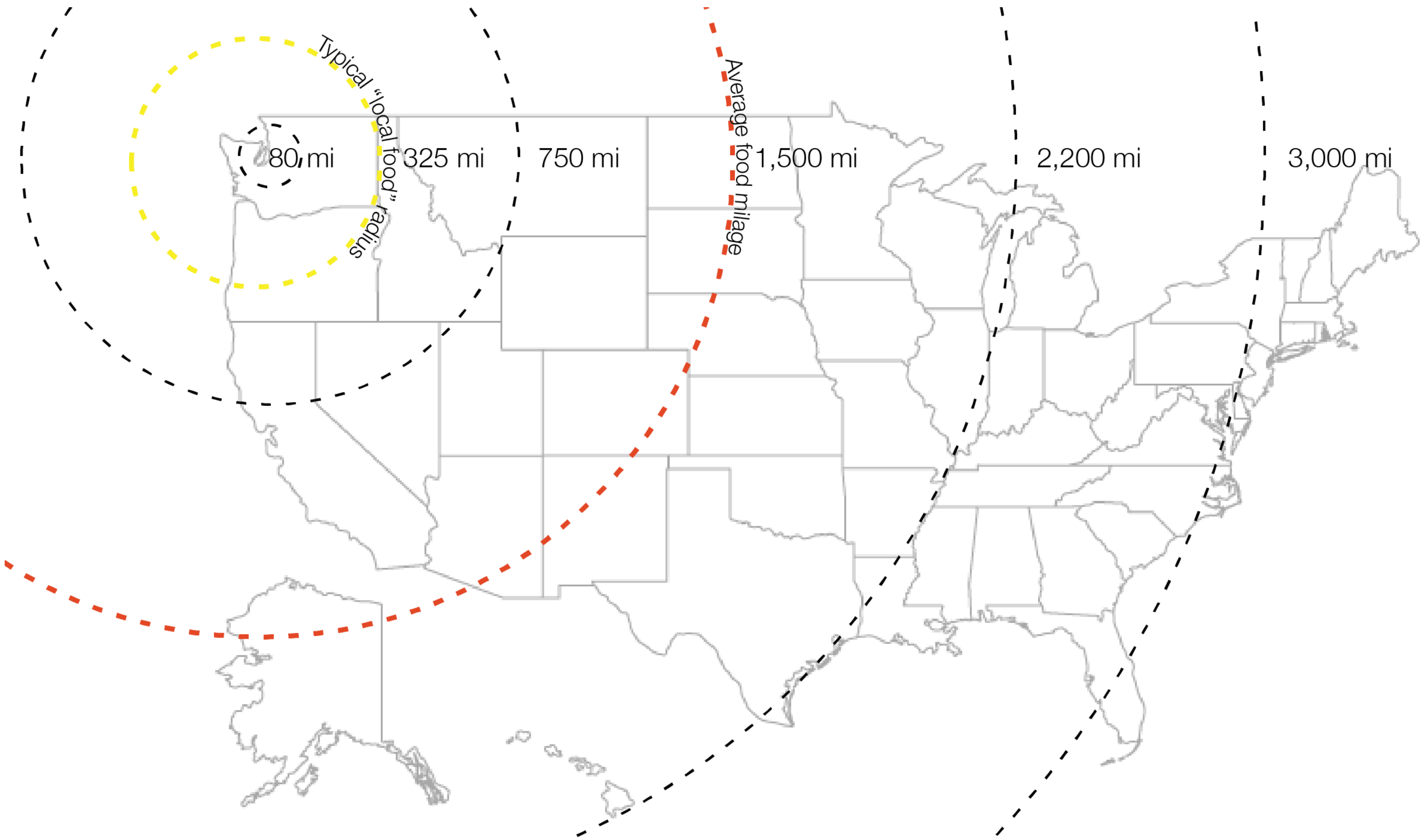

Fig. 5 | *Average Food Miles*

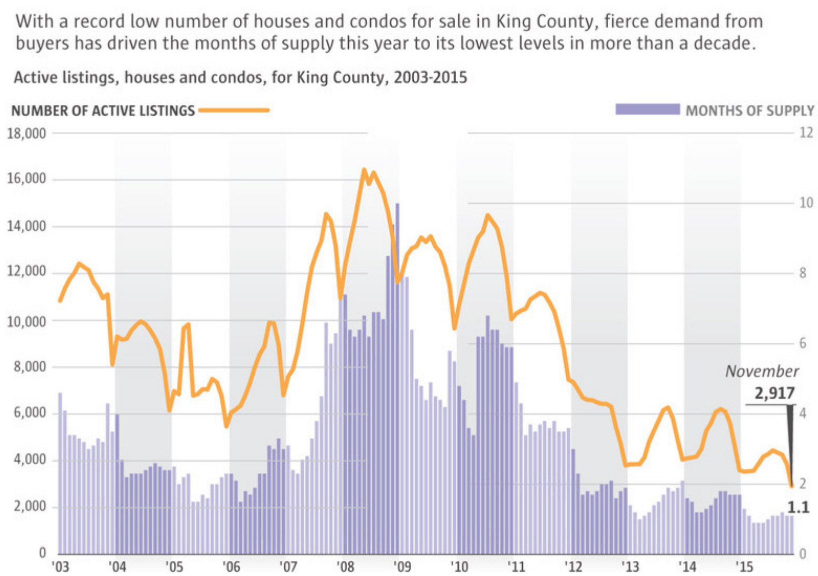

Fig. 6 | *Not Enough Homes*

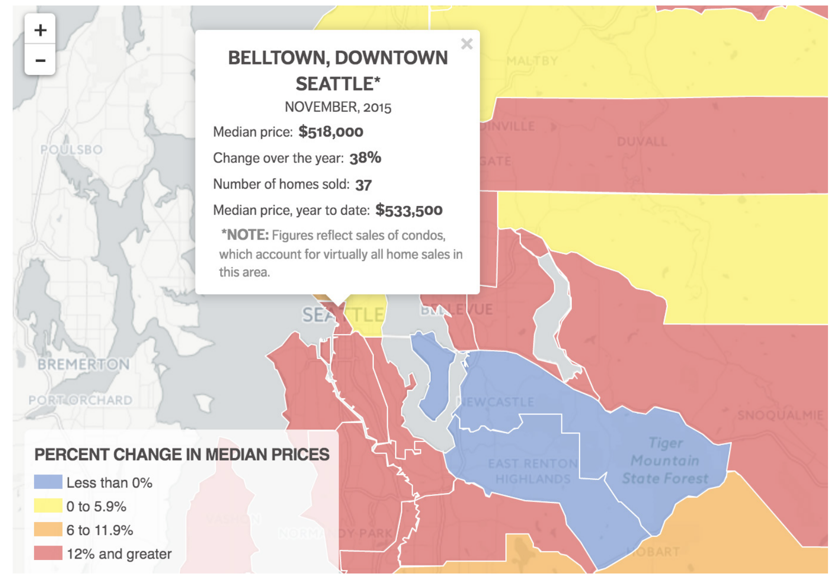

Fig. 7 | *House Sales by Submarket*

— straining the global capacity to continue these unsustainable practices. In addition to resource consumption, agriculture's ecological footprint is amplified with carbon emissions as a result of the industry's energy consumption and reliance on fossil fuels. Considering the effects climate change will have on water and land resources, a more compact, efficient, and integrated model is needed to supply fresh food to urban communities.

In addition to exhausting food production, rapid urban growth influences rising costs of living as housing demand outmatches supply. Currently, Seattle is one of America's fastest growing cities, creating a housing scarcity as the population grows faster than housing can be constructed. Housing scarcity is influencing housing prices and rents to inflate — testing the affordability of the city. Thousands of workers and families are being priced out as they are unable to afford the cost of living. This dynamic effects the accessibility, diversity, and equity of Seattle. Recently, Mayor Edward B. Murray released an affordable housing plan to address the issue, stating that "we are in the midst of a housing crisis that demands creative and bold solutions" and "we all share a responsibility to make Seattle a more affordable and equitable city."[3] Economic growth presents many opportunities for the city, but is also resulting in challenges that will require responsible and innovative solutions as development seeks to capitalize on the circumstance.

Looking at the dual problem of food and housing insecurity, this thesis will explore how integrating the two together in an architectural response can begin to resolve adverse effects of rapid urban growth. Currently on the rise in many U.S. cities, urban agriculture is an emerging sector of local food economies — showing promising benefits for improving the social and ecological health of urban centers. The dramatic increase in interest for urban agriculture is associated with it being at the nexus of a variety of issues that are critical to the sustainability and livability of the urban environment. Founded on a mission of resilience and self sufficiency, urban ag empowers communities, contributing to the the health of urban communities at a social and ecological level by improving public health, food access, green space, air and water quality, economic development, and social interaction.[4] K. Ackerman states, "Urban agriculture [therefore] functions primarily as a catalyst to spur systemic changes to the food system and challenge to a culture of consumption that is increasingly viewed as unsustainable."[5] Within the urban agriculture spectrum, a practice called building integrated agriculture (referred to as BIA for the remainder of the thesis) has the strongest relation to architecture. BIA is where farming systems are located on and within a host building, designed to exploit synergies between the built environment and agriculture — becoming an environmentally sustainable strategy for urban food production..

In response to the need for housing in Seattle, the host building for this thesis is a housing project. Due to the practical challenges of integrating agriculture with a conventional development, a co-housing typology called baugruppen is employed as a more feasible option. Primarily driven by economic forces, the architect-led and collectively funded German practice of baugruppen (building groups) offers an opportunity for significant savings over traditional developer-driven models. The concept behind baugruppen is based on a partnership between a group of individuals in order to pool resources into an invested interest—utilizing economic and social capital to realize a new housing model. Furthermore, part of the baugruppe ethos is a focus on sustainability and as a result of the collaborative nature the potential for highly individualized units, innovative construction methods and a specific program of spaces and uses such as a commercial farm can be realized.

3 "Housing Seattle: A Roadmap to an Affordable and Livable City" *HALA Action Plan*, City of Seattle, Proposed by Mayor Ed Murray, p. 1.

4 K. Ackerman, "Urban Agriculture: Opportunities and Constraints" (*Metropolitan Sustainability* Woodhead Publishing Limited 2012) p. 118.

5 Ackerman, p. 118.

Thesis Statement

This thesis posits that a partnership between a community group and entrepreneurial urban farmers can work together to address food and housing insecurity by integrating agriculture with a baugruppe in a rapidly growing Seattle. By activating under-utilized space in the city for food production, agricultural impacts on water, land, and greenhouse gas emissions will be reduced — while providing an alternative model for housing development in the metro area. The agriculture and building industries are both large resource consumers and inherently have significant footprints. The thesis will explore how integrating the two can aggregate the impacts into a shared infrastructure and act as an affordable, responsible model for housing in Seattle. Furthermore, Seattle's innovative and environmentally conscious community makes it an ideal location to become a progressive leader in BIA and baugruppe, potentially influencing the shift into a new paradigm for a sustainable food system and housing type.

Urbanization in the United States is not expected to increase as significantly as the rest of the world—in which developing countries are witnessing the most rapid urban growth. Yet the current urban population nationally is much higher than the world average with 80.7 percent of the population living in urban areas.[6]

6 "Growth in Urban Population Outpaces Rest of Nation, Census Bureau Reports" (*U.S. Census Bureau* 26 March 2012) accessed 26 April 2016.

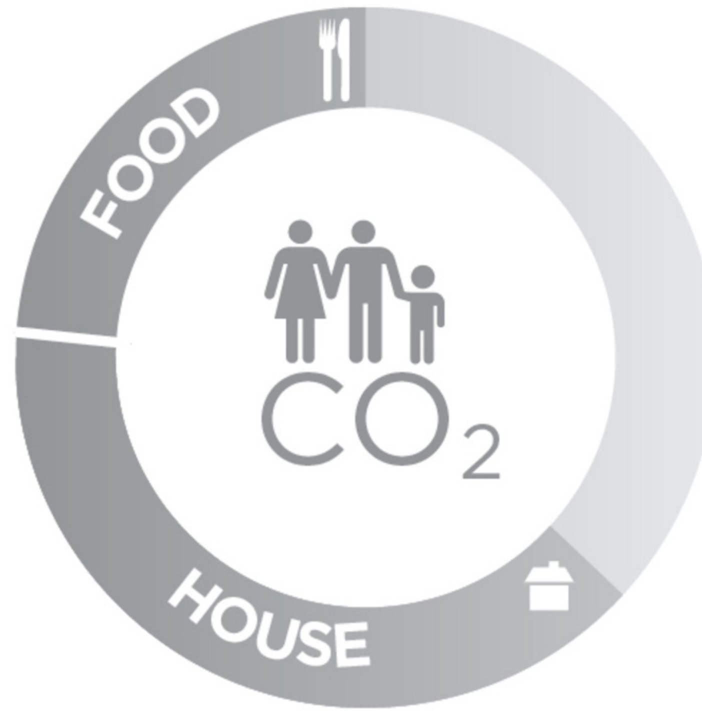

Fig. 8 | *60% of CO_2 Emissions come from Agriculture and Building Industries*

Thus, while urban growth is not as rapid, it has already reached a significant threshold where integrating agriculture into the urban fabric is past due.

Seattle is currently the 10th most densely populated city in the United States and has witnessed the highest density increase since 2010 compared to the other 9 cities in the top 10 with a 9.8 percent increase.[7] The city is becoming a destination for tech companies and creative class citizens and the growth is not foreseen to slow down anytime soon. Seattle's population is estimated to grow by 120,000 people in the next 20 years,[8] which translates to 20 percent growth in the next two decades. This growth presents challenges for the food system, influencing an increased ecological footprint as Seattle's geographically constricted area relies on importing supply from agricultural areas. Already out of the fifteen largest U.S. cities surveyed, Seattle has the largest ecological footprint per capita, with food accounting for roughly half of each citizen's footprint.[9] Extensive infrastructure is needed for food transport and distribution, adding to fossil fuel consumption and carbon emissions. To reduce the city's ecological footprint, it must establish alternative food sources that are integrated into its built environment. When agriculture is integrated into housing, it will not only yield environmental benefits, but economic and social benefits as well.

This thesis proposes a mixed-use, multifamily development located in an Seattle urban district — focusing on two main goals:

FOOD: Integrate compact and efficient agricultural systems into Seattle's built environment to accommodate population growth while leveraging a new model for living.

SHELTER: Create an affordable housing model that acts as a vehicle for sustainable food production.

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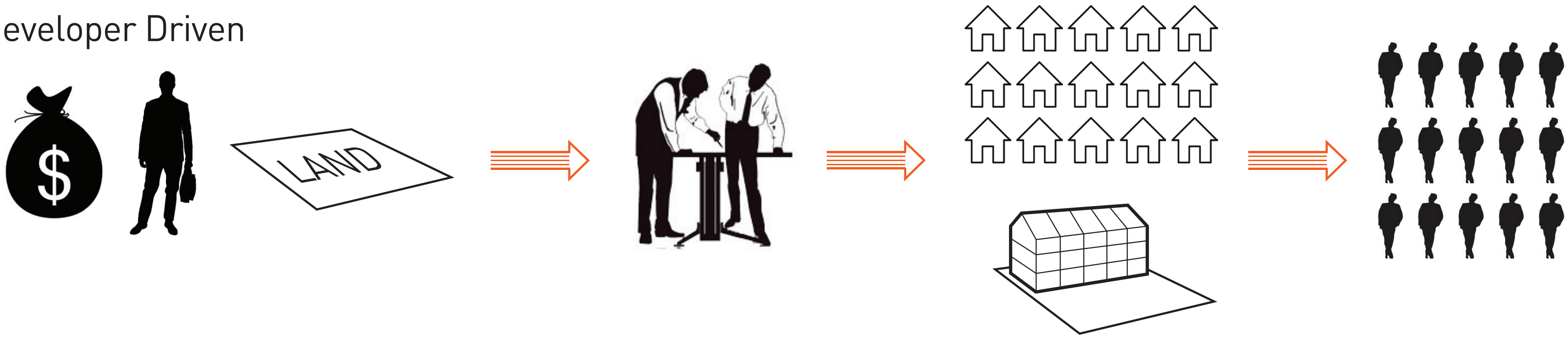
7 Gene Balk, "Seattle among top 10 most densely populated big cities in the U.S. for first time ever." (*Seattle Times* 7 February 2016) accessed 26 April 2016.

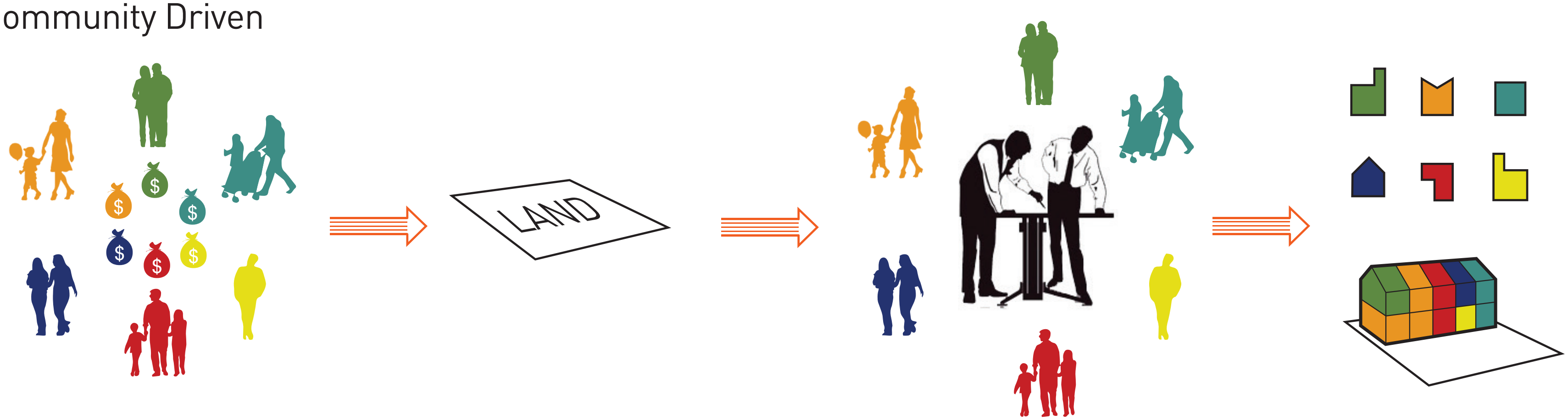
8 *HALA Action Plan*, p. 2.

9 David Moore, "Ecological Footprint Analysis San Francisco-Oakland-Fremont, CA" (2011) p. 6.

Developer Driven



Community Driven



2: [RE-IMAGINING FOOD AND SHELTER]

Chapter Two will investigate the various dimensions of the proposition introduced in Chapter One, and is divided into three sections. First of which addresses the current state of industrialized agriculture, its history, and BIA as an emerging, viable alternative for a more sustainable food system. The second addresses the current housing situation in Seattle and the potential for a new model of cooperative housing. The third reveals how the two components of food and shelter can become synthesized into a symbiotic relationship, working together to mitigate environmental impacts and provide affordable homeownership in the midst of rapid urbanization.

2A: Environmental Impact & the Case for BIA

Understanding the cause and effect of industrialized agriculture provides insight into how the food system can evolve into a more sustainable system. Recent efforts in small-scale organic farming, local farmer's markets and food hubs are steps in the right direction, however they can not viably fulfill the demand needed to feed the population. To find an appropriate alternative, a new way of growing needs to be investigated and understood in terms of its relationship to current practices.

Agriculture Industrialization

The industrialization of agriculture and residual environmental impacts is not by accident. It is the result of an urbanizing, modern, industrial nation with economically driven approaches to efficiency and productivity. A combination of technological advances and changes in behavior are contributing factors that became entangled in a way that foreclosed any other possible alternatives.

Industrial agriculture is an American creation, developed out of land abundance and industrial development in the mid-1800s; being virtually exclusive to the United States until the 1940s.[10] In contrast to Europe, the United States had plenty of land with low labor to tend to it — sparking agriculture innovation and mechanization.[11] With seemingly limitless fertile lands in the west, farmworkers had no concern for conservation or maintaining soil health. Instead, they focused on mechanization in order to increase

10 John Robert McNeill and Erin Stewart Mauldin, *A Companion to Global Environmental History* (Blackwell Companions to History, Chichester, West Sussex; Hoboken, N.J.: Wiley, 2012) p. 412.

11 McNeil, et al, p. 412.

yields in relation to labor. Advances in farming technology freed labor from working in the field to being able to work in factories, which increased urban populations, boosted the economy, and encouraged more agriculture industrialization. Introducing steam power — and shortly after the combustion engine — mechanization accelerated production while initiating fossil fuels as a primary input. Gas powered combustion engines were integrated into farm practices, while steam power was more connected to transport.[12] Gaining connections and efficiencies in transport expanded distribution networks, which in turn expanded the market and enabled the ability to live farther away from food production — ultimately commercializing agriculture.[13]

Beyond mechanization, chemical inputs pushed industrialization beyond the fossil fuels that powered tractors and transportation systems. In 1910, German chemists invented the first synthetic nitrogenous fertilizer.[14] Nitrogen, being a primary nutrient needed to grow food, is found in small quantities in organic compost

12 McNeil, et al, p. 414.

13 McNeil, et al, p. 414.

14 McNeil, et al, p. 415.

Fig. 9 | *Industrial Crop Spraying with Agrochemicals*

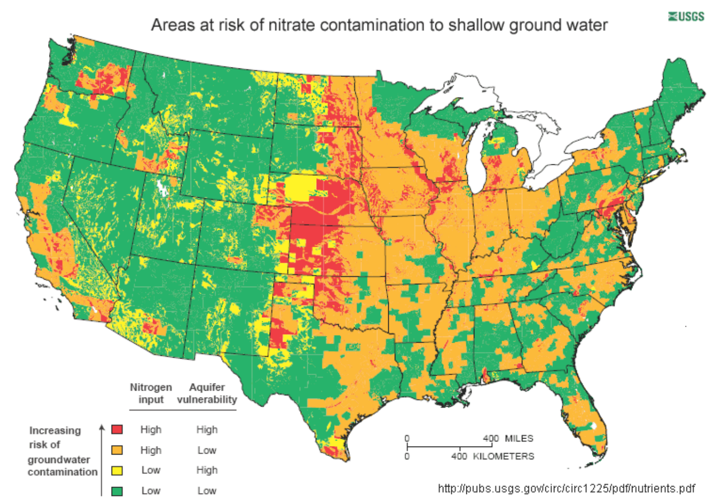


Fig. 10 | *Areas at Risck of Nitrate Contamination to Shallow Ground Water*

Fig. 11 | *Industrial Harvesting of Wheat* and manure. The introduction of synthetic nitrogen as a chemical fertilizer revolutionized food production, viewed as one of the 20th century's most important invention.[15] Widespread use was not until the 1940s, where chemical fertilizer use rose by 20 times a year after WWII ended.[16]

Fertilizers work alongside other technologies, sparking a proliferation of new chemicals such as pesticides and herbicides to agriculture. Agrochemicals, as they have become to be known, have been key to not only increasing crop yields, but also allowing farmers to end crop rotations with no short term effects — increasing efficiency in the field. Agrochemicals are arguably responsible for the most destructive environmental consequences, being the number one polluter of water bodies. Chemical fertilizers, pesticides, and herbicides have been detrimental to natural waterways, damaging ecosystems through toxic runoff and eutrophication. Carbon emissions from agriculture contribute to acidification of coastal waters, killing off coral that rely on a balanced pH to produce their skeletons and the organisms that rely on the reef for habitat.

The success of each innovation rests on the one before it, developing a positive feedback loop. Mechanization resulted in a monoculture, which meant more fertilizer to compensate for deficiencies which meant more mechanization. At the same time,

15 McNeil, et al, p. 415.

16 McNeil, et al, p. 415.

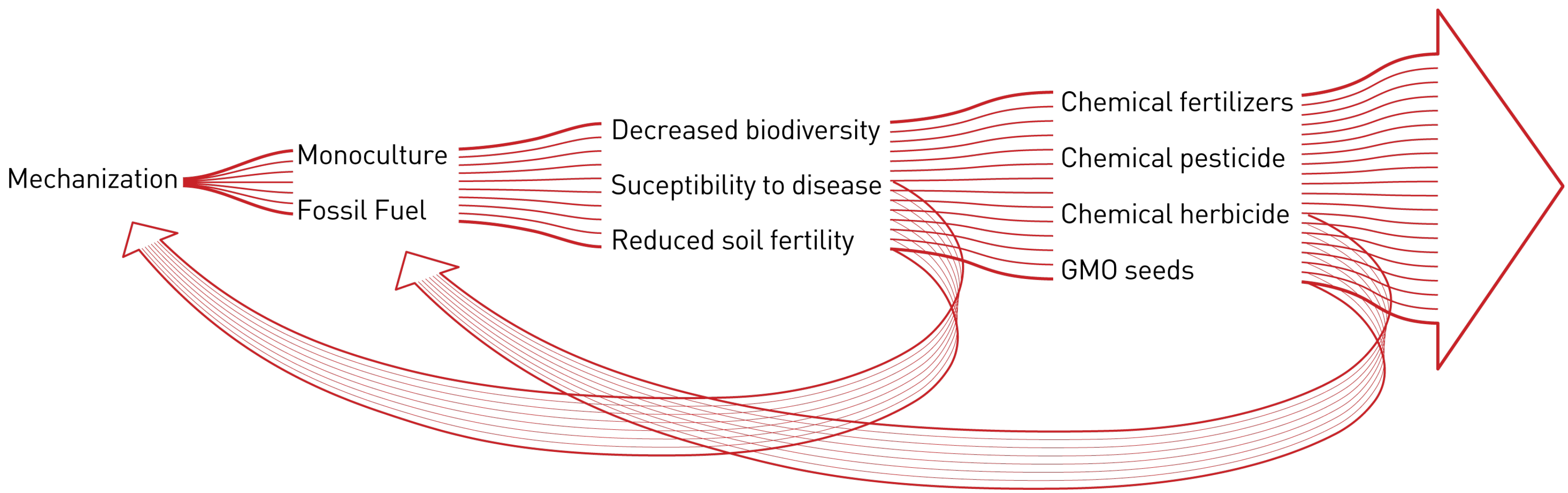


Fig. 12 | *Cause & Effect: Diagram of Positive Feedback Loop in Agriculture* more pesticide and herbicide worked alongside, which led to more genetically modified seeds, which in turn meant more mechanization.

According to the Environment Protection Agency (EPA), 24 percent of global greenhouse gas emissions come from agriculture, forestry, and land use.[17] Most of that percentage is from agriculture, primarily from processing, transporting and storing of food as well as deforestation to accommodate agricultural growth. The separation between people in urban centers and the regions where their food is grown is expanding as transportation technologies are able to outsource food farther and farther away. The average food miles in the United States is 1500, predominately transported by refrigerated trucks that run on diesel. There is economic and social benefits to shipping food get apples from Washington in Florida, or a tomato from Arizona when they are out of season in New York. Yet the heavy carbon footprint that imposes on the environment when the carbon dioxide in the atmosphere has already breached a dangerous threshold of 400 parts per million should make the population question the current standard of food exports.

With 37,000 farms, agriculture is an important aspect of Washington's economy. Led by the state's apple and tree fruit industry, WA is an incredibly productive growing region. The state's cultivated farmland is primarily located on the east side of the state, where arable land is plentiful and soil is fertile. However, the majority of WA's population is located in the Seattle-Tacoma region — an area with less available land, glacial till and geographically separated from the majority of the state's farmland by the Cascade mountains.

Fig. 13 | *Algae Blooms in Lake Erie Resulting from Fertilizer Runnoff*

17 EPA, "Global Greenhouse Gas Emissions Data" (Environmental Protection Agency, 23 Feb 2016) accessed 26 April 2016.

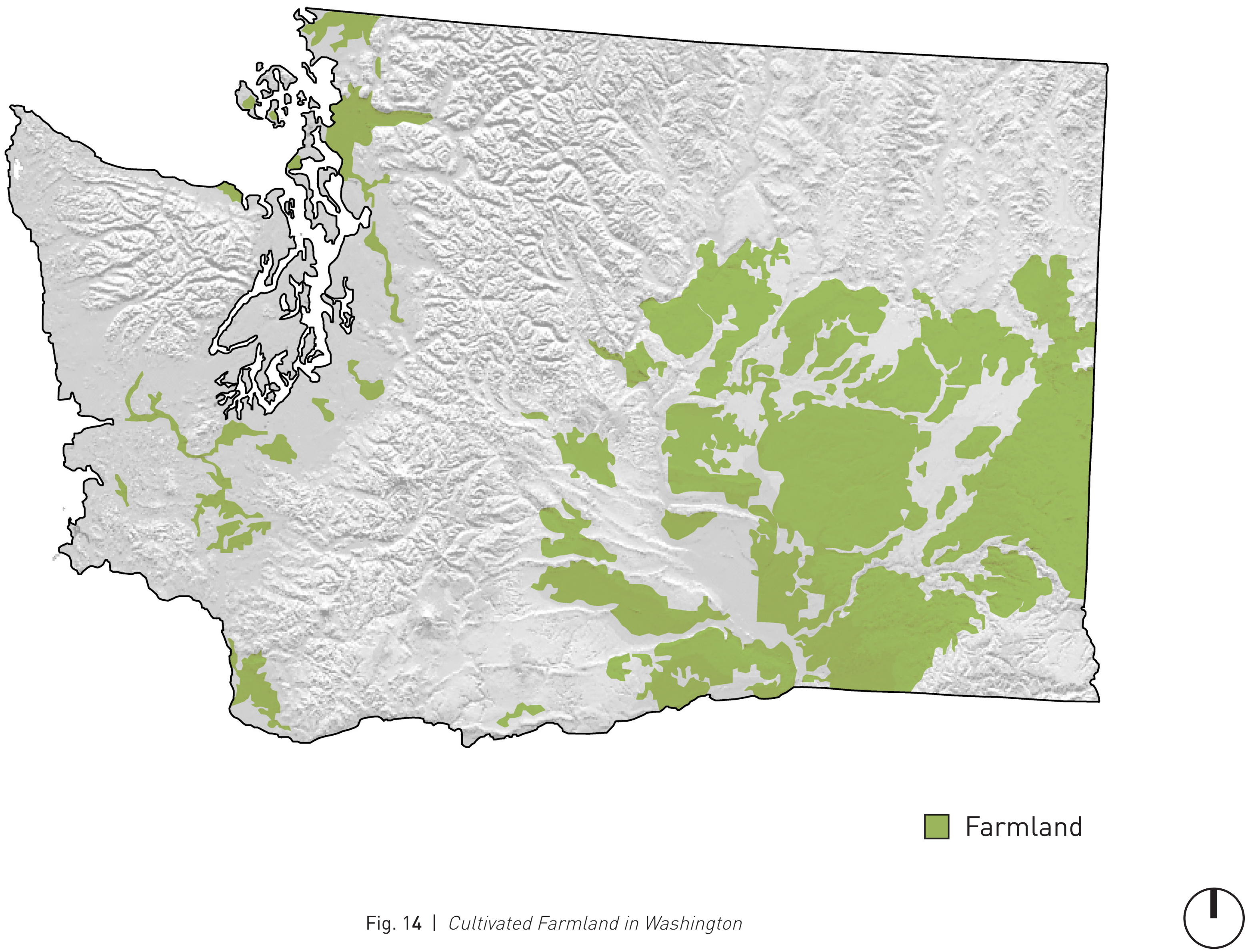


Fig. 14 | *Cultivated Farmland in Washington*

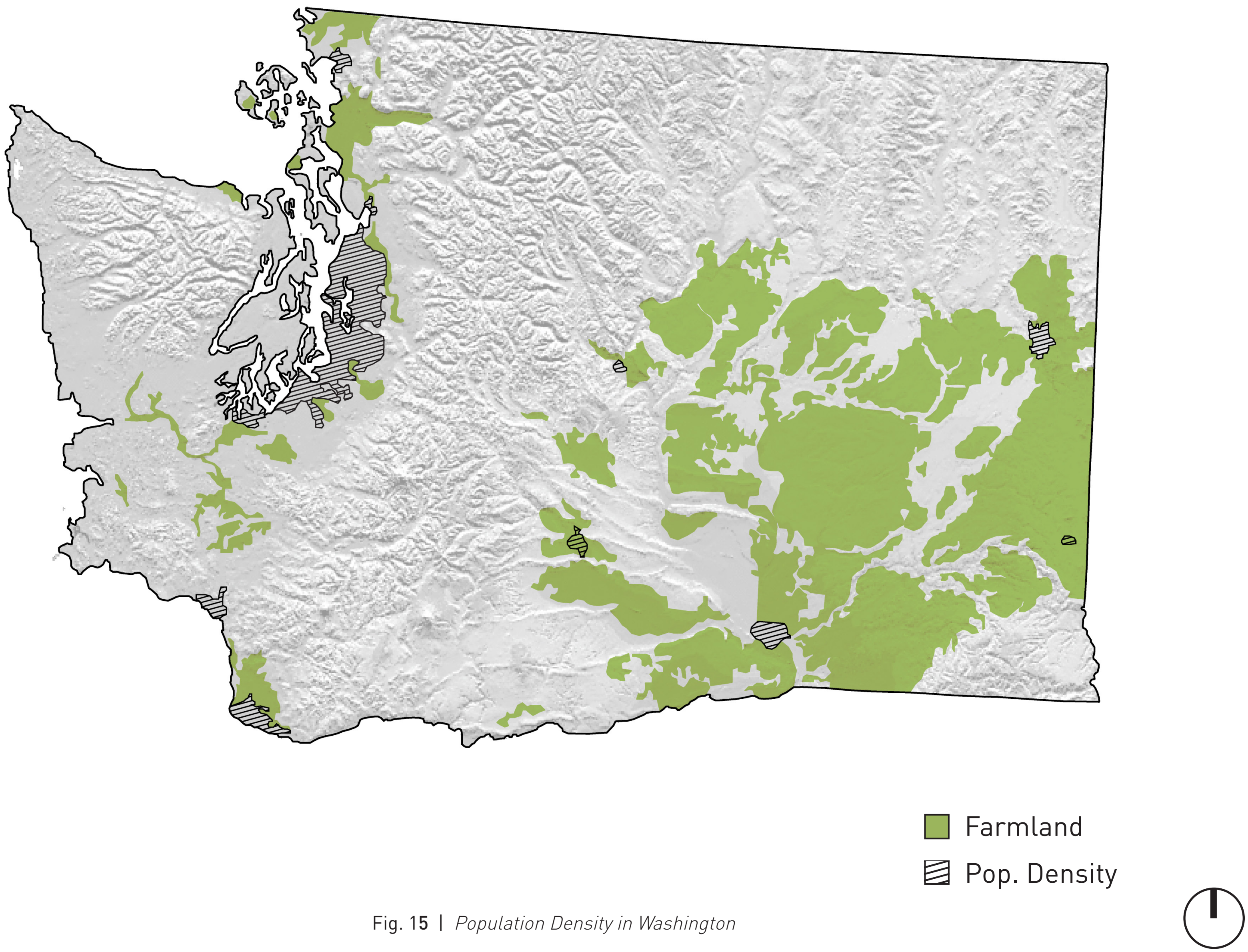


Fig. 15 | *Population Density in Washington*

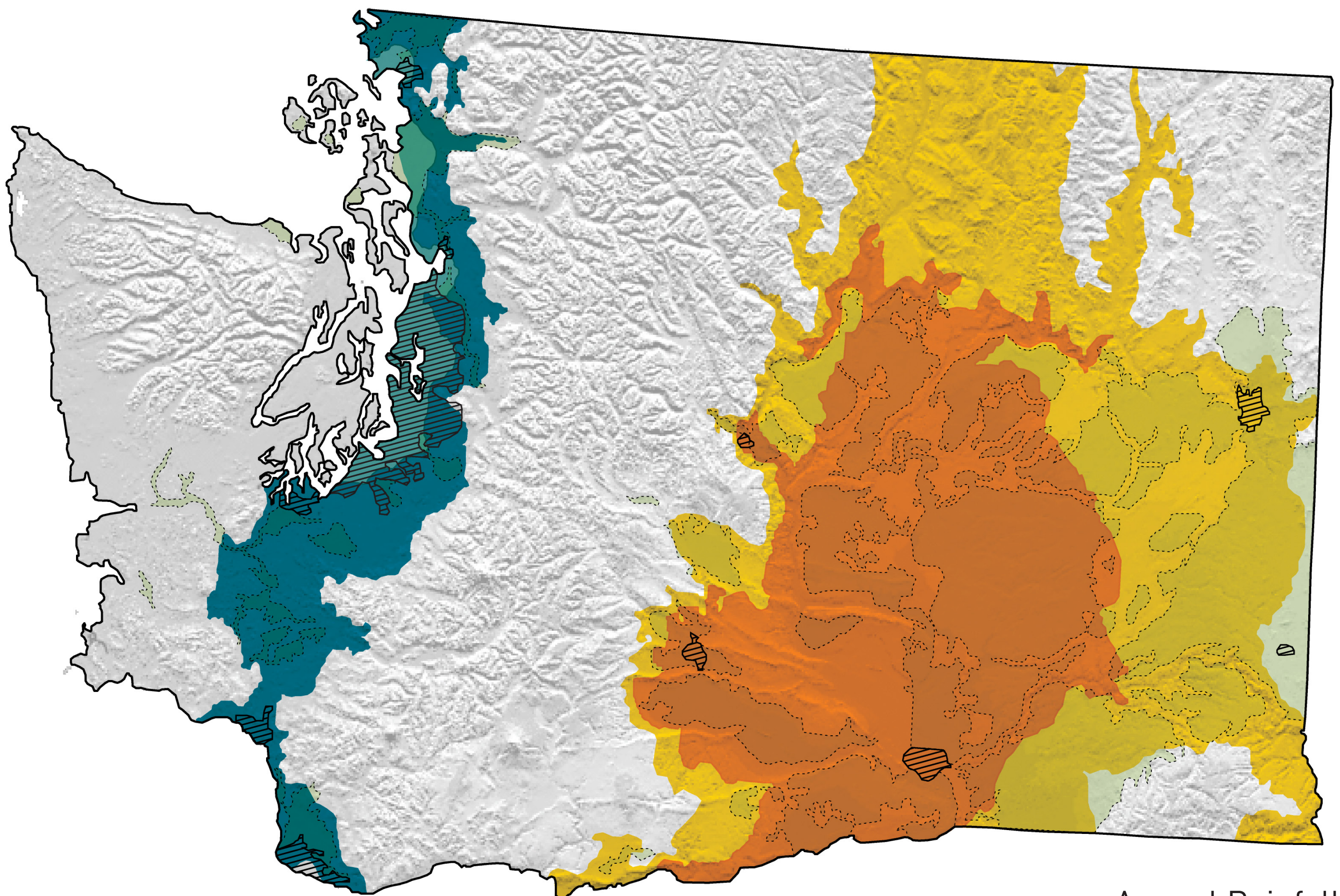


Fig. 16 | *Annual Rainfall in Washington*

One of the key factors in WA's agricultural production is large scale irrigation. The majority of WA farmland is located in the driest part of the state, receiving less than 10 in of annual rainfall. While the Seattle area receives 30-40 in. Agricultural water use is a main concern and the ability to conserve in addition to mitigate pollution is paramount.

Water is typically used poorly and wasted in the agriculture industry. The most typical form of crop irrigation is rotating sprinkler heads. This style of irrigation is common due to it's easy application and cheap infrastructure, but results in a majority of the water being either evaporated or soaking unplanted soil in the field. The use of drip irrigation, which can reduce water usage by 40 percent and energy by 15 percent,[18] is becoming more prevalent, but mostly in small-scale organic operations due to the labor intensive implementation for large scale, industrial farms.

Energy Consumption: Building Industry

Similar to the agriculture industry, the built environment is also a massive resource consumer, stemming from the refining and transport of materials to the costs of heating, cooling, and lighting interior space. The building industry is the largest contributor to green house gas emissions with 1/3 of total emissions and consuming about 40 percent of global energy.[19] The United States is one of the main culprits in this figure, being the second largest producer of CO_2 emissions in the world.[20] Considering that the U.S. population is a small percentage of the world's population, this rank is drastically out of proportion.

Here in Seattle, buildings account for about 23 percent of total energy consumption and the subsequent GHG.[21] The concern for the environment and climate change has enacted several programs and policies to help manage the situation, but with unprecedented growth, meeting the new standard is becoming increasingly ambitious.

Building Integrated Agriculture

The dire circumstances of the agriculture and building industries leads to an innovative concept: bring the two together in order to aggregate and reduce the impacts of each. By growing in buildings, new cleaner technologies can be utilized while improving the health and performance of the building. Urban agriculture presents an opportunity to reconnect with the food system and integrate cities into a productive landscape. Growing food within

18 Dr. Michael E. Webber, "How to Make the Food System More Efficient" (Sustainable America. 12 Oct 2012) accessed 27 April 2016.

19 UNEP, "Why Buildings?" *United Nations Environment Programme* in collaboration with *Sustainable Buildings and Climate Initiative*, accessed 29 April 2016.

20 EPA, web.

21 Sandra Mallory and Wes Hoppler. dir Jill Simmons, "2012-2013 Energy Performance Report" (Seattle Office of Sustainability & Environment: 2014) p. 3.

the city has the potential to contribute to the the health of urban communities at a social and ecological level by greening vacant lots, creating new jobs, encouraging social networks, empowering individuals by improving food security and health.

In contrast to the conventional food system, urban agriculture is directly dependent on the awareness and support of the surrounding community—providing the customer base, population density, and food culture that allows "hyper-local" food production to thrive. Support arises out of concerns over the capacity of the current food system to supply the rapidly growing population with food in the face of uncertainty regarding economic collapse, fossil fuel availability, and climate change.[22] Urban agriculture is founded on a mission of resilience and self sufficiency, enabling community empowerment.

The diverse array of urban agriculture projects range from small scale, dispersed gardens to high-tech, capital intensive commercial projects. The varying approaches are subject to the conditions and context of the site and overall goals. Most urban farms are ground-based approaches located on vacant or underused lots.[23] Although this approach presents an opportunity to rehabilitate underutilized urban space, limiting factors are site availability and land values that become space and cost prohibitive for soil-based farming. Contaminated soil from decades of exposure to urban pollutants are also factors of major concern. High probability of pollutants such as lead and arsenic being found in the soil on urban sites lead to expensive and time-consuming remediation processes such as excavating, geo-textile capping, and soil washing. Some biological techniques that use microbes to degrade contaminants can be used at a much lower capital, but require significantly more time.[24]

Based on these constraints and the central focus of producing high yields through intensive growing practices, this thesis will center on the high-tech, building integrated side of the urban agriculture spectrum. Building-integrated agriculture (BIA), where farming systems are located on and within mixed-use buildings and are designed to exploit synergies between the built environment and agriculture, is an environmentally sustainable strategy for urban food production. Engineered to provide optimal growing conditions all year round, this approach uses hydroponic growing methods in a controlled environment often on rooftops, not only because of the usual challenge of land availability and costs but also because greenhouses require ample access to sunlight to function effectively – a condition that is difficult to find at ground level in dense urban areas. Extended growing season and greater degree of control over nutrient levels and pests as reasons to believe that such techniques

22 Ackerman, p. 119.

23 Ackerman, p. 123.

24 Ackerman, p. 124.

Fig. 17 | *Rooftop Greenhouse in Brooklyn*

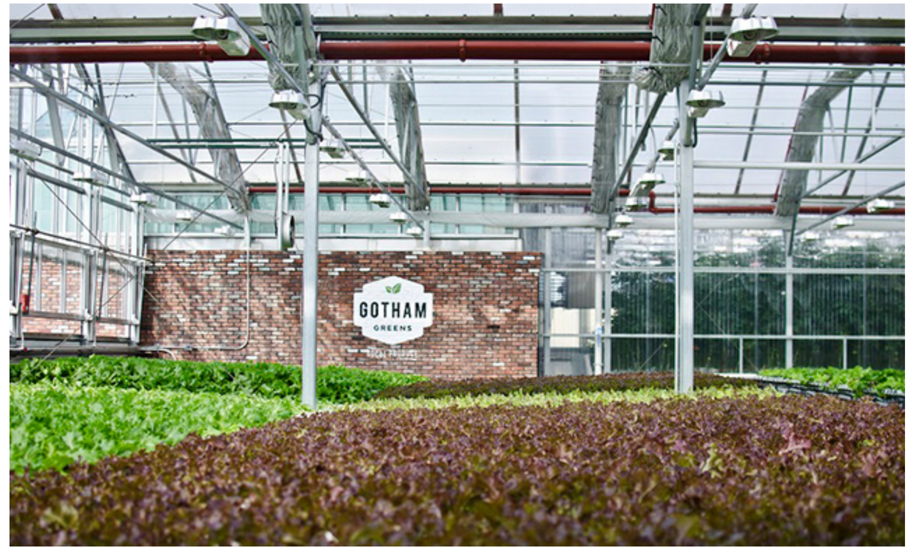


Fig. 18 | *Inside Gotham Green's Greenhouse*

will be critical to feeding urban populations in the future, especially given concerns over soil nutrient depletion, desertification, water shortages and climate change.[25]

One of the main impacts of BIA on the surrounding community is accessibility to a healthy, high quality product. By having the produce grown within a short radius from the markets, a highly perishable product can be harvested, delivered and sold within a 24 hour period. The reduction in transport and waste reduces added costs that are passed on to the consumer, ensuring affordability.

25 Gould and Caplow, p. 150.

Gotham Greens

Gotham Greens is a Brooklyn based urban agriculture company that specializes in rooftop CEA. In 2009, co-founders Viraj Puri and Eric Haley were awarded a grant from the New York State Energy Research Development Authority (NYSERDA) along with other private financing to invest in the construction of the nation's first commercial hydroponic farm in an urban setting. After construction of the flagship greenhouse in Greenpoint, Brooklyn was completed in April 2011, the company began growing and distributing leafy greens to local markets and restaurants. Two years of planning, fundraising, coordinating, permitting, and reviewing was rewarded with a highly successful year with 100 tons of produce

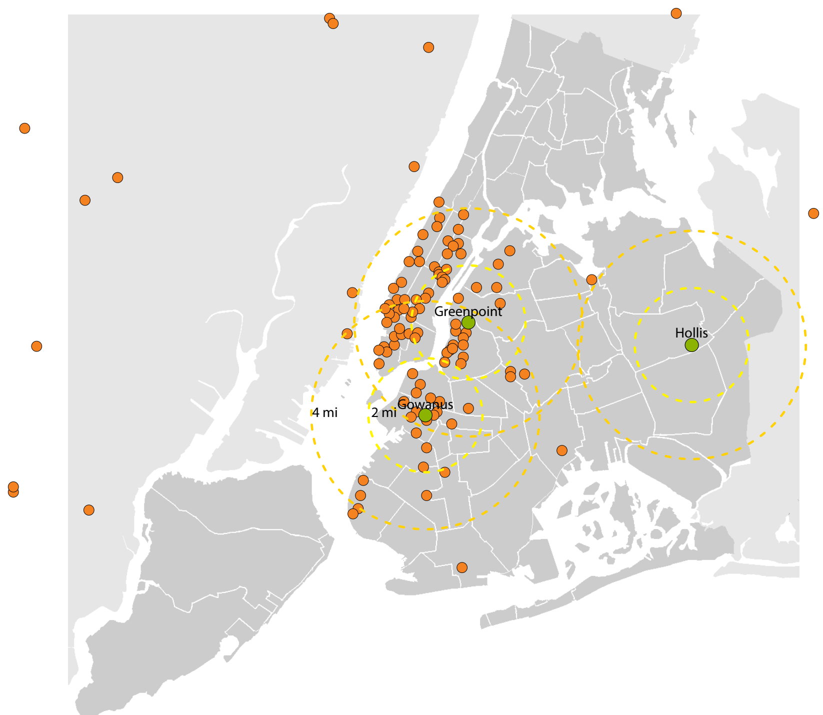


Fig. 19 | *Gotham Green's New York City Marketplace*

harvested from the 15,000 square foot facility.[26] Drawing acclaim and coverage from various outlets, Gotham Greens was encouraged to grow as a company, providing a promising precedent for rooftop CEA and the urban agriculture movement. Since the success of the first facility, Gotham Greens has expanded to two more facilities in the New York area and one in Chicago. The company has partnered with Whole Foods and Method Soaps, developing rooftop greenhouses for one of Whole Food's supermarkets in Brooklyn and the Method Soaps manufacturing facility in Pullman, IL outside of Chicago.

The company utilizes an NFT hydroponic growing system in all 4 operations, ensuring a consistent product year round and a space-efficient design producing high yields per ft2. Along with saving water and energy, the system allows the company to grow produce free of pesticide, herbicide, and chemicals — further promoting their environmental stewardship.

Choosing New York City as a launch point for a greenhouse farming company is a curious decision considering the cold winters and northern latitude, but would prove ideal for an urban agriculture model. In an interview with Paul Solman at PBS Newshour, Puri states:

> Brooklyn is a special place, and we're seeing so much innovation. It's on the cutting edge of science, media, art, fashion and food. We have this growing urban population that increasingly cares about where they get their food, how it's grown, who the people are growing it, whether itis close enough to them and what it really represents.[27]

The ability for BIA to grow year-round and in inclement weather also increases food accessibility and food security.

26 April Philips, *Designing Urban Agriculture: A Complete Guide for the Planning, Design,Construction, Maintenance and Management of Edible Landscapes* (Hoboken, NJ: Wiley, 2013) p. 42.

27 Paul Solman. “Making Use of Empty Space.” PBS Newshour Oct. 2015.

2008
- Working as an engineer at Sun Works, Viraj Puri decides to develop an urban agriculture company

2009
- Puri and partner Eric Haley found Gotham Greens Farms LLC
- Awarded grant from NYSERDA
- Grand Prize - New York Green Business Competition

2010
- Began contacting supermarkets and restaurants
- Jun. - Submited final construction drawings
- Sep. - Completed all financing
- Oct. - Began purchasing materials and equipment
- Nov. - Construction commenced

2011 (15,000 ft²)
- Mar. - Installation of growing systems and climate control systems
- Apr. - Completes construction of 1st greenhouse in Greenpoint, Brooklyn
  - 1st commercial scale urban rooftop greenhouse in the nation

2012
- CEA Center Mission Award - University of Arizona

2013
- Made in Brooklyn Award - Brooklyn Chamber of Commerce
- Environmental Excellence Award - New York State Department of Environmental Conservation

2014 (35,000 ft²)
- 2nd greenhouse in Gowanus on top of Whole Foods Market
  - 1st commercial greenhouse farm integrated into a super market
- 40 under 40 - Greenhouse Product News
- Annual Supplier Award - Product Innovation Whole Foods Market

2015 (95,000 ft²)
- 3rd greenhouse in Queens
- 50 Coolest Businesses in America - Business Insider
- Martha Stewart American Made Award Winner
- (170,000 ft²) 4th greenhouse in Pullman, Il outside of Chicago
  - At 70,000 sqft. the greenhouse is the largest commercial rooftop green house in the world

2016

GREENPOINT, BROOKLYN

GOAWANUS, BROOKLYN

HOLLIS, QUEENS

PULLMAN, CHICAGO

Fig. 20 | *Timeline of Gotham Green's Grow Operation*

Following the large storm Hurricane Sandy in 2012, Gotham Greens being centrally located in Brooklyn, was one of the only supplier of fresh produce after distribution channels broke down.[28] Being located on an isthmus at sea level in a seismic area, Seattle is vulnerable to being cut-off in the event of a natural disaster. Additionally, having food grown in a closer vicinity to the consumer and within a more controlled environment greatly reduces the risk of food-borne illness as a result of pathogens.

According to the University of Wisconsin Center for Integrated Agriculture Systems, a large-scale organic vegetable farm over 12 acres requires about 554 labor hours per acre to operate annually.[29] Assuming 2000 annual labor hours for a full-time job, one person can manage 4 acres of farmland. In the same study, medium-scale operations of 3-12 acres required an average of 850 hours per acre, or about 2.5 acres per full-time position.[30] The labor intensive model of hydroponic operations can require up to 26 full-time employees per acre of growing space.[31] Although it puts pressure to have consistently high yields, job creation for the surrounding community is significantly better in hydroponic

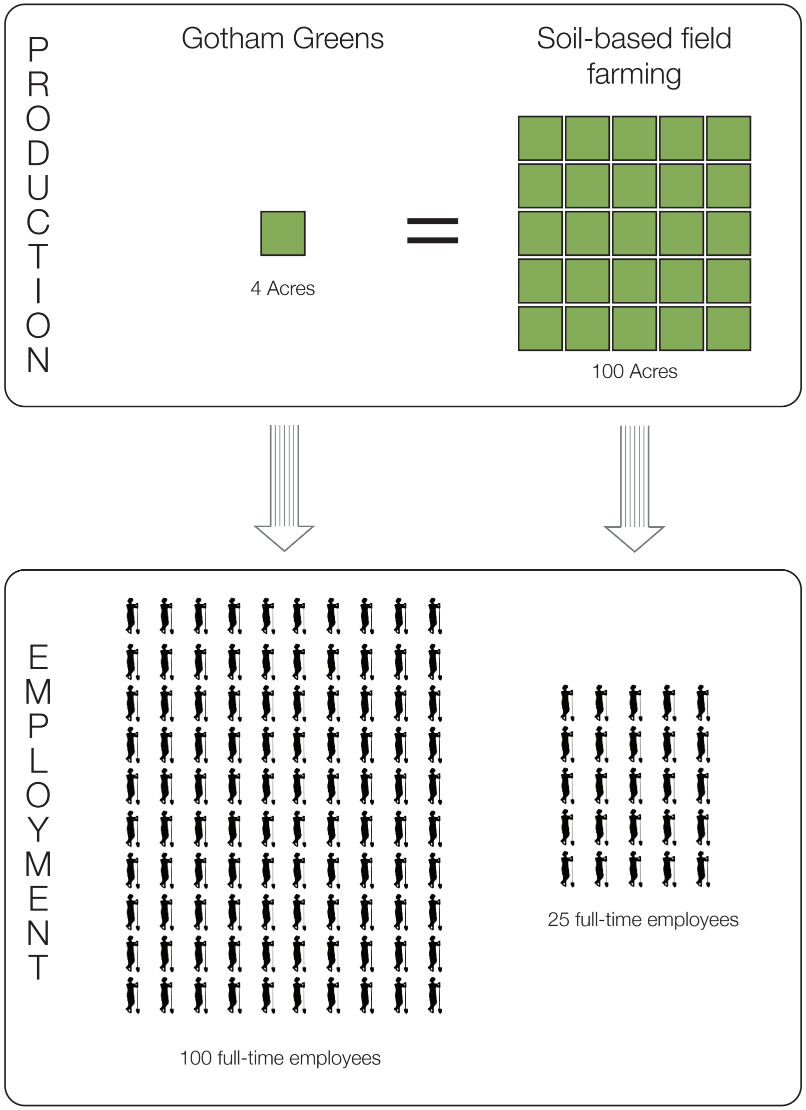


Fig. 21 | *Labor Comparison between Hydroponic and Soil-based Farming*

28 Elizabeth Royte, “Urban Farming Is Booming, But What Does It Really Yield?” (*Ensia* April 2015) accessed 12 March 2016

29 John Hendrickson, *Fresh Market Vegetable Farms at Three Scales of Production*, UW-Madison Center for Integrated Agriculture Systems p. 2.

30 Hendrickson, p. 2.

31 Agrilyst, *State of Indoor Farming - Report - 2016* (Agrilyst, Sept. 2016) p. 22.

operations than soil-based field farming.

It is important to note that a marginal employment increase for 4x the grow space has been observed in the precedent analysis, showing that a baseline amount of labor is needed to operate a rooftop greenhouse, but similar to many industries the employment is not necessarily congruent with growing capacity. As the system becomes more streamlined and operates more autonomously the system can grow more with less help once the infrastructure is in place and the baseline labor met. Therefore, hydroponic BIA such as Gotham Greens is proven to create more jobs than conventional farming, but is subject to economies of scale. This is vital to produce revenue, but inherently has an employment cap as the operations get bigger.

2B: Seattle Housing & Baugruppen as an Affordable Option

Affordability Crisis

Seattle's rising population increases housing demand and subsequently housing cost—threatening diversity and creating the potential for increased sprawl as low-income residents move away from the city center.[32] Addressing the affordable housing challenge is imperative to ensuring a sustainable, equitable future for Seattle. Increasing density is critical as the city grows, but must involve affordable options. In 2011, 38 percent of all Seattle households were cost-burdened (rent exceeded 30 percent of income) and 43 percent of renters.[33] This figure is significantly skewed toward low-income households with 77 percent being cost-burdened.[34]

The average rent for new construction 1BR/1B is $1,780 and the average rent for an existing 1BR/1B is $1,412.[35] This figure puts many critical professionals such as nurses, teachers, and firefighters into cost-burdened territory, potentially leading to displacement from the city into sprawling suburbs. This figure also disproportionately impacts minorities with 34 percent of African-American families spending over half of their income on rent.[36]

The city is in need of housing reform, which not only needs to be a policy shift, but also in terms of architectural design. Currently short-term thinking trumps a long-term perspective when it comes to affordable options in Seattle. High-density, mixed-use developments are increasingly becoming manufactured commodity buildings of poor quality and with little in the way of thoughtful public amenities. In addition, the costs of rent for these new developments are disproportionate to the affordability of the surrounding

32 "Affordable Housing Strategies for Seattle" (*Futurewise* Feb. 2015) p. 1.

33 Futurewise, p. 3.

34 Futurewise, p. 3.

35 HALA Action Plan, p. 2.

36 HALA Action Plan, p. 2.

community, encouraging the continued rise in rent at the expense of a sustainable and equitable community. The necessity for affordable housing should be coupled with quality and longevity.

In terms of implementing sustainable building practices in affordable housing, difficulties arise in the short-term cost. Author William Bradshaw states, “The current affordable housing finance system, characterized by a focus on initial capitol costs, cost caps, and other regulatory and financing constraints, often impedes the realization of benefits of green building.”[37] The commercial viability of BIA could potentially offset costs. In addition to commercial use on the ground floor, a new longterm perspective, and concept of ownership bring potential to subsiding costs for sustainable affordable housing.

Baugruppen as an Affordable Option

Primarily driven by economic forces, the architect-led and collectively funded German practice of *baugruppen* (building groups) offers an opportunity for significant savings over traditional developer-driven models. The concept behind *baugruppen* is based on partnership between a group of individuals in order to pool resources into an invested interest — utilizing economic and social capital to realize a new housing model. They are self-build projects where future owners/tenants contribute to a central fund and work directly with an architect to design customized, cooperative housing affordably at an urban scale. The collaborative effort allows individuals who are being priced out of neighborhoods to combat market rate development and live centrally in increasingly expensive urban districts. Unlike communes and other co-housing typologies, *baugruppen* are derived from economic pragmatism as opposed to seeking a utopian vision.

Initiated by soaring rents and home values in Germany’s major cities, *baugruppen* are becoming increasingly popular as a viable housing alternative—gaining government support and financial banking options.[38] Similar to Seattle, only 43 percent (considerably low) of the housing in Germany is owner occupied, as estimated in the most recent national census from 2011.[39] Shortage of housing stock and lack of affordable options in urban centers led to a crisis where alternatives were vital to sustaining the equity of cities such as Berlin and Hamburg where sustained population growth has altered their demographic and generated intense pressure at the entry-level of their housing markets.

Baugruppen are distinctive beyond simply the co-operative ownership of buildings. They offer a broader response to three

37 William Bradshaw, *The Costs and Benefits of Green Affordable Housing* (Boston, MA: New Ecology, 2005) p.15.

38 Jessica Bridger, “Don’t Call It A Commune“ (*Metropolis Magazine* May 2015) accessed 29 May 2016.

39 Bridger, accessed 29 May 2016

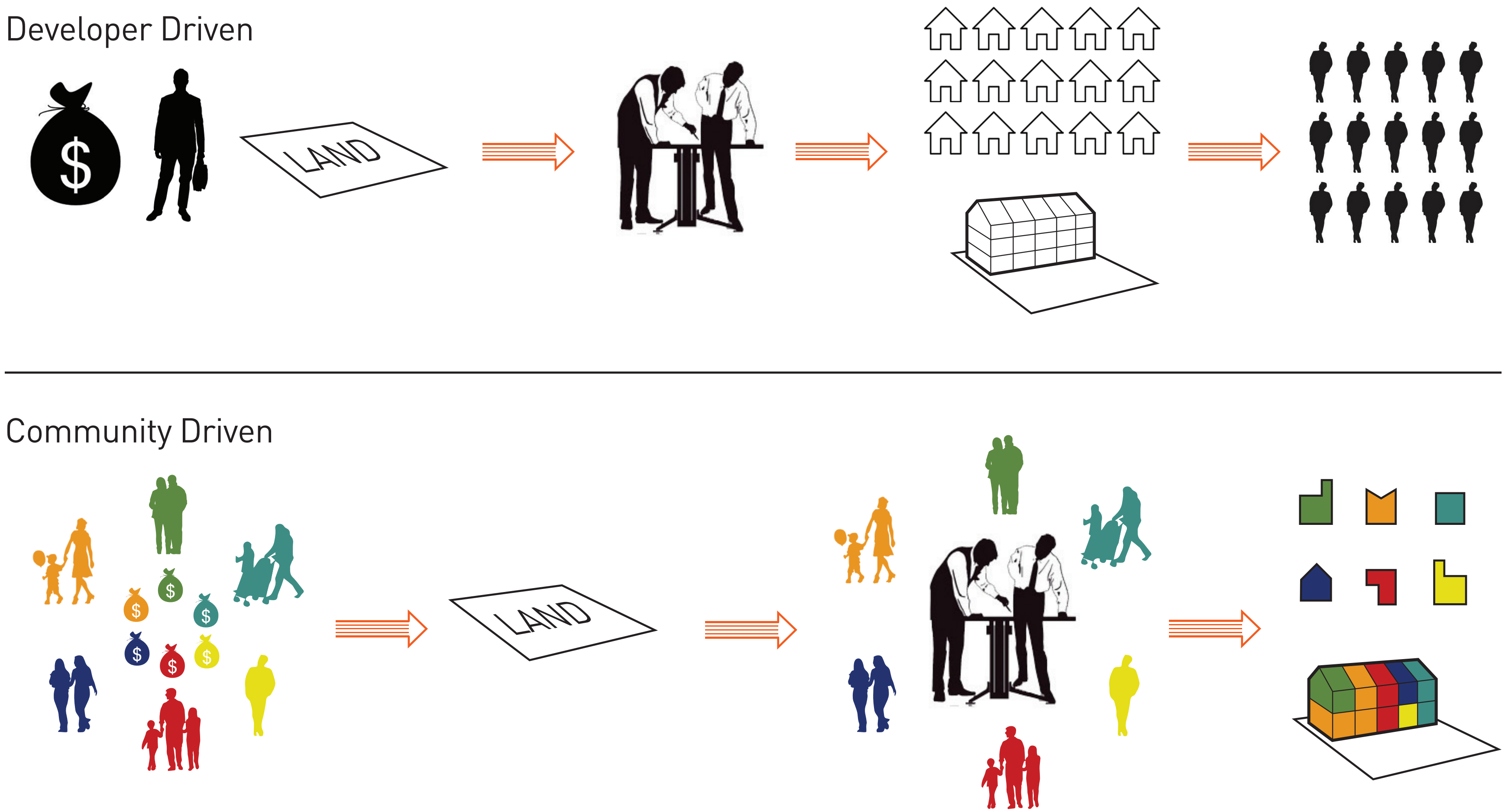


Fig. 22 | *Developer vs. Community Driven Models of Housing Development* key issues in housing policy: affordability, social cohesion, and individuality. First, there is substantial evidence to suggest that the cost of self-build compares favorably with developer-built housing.[40] Cost savings derive from the advantages of self-build projects versus speculative development. The end price becomes the cost of land, design and construction as opposed to being determined by the market value. Elimination of profit, venture capital, marketing costs, and vacancy rates can produce savings of 20-30% per square foot.[41] Additionally, savings can be found in the economies of scale that collective schemes deliver relative to individual single-family projects [traditionally known as the prominent self-build project type].

Secondly, high levels of social interaction, as evidenced by higher levels of communication and social ties needed to build cooperatively with neighbors, develops community connection and stability. Conventional development often leads to anonymous living, while the process and nature of *baugruppe* creates identification with a location, home and group — leading to high neighborhood quality. The architecture is largely driven by the social components of community-based living. Similar to co-housing, *baugruppen* typically incorporate shared common areas, providing greater opportunity for social interaction among tenants. Theses spaces are critical to the functionality of the project and are a defining characteristic.

And thirdly, *baugruppen* offer a distinctive approach to housing development that is reflected in the diversity and distinctive qualities of housing produced,[42] with homes more closely matched with the needs of occupant households. Spaces are created that are closely aligned to individuals' needs, aspirations and ideals. Need-oriented housing contributes to urban diversity with long-term thinking for a multi-generational and diverse user group — contrary to the formulaic design of profit-driven housing. Moreover, self-build is a reflexive process through which individuals better understand the needs and constraints of their physical environment. *Baugruppe* projects extend this 'person-place' relationship and, because of the interdependencies that play a crucial part in this particular act of domestication, produce a broader social outcome, creating home from a collection of houses.[43] In regards to a baugruppe on the Spree river in Berlin, Kristien Ring states:

> "This project, along with others of a similar nature, not only creates living spaces that are based on the real needs of people today, but also bring new neighbors into existing communities that have a vested interest in staying there and "making the city". These urban forms support micro economies and sustainable,resilient development.

40 Iqbal Hamiduddin and Nick Gallent, "Self Build Communities: the rationale and experiences of self-build housing development in Germany" (*Housing Studies* Routledge: Taylor & Francis Group, 2015) p. 5.

41 Hamiddudin and Gallent, p. 5.

42 Hamiddudin and Gallent, p. 2.

43 C. C. Marcus, House as a Mirror of Self: Exploring the Deeper Meaning of Home (Lake Worth: Nicolas-Hays, 2006)

Fig. 23-25 | *Images of R50 in Berlin*

With rising demand outmatching supply in Seattle, *baugruppen* are an applicable option for middle-income residents seeking homeownership in the city. In response to the possibility of American adoption of *baugruppen*, Mike Eliason, *baugruppe* enthusiast and passive house designer at Bjarko Serra Architects in Seattle says "My hope is that with enough education, exposure and promotion from governmental agencies, [Baugruppen] could become a viable alternative for those that aren't just hanging out in the upper quintile."[44]

2C: Integrating Agriculture into a Baugruppe

Part of the ethos of the baugruppen movement is a focus on sustainable urbanism providing a vehicle for experimental modes of construction for housing.[45] Community-led development has been centrally important in the development of sustainable housing across Germany, delivering places with not only physical qualities but a particular social quality as well.[46] The willingness to implement sustainable building practices is another advantage of a "people over profits" mentality and long-term thinking versus traditional models of housing where experimentation and innovation can prove difficult.

In Berlin, a *baugruppe* project called E3 became the first 7-story mass timber building in Europe.[47] The decision to use cross-laminated timber (CLT) and glulam construction was part of the group's central focus on sustainability and was adamant on using a renewable building material. Until 2002, timber constructions in Germany were restricted to only three stories. Even Berlin's new regulations restrict timber construction to 5 stories. But the use of CLT in the project earned a code departure that allowed the building to be constructed with special conditions. One of the main conditions was the egress stair had to be detached from the structure, and egress paths had to be shorter than what the code allows. This constraint turned into a design opportunity, where the building setsback from the adjacent property, creating an open court that greets the street. The stairwell, a concrete structure, is set apart from the rest of the structure, and stands next to the fire wall of the neighbouring building. It is connected to the individual apartments via cantilevered footbridges. This provides fire protection as well as additional light for internal areas via a third façade as a result of the setback.

A project such as E3 would arguably not be built under a developer driven model. Not only would the more costly CLT construction be considered, negotiating with the city for special

44 Johnny Magdaleno, "Build Your Own Baugruppe - A Home for the Rest of Us," (*Impact Design Hub* 8 Feb 2016) accessed 28 May 2016

45 Hamiddudin and Gallent, p. 2.

46 Hamiddudin and Gallent, p. 2.

47 Kristien Ring, "Self Made City: Strategies for Future Urban Living" (*Design and the City* Lecture, Amsterdam University of Applied Sciences, April 2016) accessed 26 November 2016

Fig. 26-28 | *Images of E3 in Berlin*

permits that ultimately resulted in a setback that greatly reduced the building's FAR and maximum unit count would certainly go against a developer's principals. Yet, as a result of the E3 *baugruppe's* progressive mission, environmental stewardship and long-term thinking, the project (completed in 2008) has become an exemplary project of mid-rise mass timber.

In addition to E3, anonther environmentally innovative *baugruppe* project, called Wohnen Arbeiten, became the world's first mixed-use building built to Passive Haus standards.[48] Again the sucess of this project is attributed to the group-build agenda and willingness to try something new. Art and architecture writer and *baugruppe* member Andreas Toelke says, "Even though the process of co-creating a residence can be long and arduous, one of the benefits is the feeling that it's our project and we all feel responsible for it."[49]

Due to the nature of designing and building in a group, there is potential to incorporate not only highly innovative construction methods, but a specific program of spaces and uses as well.[50] Therefore, integrating agriculture into a *baugruppe* project appears to be a more feasible option than a conventional development, given the base of all the residents signing on to a central concept and working together to attain a successful urban farm. Due to the initial costs of constructing a greenhouse, it would be a hard sell to a developer to include one in a project. To take the concept seriously, a partnership between a baugruppe and an urban farm company could initiate such an innovative project. Providing the required long-term thinking, non-speculative nature of the develpment model, and high ecological building standards that could enable the decision-making processes to focus productively on the good of the community.

48 Ring, Lecture

49 Frances Anderson, "Berlin's R50 Baugruppe is a Model of Living Affordably, Collectively," (*KCRW Design & Architecture* 31 July 2015) accessed 28 May 2015.

50 Mike Eliason, "Baugruppen: Innovative Constructs," (*The Urbanist* 27 May 2014) accessed 28 May 2016.

Fig. 29-31 | *Images of Wohnen Arbeiten in Freiburg*

3: [DESIGN METHODS]

Partnering BIA with a cooperative baugruppe, the goal of affordable home ownership and ecological benefits can be achieved in a rapidly growing Seattle. Cooperation and partnership are fundamental concepts within this goal. Fritjof Capra states, "In recent years, biologists and ecologists have begun to shift their metaphors from hierarchies to networks and have come to realize that partnership — the tendency to associate, establish links, cooperate, and maintain symbiotic relationships — is one of the hallmarks of life."[51] Establishing a cooperative baugruppe partners a group of individuals into an invested interest — utilizing economic and social capital to realize a new housing model. Conceptually, a cooperative partnership in housing pools resources as means to sidestep policy issues, delays and shortage of subsidized affordable housing; BIA uses the baugruppe as a vessel towards sustainable growing methods and in turn the baugruppe uses BIA as a method to further offset costs.

51 Fritjof Capra, *The Hidden Connections: Integrating the Biological, Cognitive, and Social Dimensions of Life into a Science of Sustainability* (New York: Doubleday, 2002) p. 99.

Achieving success relies on employing efficient and appropriate BIA systems that mitigate water usage, pollution, land consumption, and greenhouse gas emissions while producing a high enough yield not only to supply the housing group with food, but also to sell excess as a way to produce revenue — subsidizing part of the housing costs and creating jobs. The thesis will capitalize on site and program opportunities to ensure consistent and functional operations by partnering spatial and systematic components.

3A: Goals and Objectives

This thesis sets out to reduce the cost of housing by developing a baugruppe that incorporates an income-producing farm into a residential building by:

- Creating a multigenerational community of home owners in a dense mixed-use building
- Creating opportunities for marketing produce to the surrounding neighborhood and city
- Integrating revenue producing program elements that become an amenity for the neighborhood
- Utilizing growing techniques that allow efficient production of crops on the farm—reducing resource consumption while maintaining consistent yields.

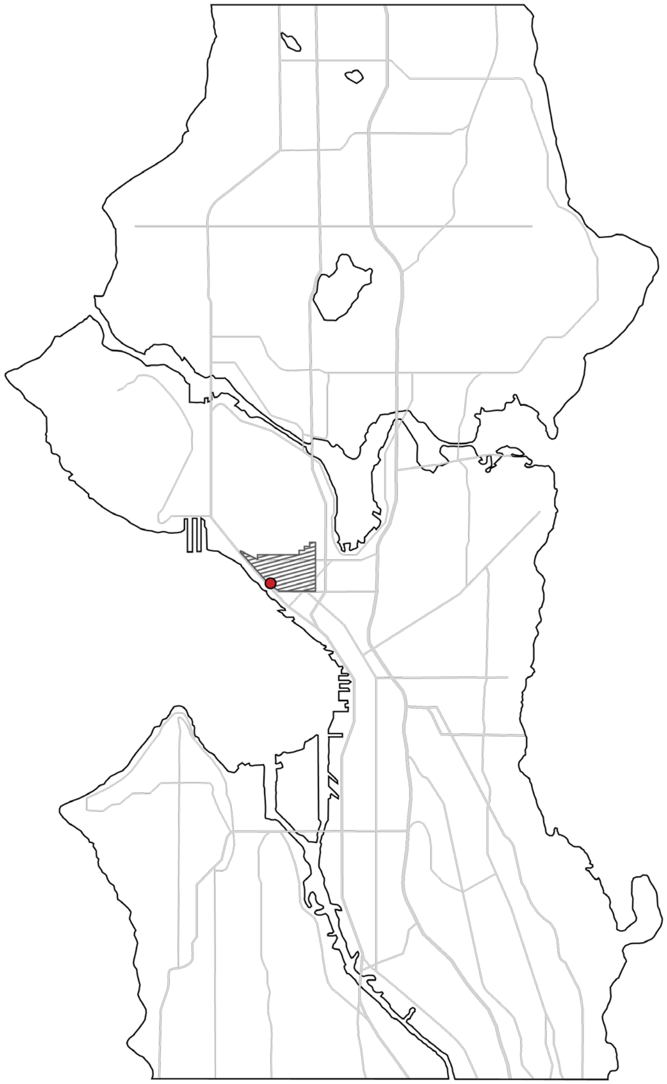


Fig. 32 | *Uptown in Relation to Seattle*

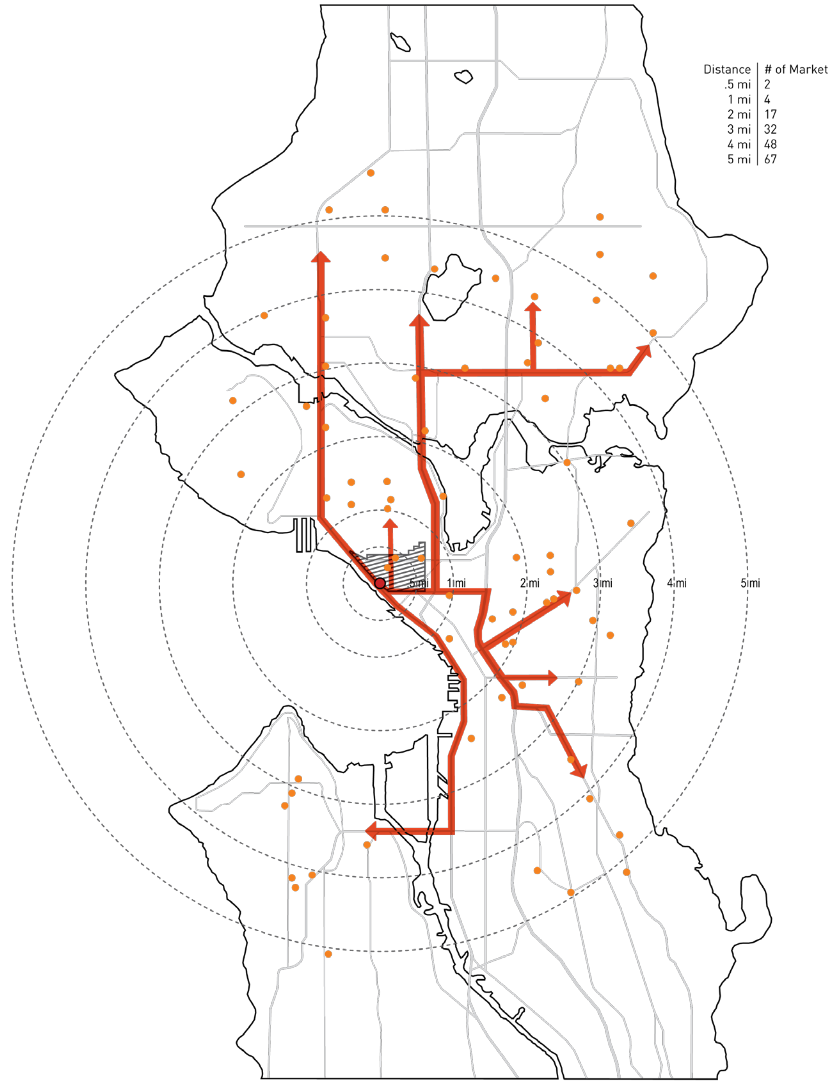


Fig. 33 | *Connection to Surrounding Marketplace within 5 miles*

3B: Site Selection

Key factors in determining the optimal neighborhood for the proposal include: an urban area with abundance of under-utilized space transitioning as a direct result of Seattle's growth with a demand for mixed-use development and connection to jobs, transit, public and civic amenity. With these criteria in mind, an ideal location would be in Seattle's Uptown neighborhood. It is one of Seattle's oldest neighborhoods, established as a Donation Land Claim in 1853 by David and Louisa Denny, playing a vital part in the urbanization of the city. After subdividing a portion of their claim, the Dennys' labeled the area "North Seattle" and made a significant contribution to the future growth of Seattle by laying out the street grid that remains unchanged today.[52] The grid is the primary framework for the area, acting not only as a network for travel, but defines the public realm and neighborhood character.

Throughout the early 20th century Uptown experienced rapid growth, especially during the Progressive Era years between 1890 and 1922 as a result of national western migration, pre-WWI patriotism and the post WWI boom. Notable events reflecting growth were the establishment of the Counterbalance on Queen Anne Avenue in 1905, major infrastructure improvements, completion of the first phase of the Denny Regrade in 1911, and flourishing commercial development along streetcar lines in the early 20th

52 Florence K. Lentz and Mimi Sheridan, "Queen Anne Historic Context Statement" Seattle Department of Neighborhoods, Historic Preservation Program and the Queen Anne Historical Society (Oct. 2005) p. 3.

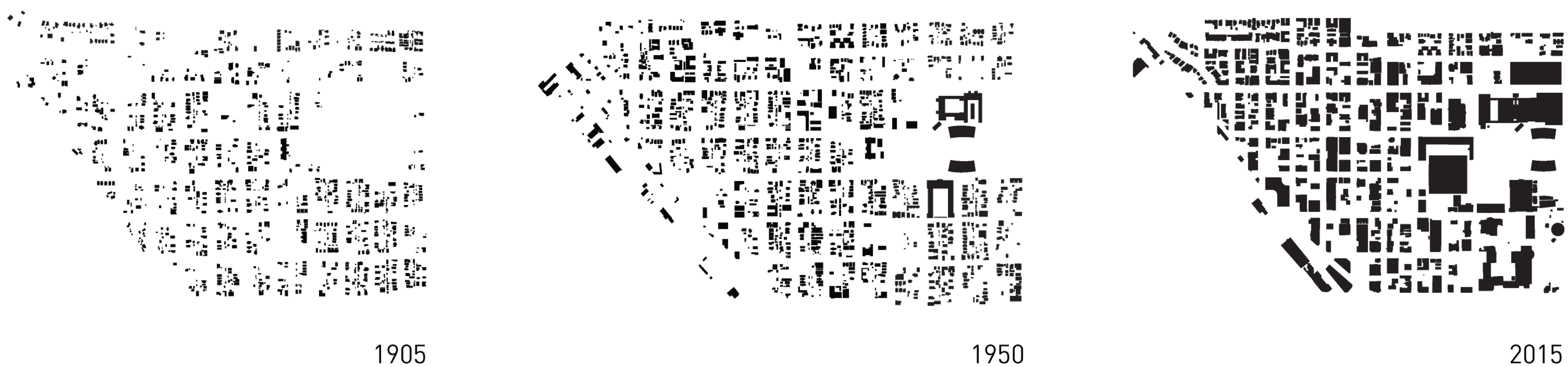


Fig. 34 | *Figure Ground Evolution in Uptown* century. The Counterbalance established the main commercial core of Uptown that is still very active today. In 1923, new zoning allowed mid-rise multifamily housing adjacent to the single family housing — transforming the neighborhood to a denser urban environment.[53]

In 1962, Uptown experienced one of its largest historical events. The Civic Center Complex was adopted as the site for the Seattle World's Fair Century 21 Exposition. Designating the site for a more national spotlight forever changed the cityscape of Uptown. The Civic Center was displaced from the Uptown community, shifting the sense of ownership from the neighborhood to the city[54] while cutting the neighborhood off from an east-west connection. The isolation resulted in piecemeal development in the last half century, creating an abundance of empty lots and a heterogeneous nature of Uptown's building types — contributing to a lack of identity more than to a vibrant cityscape. Uptown's historical background has supplied an architectural pedigree of various generations with challenging urban design questions, leading to an effort from the Seattle Department of Planning and Development to strategize for the neighborhood's future. This combined with Seattle's recent economic boom has attracted development to Uptown, returning to its role as a key factor in the city's growth.

Currently experiencing rapid change and transition into an urban district, Uptown is in need of a responsible and affordable housing type that could benefit the surrounding area with BIA. The neighborhoods proximity to South Lake Union and Downtown is subjecting the area to expensive market rate development, catering to a young and often temporary demographic. Currently, owner occupied housing in Uptown is 22 percent, well below the citywide 48 percent.[55] The need for affordable homeownership options is vital for Uptown to cultivate a diverse and equitable community. The neighborhood is about 300 acres in its entirety, bordered by Belltown to the south, South Lake Union to the east, and Queen Anne to the north. Being within a couple miles to Downtown has garnered a history of development in Uptown that reflects the influx population growth of Seattle. It has been designated as one of six "Urban Centers of the City" in the Seattle and King County's Comprehensive

53 Lentz and Sheridan, p. 11.

54 Lentz and Sheridan, p. 24.

55 Uptown Urban Design Framework: Uptown Background Report (Prepared by Seattle DPD: January 2014) p. 3.

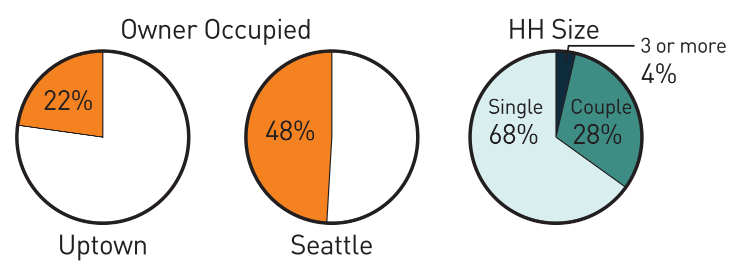


Fig. 35 | *Snapshot of Housing Statistics in Uptown*

Fig. 36 | *Street Conditions Around Site*

Plan, reinforcing its critical role as a location for jobs and housing of regional significance.[56]

Selecting a site within Uptown was determined by several factors. The site needed to be a southwest corner lot in order to maximize unobstructed sun exposure, be an underutilized space, retain maximum visibility and frontage, and be on a street that can support a mixed-use development. In addition, the site needs to be large enough for 30 plus units, farming systems, commercial programming and outdoor space.

The site chosen for the proposal is located in the southwest corner of the neighborhood bordered by West Thomas Street, 3rd Avenue West and Elliot Avenue. Currently a surface level parking lot with open views to the south and west, the site is optimal for an

56 Uptown Urban Design Framework: Uptown Background Report, p. 1.

urban agriculture housing project. To the southwest, Elliot Avenue creates a major edge as an automobile dominated thoroughfare. Being partially located on a busy arterial offers the project visible frontage to showcase BIA while having the opportunity to maintain a residential appeal on the more quiet West Thomas Street. Elliot Avenue's high speed traffic and lack of pedestrian crossings cut off Uptown from the adjacent waterfront, becoming a barrier to a potential amenity for the residents of Uptown. Near the site, the Thomas Street Bridge serves as an important node for Uptown, being one of the only safe crossing points on Elliot Avenue, helping to increase access to the waterfront. However, the bridge acts alone, and is troubled with its own design difficulties, including an ambiguous connection to Uptown that makes way finding challenging once crossed. Developing the proposed site would help define and clarify the bridge's threshold to the neighborhood and West Thomas Street as a pedestrian corridor. Furthermore, the site will have better access to transportation since public transit predominately serves the edges of Uptown.

Uptown is located in the Elliot Bay Drainage Basin. This drainage basin collects runoff from Queen Anne Hill to the north and the Denny Regrade to the south and is the last neighborhood before the runoff reaches the Puget Sound. Seattle is a particularly wet climate with 39 inches of rain annually, making storm water management an important factor. Polluted runoff into the Sound has had a significant impact on the salmon and Puget Sound wildlife. With this in mind, the project will seek opportunities to collect and help manage the storm water — mitigating pollutants in the bay while irrigating crops. Currently, West Thomas Street is a proposed green street — implementing a series of bio-swale for stormwater filtration. The site is the last lot on the downhill end of West Thomas Street, making it ideal for using the stormwater and contributing to the mission and character of the green street.

The recent growth in Uptown is reflected in the development of 1,606 housing units between 2005-2013, exceeding the area's 20 year growth target by 600 plus units in only 8 years.[57] Household sizes are disproportionately 1 and 2 person compared to the city average. Sixty-eight percent of households in Uptown are single occupancy and only 4 percent of total households are 3 person or more,[58] challenging the neighborhood's capacity to retain families. The 7,600 people who live in Uptown are predominately Caucasian, with a significant concentration of men and women between the ages of 20 and 35. Diversifying Uptown with multi-room units that can accommodate families with young children and home ownership options to allow residents to age in place will benefit the area by fostering a more dynamic community.

57 Uptown Urban Design Framework: Uptown Background Report, p. 2.

58 Puget Sound Regional Council, http://www.psrc.org/data/census/, accessed 15 May 2016.

Fig. 37 | *Elliot Drainage Basin Diagram*

Housing built in last 5 years

Housing permitted for construction

Fig. 38 | *Housing Development in Uptown*

3C: OCCUPANTS

The defining characteristic of the building residents would be individuals seeking home ownership who desire to live collectively in a community oriented housing. Ranging from young couples to families to empty-nesters, the residents would have access to an affordable homeownership model in a Seattle urban district. Some residents might be seeking their first home, at an affordable cost with the potential to establish themselves into the community while others might be seeking to downsize from a single-family residence to a more centrally located urban environment. They wish to have their own private, custom space, but also wish to invest in extensive shared spaces and productive BIA. Beyond the residents, users would include a staff of greenhouse workers and locals who patronize the co-op market and restaurant on the street level, co-working space and students learning about BIA.

3D: Design Methods

Growing Method

Hydroponic growing is a soil-less system which irrigates and feeds the plants simultaneously. The water is enriched with minerals and nutrients for uptake through the plants roots. Sensors are used to monitor nutrient levels in the water as well as the water level itself, to ensure the plants are getting enough oxygen to the roots. Specifically the growing system to be used in this thesis is called nutrient film technique (NFT), which utilizes a very shallow stream of nutrient rich water consisting of dissolved minerals continuously flowing past the bare roots of the plants in a watertight channel. Using the shallow stream ensures that a portion of the root mat would be exposed, allowing a supply of oxygen for the plant to breathe.[59]

Hydroponic growing techniques are proven to reduce water and land usage. It is proven to use 10 times less water and up to 20-30 times less land for comparable yields to conventional field agriculture.[60] Considering globally, agriculture uses 60 percent of fresh water withdrawals and occupies 40 percent of the world's land surface,[61] utilizing an efficient growing system that conserves water in a compact area can greatly reduce the ecological impact. A hydroponic system decreases water usage by re-circulating excess water, eliminating any waste. In addition, the system does not use very much water in the first place; by watering directly to the roots the system does not need to account for water loss due to saturation of unplanted soil and evaporation before the water reaches the roots. When water is absorbed through the plant's roots, up to 90

59 Brandon Merril, Southwest Environment (University of Arizona, May 2011) Web, accessed 19 April 2016.

60 Gotham Greens, gothamgreens.com (Gotham Greens Farms LLC, 2016) Web, accessed 19 April 2016.

61 Gould and Caplow, p. 148.

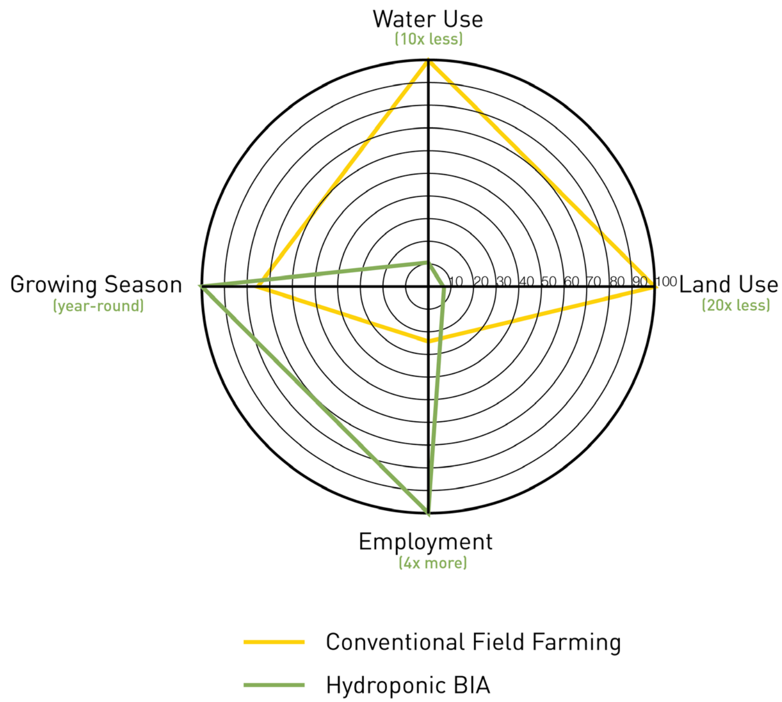


Fig. 39 | *Field Farming vs. Hydroponics*

percent is still wasted due to evapotranspiration through the plant's leaves.[62] When growing in a controlled environment, the moisture from evapotranspiration is not immediately lost to the atmosphere, but can be captured through the buildings exhaust vents with a water condenser and reclaimed back into the system.[63] Furthermore, rainwater catchment can be implemented into the system as an on-site renewable resource that mitigates the amount of offsite water reliance. This is significant to places like Seattle, where rainwater is in abundance and needs stormwater management in order to not stress its infrastructure and reduce polluted runoff into the area's waterways.

62 Merril, web, accessed 19 April 2016.

63 Merril, web, accessed 19 April 2016.

Without the need for soil, wide rows for tractors, and crop rotation, the plants can be arranged more compactly and be grown year-round in a hydroponic greenhouse. Not only does the amount of land become reduced, the system can activate under-utilized land in urban areas such as rooftops and vertical surfaces that have ideal solar exposure — transitioning food production from the field to the city.

Being a high-tech system, hydroponic greenhouses use sensors coordinated with computer controls to manage greenhouse temperature, water level, nutrient levels, fans, ventilation, shading devices and artificial lighting. The greenhouse tech is synced and regulated by a rooftop weather monitoring system analyzing wind, rain, temperature, humidity, carbon dioxide and light intensity. Electronic data are displayed at a central computer on the rooftop. The use of tech makes vegetable growing a highly calibrated system that increases quality and predictable yields by keeping the greenhouse at desired conditions. The quantifiability of the operation lends to successful marketing and commercial viability. The system also develops an immunity to drought and natural disaster, becoming

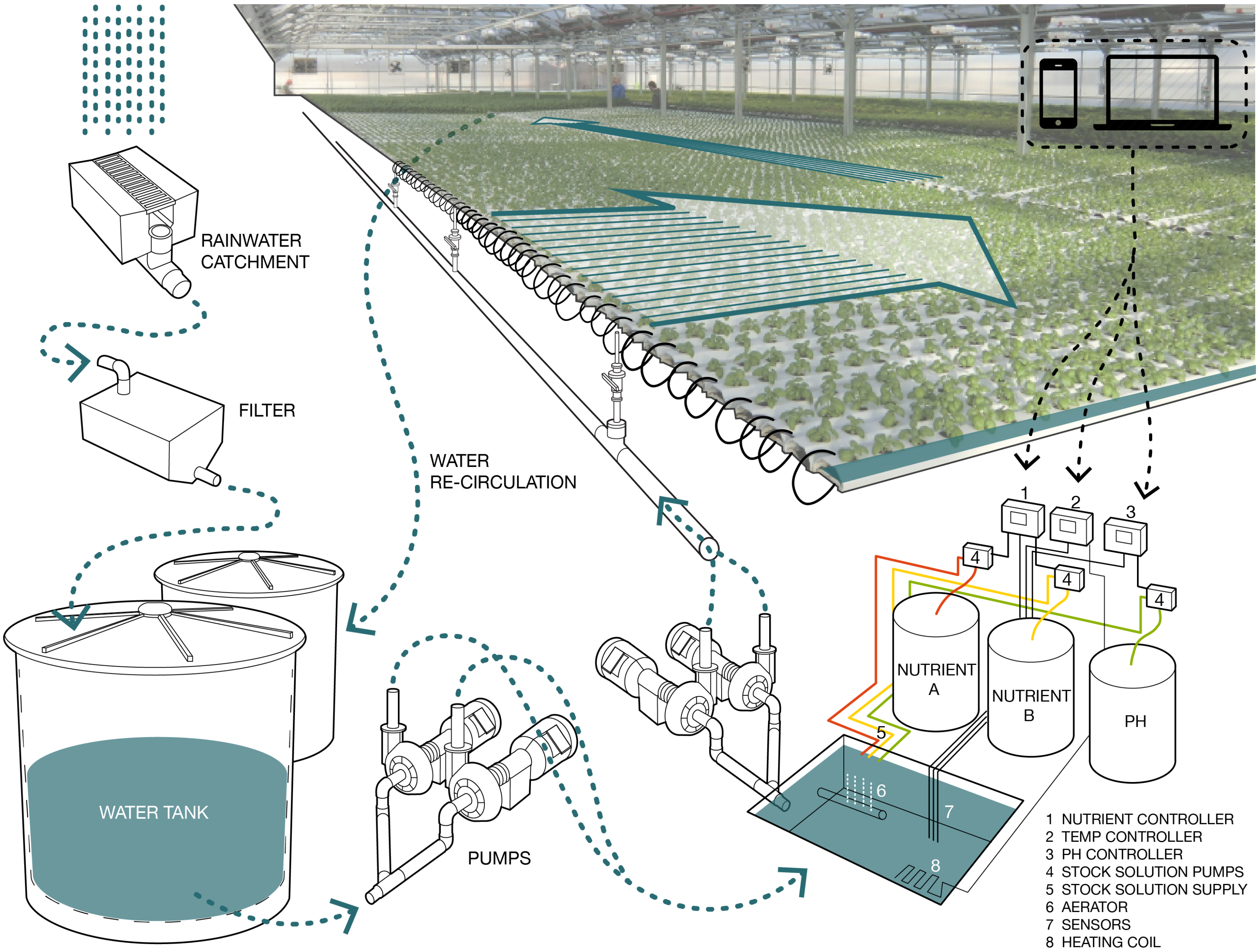


Fig. 40 | *Hydroponic Growing System: Process Flow of Water* a consistent model that reduces risk and maximizes reward.

One of the drawbacks for high-tech hydroponics is that the system lends to developing a monoculture within the greenhouse, due to the specialized nutrient recipe and the distribution within a closed loop. It makes sense to have all the same crop in a system to ensure proper growth. Also different plants require different climate conditions. Leafy greens need cooler conditions while tomatoes need a warmer one. To grow the two together would require a partition that increases cost and reduces efficiency. Minimizing this circumstance is important for the operation, limiting the extent of biodiversity at the greenhouse. Additionally, due to the expensive nature of hydroponics, growing a product with a high market premium and minimal inputs takes priority — such as greens and tomatoes and opposed to corn and potatoes.

BIA can effectively produce food without the use of chemical pesticides, herbicides, or insecticides by opting for natural solutions such as beneficial insect species that help mitigate harmful pests. Using beneficial insects as the primary method of prevention relies on the insects to target specific crop pests and eliminate them from the controlled environment, creating a symbiotic relationship between the produce and insects. Inherently, hydroponic systems do not need herbicides due to the absence of invasive weeds. This is an important fact in considering the use of GMO seeds in conventional farming practices, most of which are modified to resist powerful herbicides that are employed to combat competitive weeds in the field.

One of the key environmental factors of the water management system is the elimination of agricultural runoff of chemical fertilizers — a leading cause of water pollution and eutrophication.[64] When fertilizers get into watersheds and reach concentrated levels they can ignite rapid growth in algae that consume all of the oxygen in the water, creating a “dead zone” that greatly impacts the ecosystem.

One hundred percent of the energy to operate a greenhouse could come from renewable sources. Photovoltaic panels installed on the rooftop can integrate with the greenhouse system, supplying the energy needed for operation. Winter-time heating in Seattle accounts for the majority of energy demand and CO_2 emissions in buildings. Rooftop integration will yield direct energy savings by eliminating heating loses through the building roof and greenhouse floor, when compared to slab-mounted greenhouse design.[65] Part of the greenhouse design includes double glazing and thermal blanket, to reduce heating losses in the Seattle climate. Being located in a densely populated urban area allows the growing operations to take advantage of and mitigate the heat island effect simultaneously, a condition where a metro area is significantly warmer than

64 Gould and Caplow, p. 154.

65 Gould and Caplow, p. 155.

surrounding rural areas due to human activities.

Artificial lighting can be used in the greenhouse as a supplemental strategy during low light conditions, especially in Seattle's climate and location. The lighting for crop production is very energy intensive compared to conventional lighting, but the artificial lighting is only used a few hours a day for part of the year. The additional energy consumption is outweighed by the ability to grow year round, substituting for the worse alternative of transporting produce from regions that can grow during the winter months. Furthermore, when used in conjunction with the monitoring systems, the lighting is only employed when needed in order to maximize efficiency.

Transporting and distributing food into the city is a major contributor to energy consumption, with approximately 80 percent of the energy consumed in the US food system being used for the processing, packaging, transporting, storing and preparing of food.[66] This figure raises the concern of food mileage, and the current agricultural practices where food travels an average of 1500 miles to reach urban consumers.[67] Growing within the urban community, the food mileage is greatly reduced from hundreds of miles to just several miles.

In addition to energy consumption and carbon emissions as result of food transport, food storage is also a major factor. Refrigeration is typically needed to ensure quality and freshness for the long haul that most of the produce in the United States has to travel. Refrigeration has a high energy demand, and still results in high spoilage rates which are at a cost to the consumer. Over 25 percent of food grown in the United States is wasted due to spoilage.[68] With BIA, harvest and packaging occur daily and distributed to a local radius. The product on the shelf was harvested the same day — enabled by the flexibility of BIA to sequence plantings and harvests to ensure an array of plant maturity and ability to harvest daily for a high level of freshness.

66 Gould and Caplow, p. 149.

67 Gould and Caplow, p. 149.

68 Webber, web.

Ownership Strategy

The Baugruppe first needs a core group to initiate the project. They then get an architect involved to lead the design and coordinate construction. Often the architect becomes a member of the group, purchasing a unit within the project. A partnership with an urban farming start-up is established with the founders becoming stakeholders. The group is then filled out with additional households to complete the group. The farm employs outside individuals to help operate the farm. Mixed-use program elements are incorporated into the project that can be leased out to produce revenue for the BG as well as provide an amenity to the neighborhood.

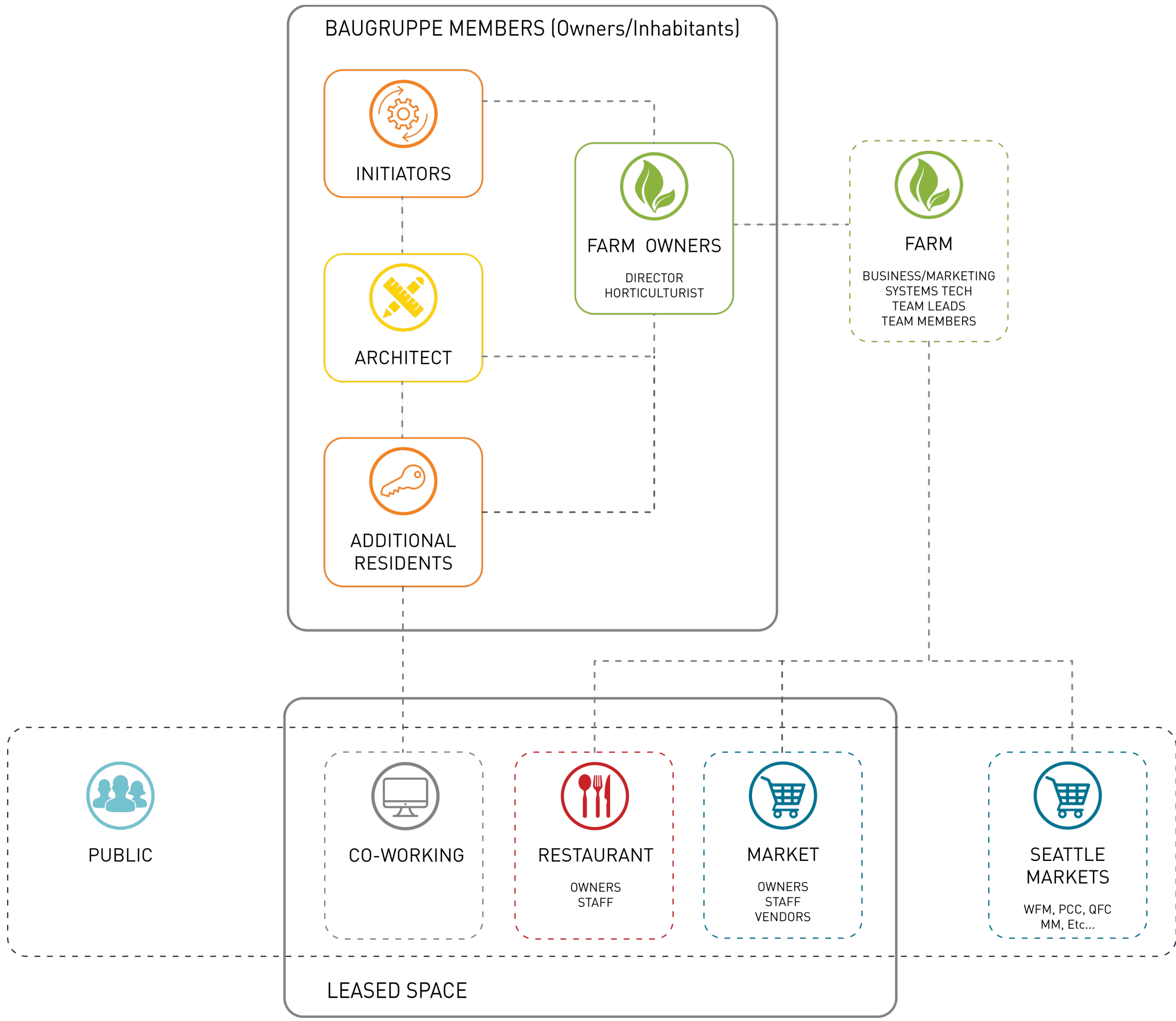


Fig. 41 | *Ownership and User Boundaries*

3E: Delimits and Limits

The scope of this thesis is not going to resolve all the issues with the current food system nor supply the needed amount of affordable units in the city. It is an architectural exploration that proposes a viable alternative for accommodating the future growth of Seattle. The scale of industrial agriculture is too large to contend with, but the methods of BIA are a step in the right direction for managing resources, ecological impacts, food security, and industry outlooks — connecting the urban population with food production. The efforts are to make a conscious decision to not continue with the current standard, but establish a new standard and create a model that focuses on cooperation and partnership among components.

Although the BIA design methods discussed in this section are proven to reduce water usage, land consumption and a reliance on fossil fuels, they inherit different material and resource challenges. For example, hydroponic systems rely heavily on plastics as part of the infrastructure. Heavy gauge polymers make up most of the plumbing and NFT channels, posing as an environmental drawback. With the recent innovation in bioplastics, derived from hemp, soy, and corn, it is assumed for the purpose of the thesis that the reliance on plastics can be resolved by the future promise of this emerging field. In addition, the minerals in the nutrient solutions are typically derived from mines. This poses another threat to the environmental stewardship of the project. Yet, with the promises of aquaponics and compost teas, the need for raw mineral supplement is dwindling. Partnerships can be established between the proposed thesis project and salmon farms or composting facilities as a means to facilitate better practices and further promote a cooperative closed loop system.

As with any project at this scale, financial backing is a significant issue in the building of a housing development especially when encompassing the expensive infrastructure of BIA. For this reason the concept of the baugruppe has been introduced not only as a way to work around the complications with subsidized affordable housing, but also to develop a hypothetical narrative of like-minded individuals wanting to invest in BIA. It is unlikely that BIA would be initiated as a developer-driven venture, but a group of entrepreneurial urban farmers who come together to pool resources to achieve affordable home ownership could very likely develop the proposed project. Part of the baugruppe model is that the members sign on to a collective mission, and in this case the collective mission is BIA.

These assumptions have been made to decrease the scope of complex issues inherent to the problem of affordable housing and the overhead cost of BIA, allowing efforts to be focused on creative problem solving and design issues considered more relevant to architecture. The hopes are that the design outcome can be a catalyst for change; an example of a new housing model that will greatly benefit the community and environment.

4: [DESIGN PROPOSAL]

Chapter 4 will investigate the particular site for the design proposal and the associated opportunities and constraints. As previously discussed, the site was chosen for the complexity of its urban condition and the transitional phase of the neighborhood.

4A: Site Analysis

The site's edge conditions vary from one another in significant ways. To the north, West Thomas Street is residential in scale and use. To the south, Elliot Avenue is a wide arterial with commercial uses and moderate to heavy traffic. On the west, a short section of 3rd Avenue — a residential street with direct connection to other housing projects to the north — becomes a continuation of the street grid connecting diagonally to Elliot Avenue. The resulting condition encourages cars to turn off Elliot and speed up 3rd Avenue — becoming dangerous for pedestrians. A service alley is located on the east side, providing an ideal location for distribution program

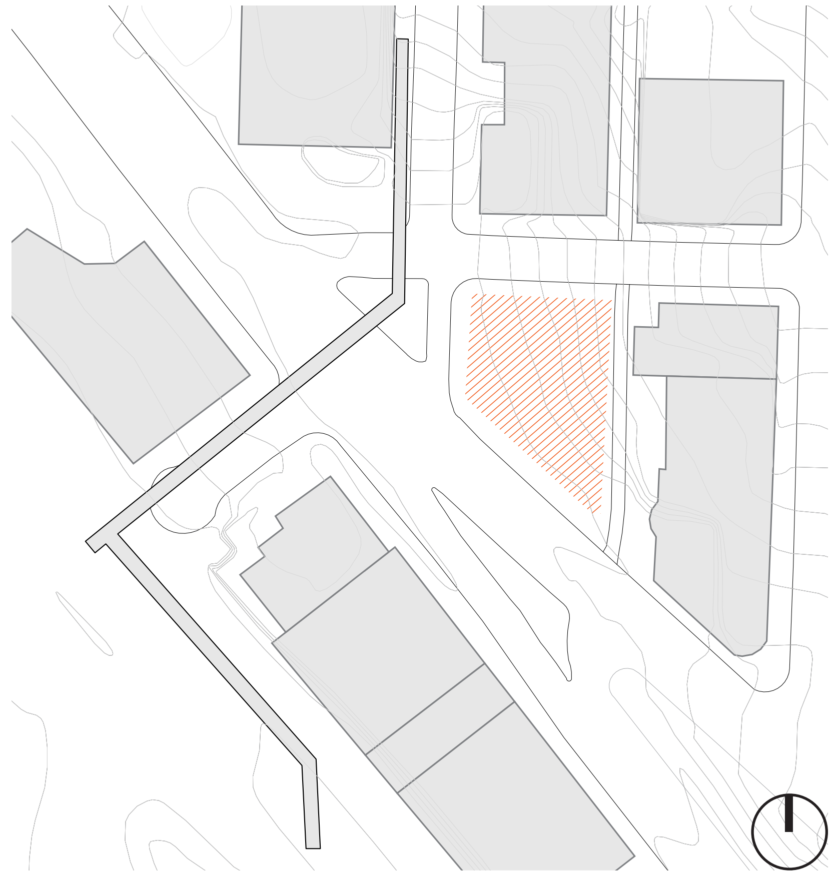


Fig. 42 | *Site Plan*

elements. Currently the alley is used for back of house operations and garage entry for the adjacent hotel.

The topography of the site has a moderate elevation change from the SW to the NE, rising approximately 10 feet in said direction as an even grade with no apparent steep sections. The geography of the site presents challenges as well as design opportunities for separate entries at different levels.

The majority of properties in the immediate vicinity of the site are multifamily (both mixed-use and single-use) and commercial office space. Commercial space in the mixed-use projects are primarily light retail such as a yoga studio and coffee shop. Directly next-door is the Queen Anne Beer Hall, an important place for social gathering in the neighborhood.

The site can be accessed by pedestrians from any direction, however, the anticipated pedestrian flow is from the east on West Thomas Street or from the north on 3rd Avenue W. An opportunity to increase connection from the west via the Thomas Street Pedestrian Bridge will become a critical element in the design proposal.

The site is located on the "lake-to-bay" loop which is a pedestrian path from Lake Union to Elliot Bay. The loop is a publid works project from Seattle's Department of Planning and Development (DPD). By connecting various nodes of cultural and civic amenity, the path aims to establish a strong pedestrian corridor and active spaces in the area. Near the site, the path crosses the Thomas Street Bridge, connecting to Myrtle Edwards Park and the waterfront.

Using the loop trail to the advantage of the project, while enhancing the connection to the bridge will be a valuable asset. Gaining exposure from pedestrian traffic to highlight the growing operation not only is a useful marketing tool, but also produces awareness with the public, sparking curiosity for growing food within the city. Additionally, the loop provides easy access to the site via walking or by bike as well as connection for the residents to their workplaces in the area.

Zoning on the site is Neighborhood Commercial with a 65 foot height limit (NC-65). As previously mentioned, Uptown has become a focal point for DPD and the 2015 Urban Design Framework proposes up-zoning on many of Uptown's blocks, including the project site from NC-65 to NC-85. Therefore, the project will reflect future changes to the area and be designed to a height limit of 85 feet.

Buildings across Elliot Avenue to the south are currently limited to 45 feet, unobstructing sun exposure on the site. Even with future up-zoning of these properties to 85 feet, the site recieves sufficient amount of daily sun exposure throughout the year. With the area being located within a view corridor, as well as being built on unstable soil fill (subject to liquefaction in a seismic event), the properties in this area are unlikely to reach heights beyond 85 feet.

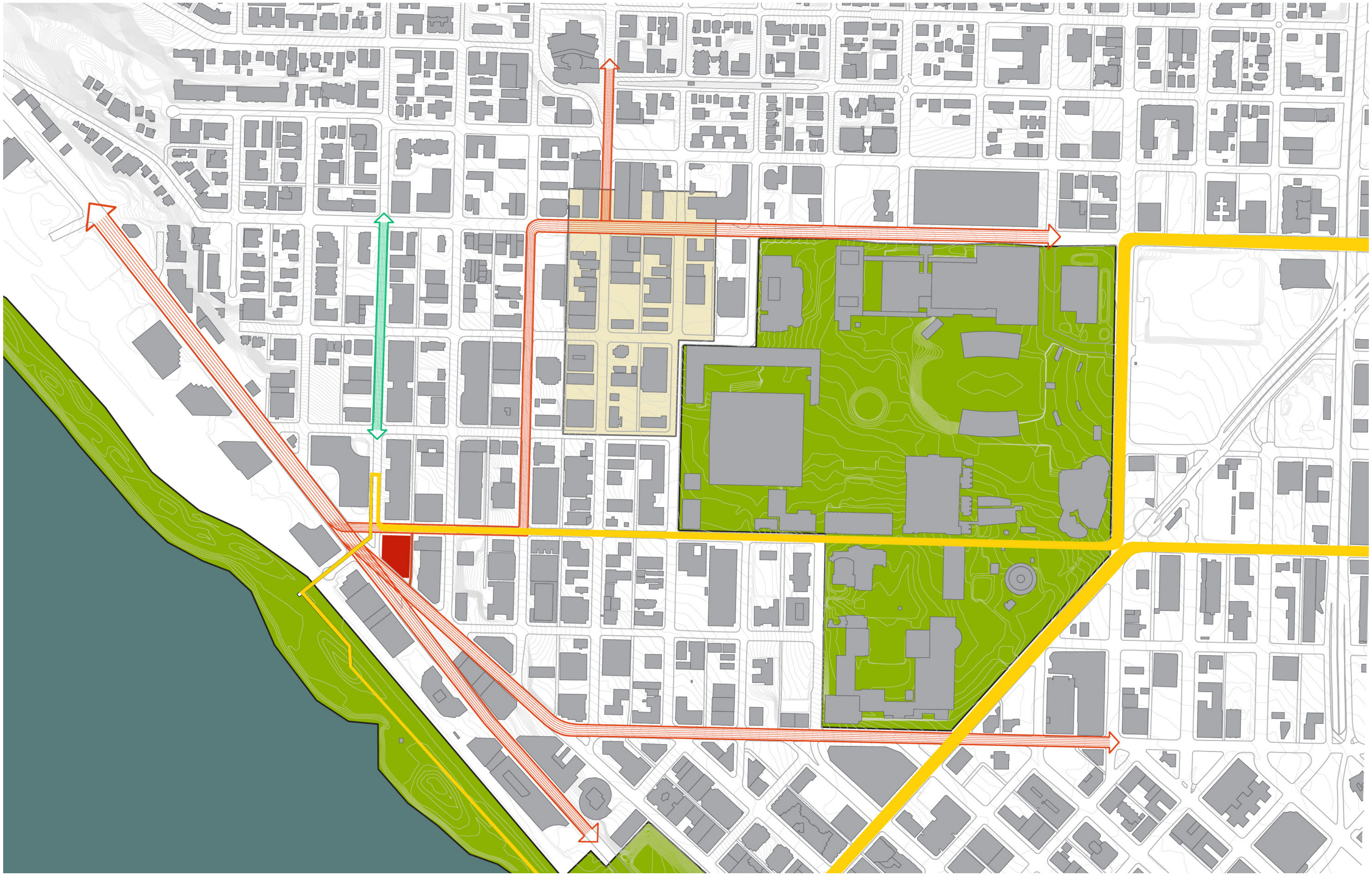


Fig. 43 | *Site Connections*

Live Work Buy Play

Fig. 44 | *Land Use*

Fig. 45 | *Ground Level Conditions*

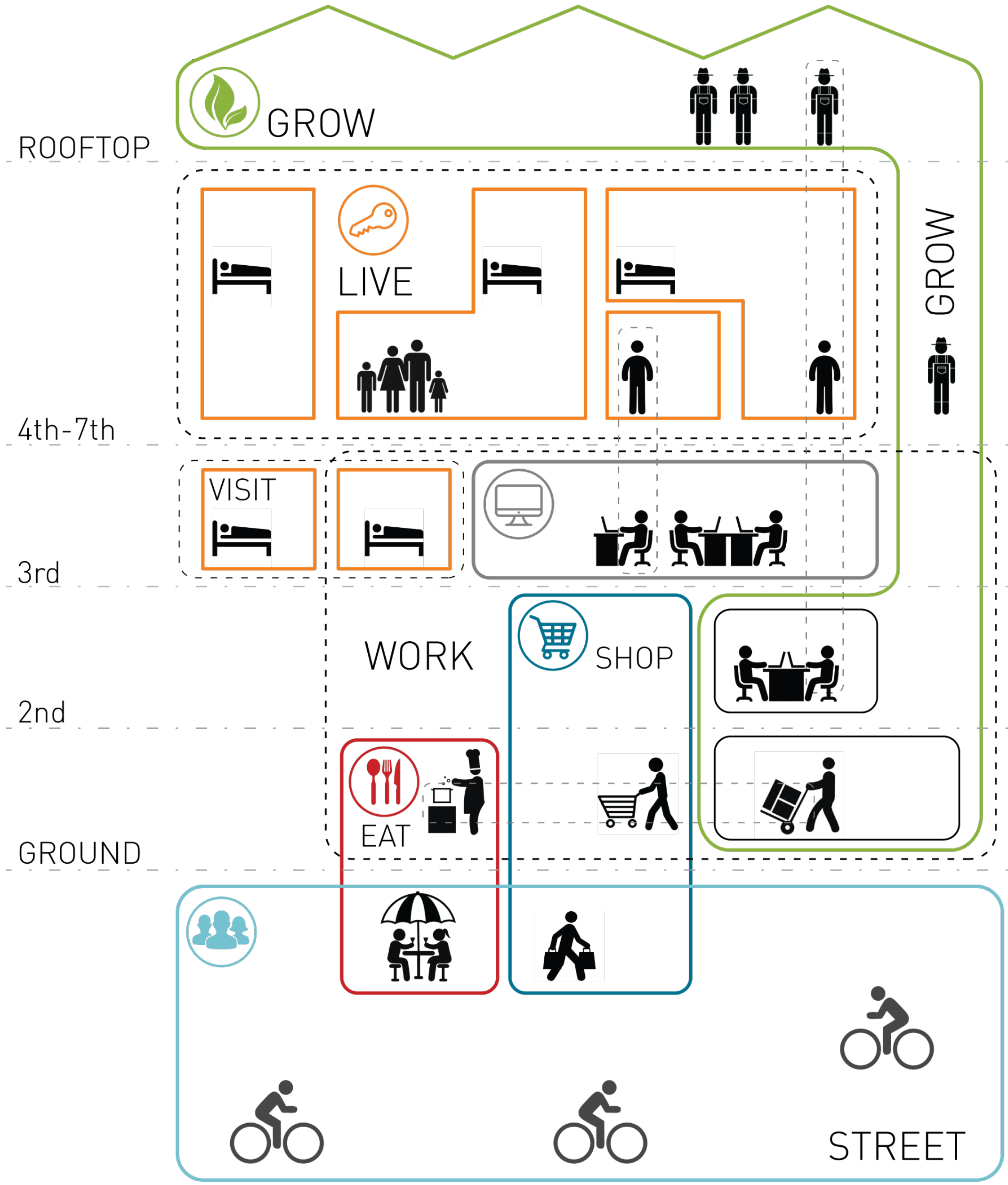


Fig. 46 | *Program Diagram*

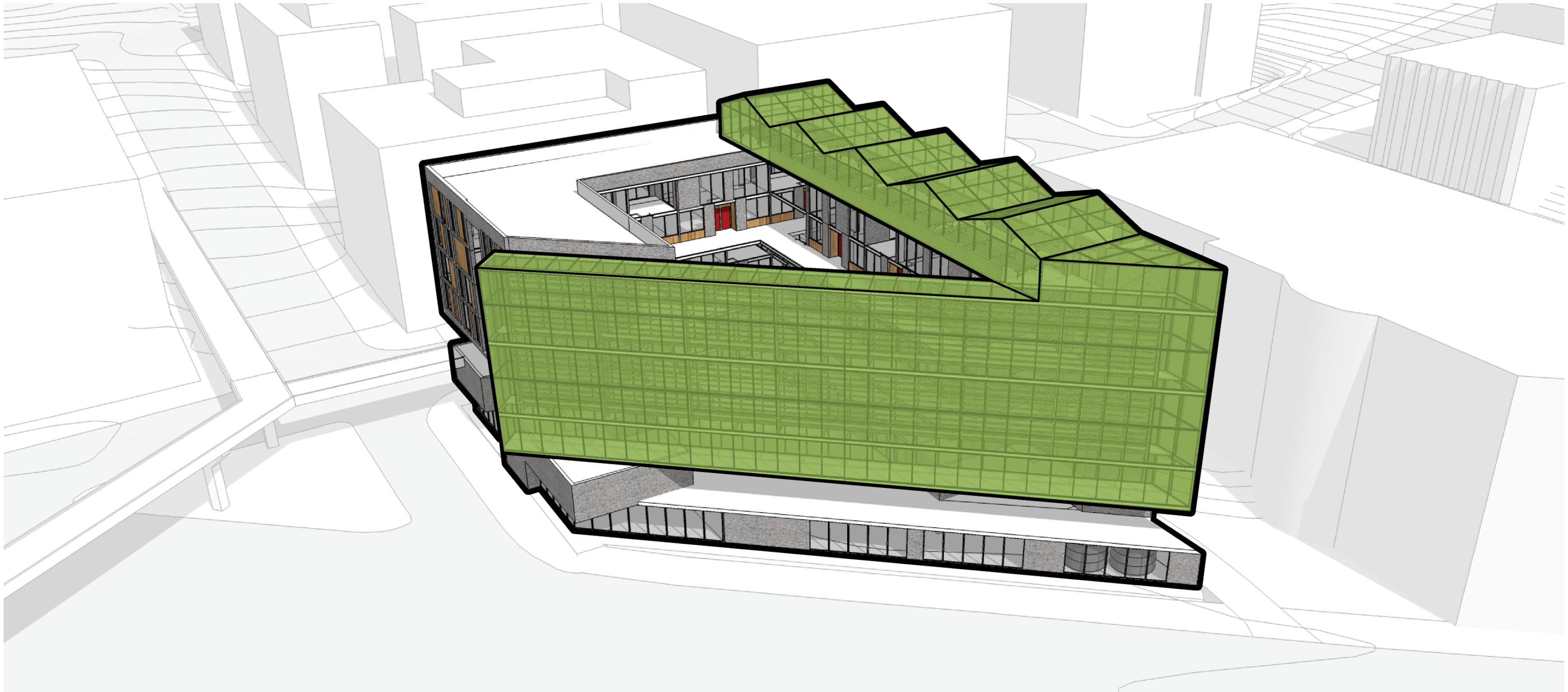


Fig. 47 | *Greenhouse*

4B: Program Analysis

The program for the proposal is complex, integrating a multitude of uses into one project that results in a diverse mixture of users, time of use, and public to private interfaces. The program includes 3 main categories: industrial (farm), residential, and commercial.

1. Farm

Greenhouse

As previously mentioned, the size of the greenhouse is determined by the amount of rainwater that falls on the site and the subsequent amount of produce that water can support. An average of 420,000 gallons of annual rainfall precipitates on the site — enough to grow 185,000 pounds of produce. 14,000 square feet of

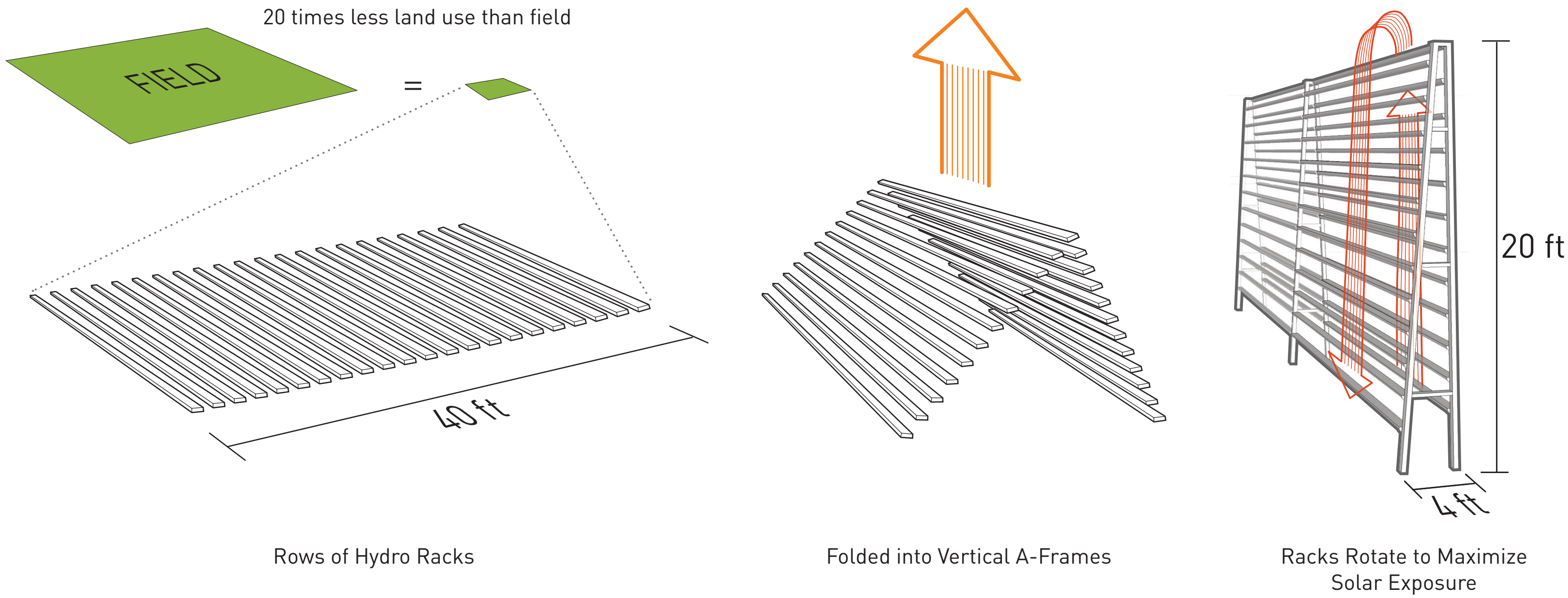


Fig. 48 | *Vertical Grow Rack Diagram*

greenhouse space is needed to grow that amount of produce. To accommodate that significant amount of greenhouse square footage, a majority of the greenhouse will be vertical. Vertical growing makes the already compact and efficient system even more compact and efficient. Having the vertical element allows the greenhouse to be split into two zones, catering to different growing conditions at a systematic and climatic level.

The vertical zone is dedicated to leafy greens, being regulated to cooler growing conditions. It has three levels, two of which are double height space giving the overall height of the zone to be 50 feet. The lower, single-height level is dedicated to the residents to grow on individual “plots”. The system for this level is smaller in scale, more of a hobbyists system than a commercial system — making it more approachable for the residents.

The two double-height levels are dedicated to the commercial farm, with 20 foot tall A-frame growing racks that rotate throughout the day to maximize sun exposure for each row of plantings and make the rows easier to tend to.

The rooftop zone is dedicated to vine crop production, being regulated to a warmer growing condition. The single level layout allows easier trellising with the ability to install different trellis types to a ceiling frame.

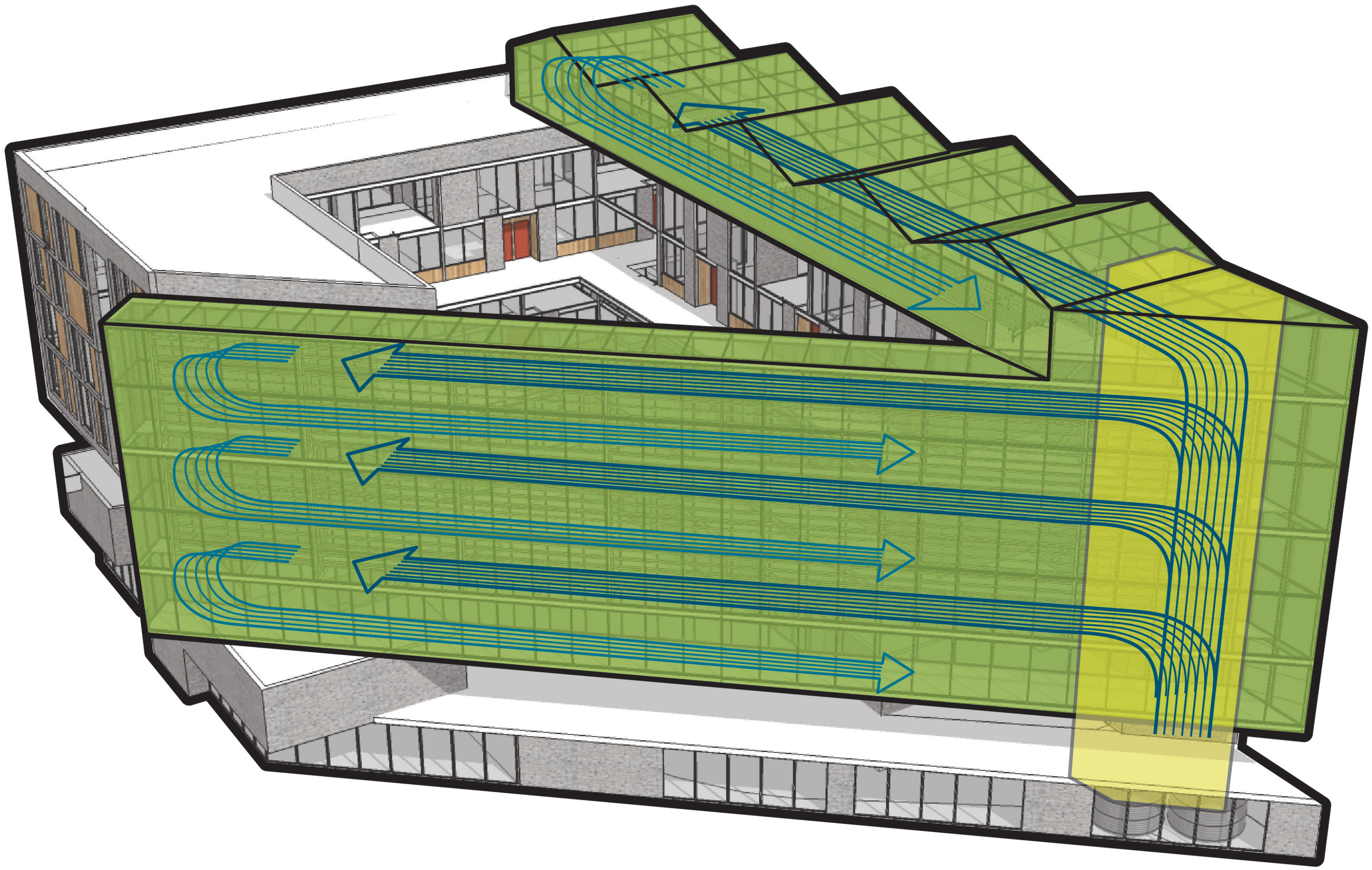


Fig. 49 | *Nutrient and Water Cycles*

A vertical core at the pivot point of the two zones provides access for the farmers as well as a mechanical shaft to transport water and nutrient to the greenhouse from the below grade reservoir.

Fig. 50 | *Perspective Rendering from Vertical Greenhouse*

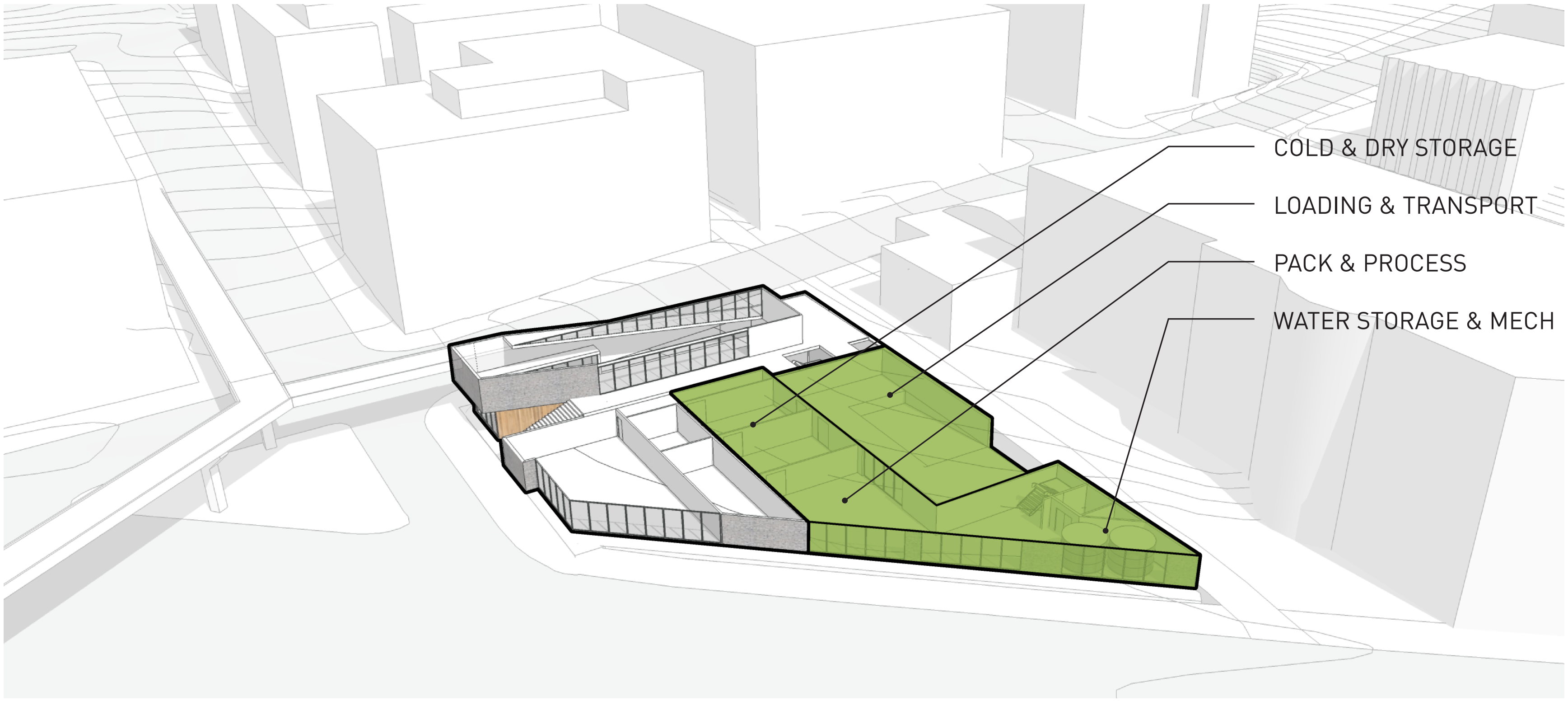


Fig. 51 | *Farm Operations*

Processing

1,536 square feet of space would be dedicated to the processing and packaging of produce after harvest. This space will accommodate trim and washing stations along with storage space for packaging material. Packaging includes recycled plastic clamshells, cardboard boxes and wax-coated cardboard boxes (stored flat and broken down until needed).

Storage

Once the product is packaged, it moves to either cold storage or dry storage depending on the product. The cold storage facility is 1,536 square feet total with 576 square feet of dedicated circulation for carts and pallet jacks, and the remaining 960 square feet for product storage. The cold storage capacity for any given time is 14,400 lbs of produce.

1 x 1.5 x 2 = 3 ft^3 per box
(12) 5 oz containers = 60 oz = 3.75 lbs per box

960 ft^2 x 12 ft h =11,520 ft^3
11,520 ft^3 ÷ 3 ft^3 = 3,840 boxes
3,840 x 3.75 lbs = 14,400 lbs of packaged greens

Variable

Fig. 52 | *Storage Sizing*

Most produce varieties being grown onsite require cold storage, while some require dry storage. At 1,024 square feet, dry storage will mostly accommodate tomatoes from the greenhouse, mixed with other local products grown offsite. As previously mentioned, not all produce varieties grow well with hydroponics, in addition to the economics not working out for all produce varieties. Therefore, some varieties will be outsourced to local farms and sold within the market for a more diverse and complete produce department.

Both storage areas are connected to each other as well as the restaurant and market, providing direct access for the produce to reach the point of sale.

Loading

On the east side of the ground floor is a loading dock with direct access to the alley and large enough to support a cargo van or medium sized box truck. Larger semi-trucks were not taken into consideration for the sizing of the loading area in an effort to promote more local distribution. Adjacent to the dock is an auxiliary landing with direct access to the storage spaces. This is where pallets coming or going from the facility can be staged to be either built-up for convenient and efficient shipping to the marketplace, or broken down before entering the storage spaces for a more organized operation.

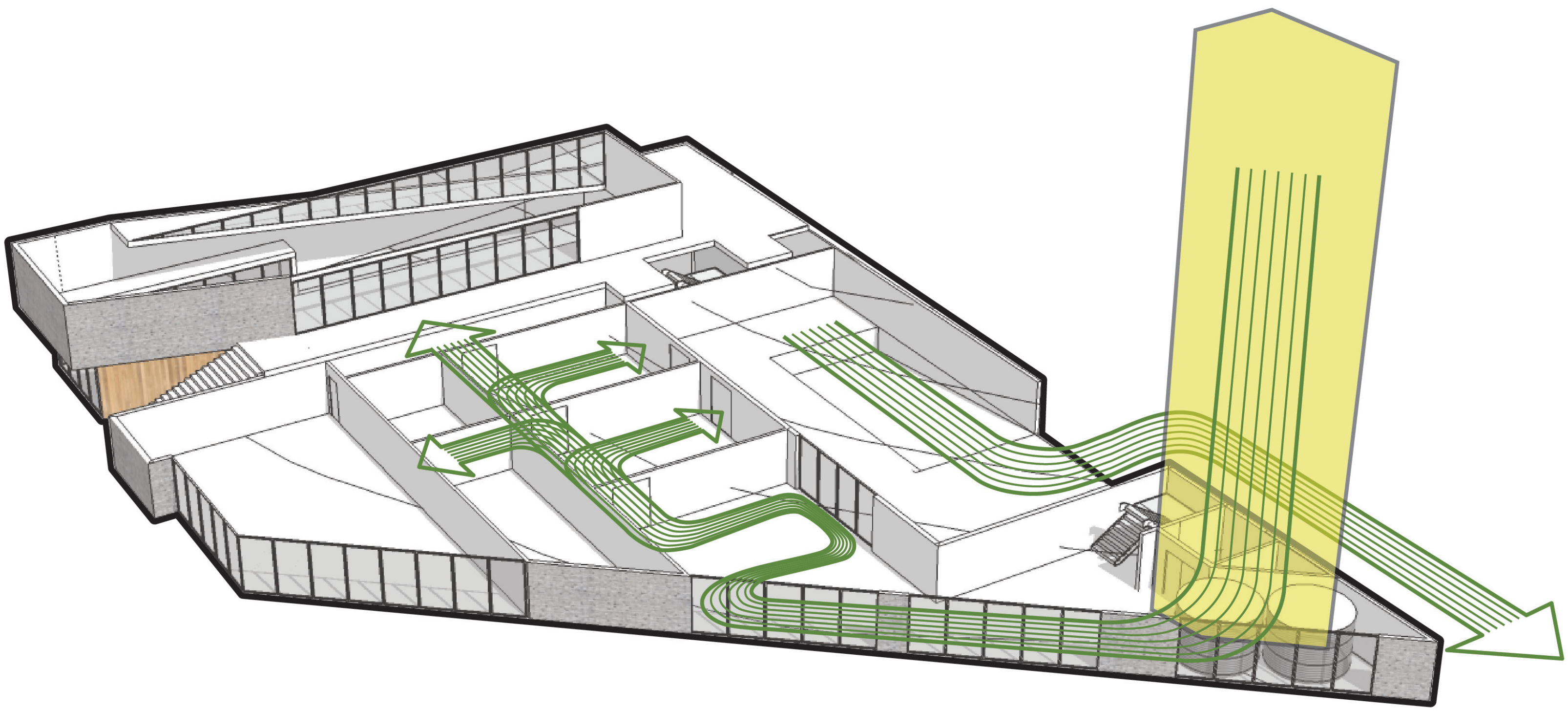


Fig. 53 | *Product Flows*

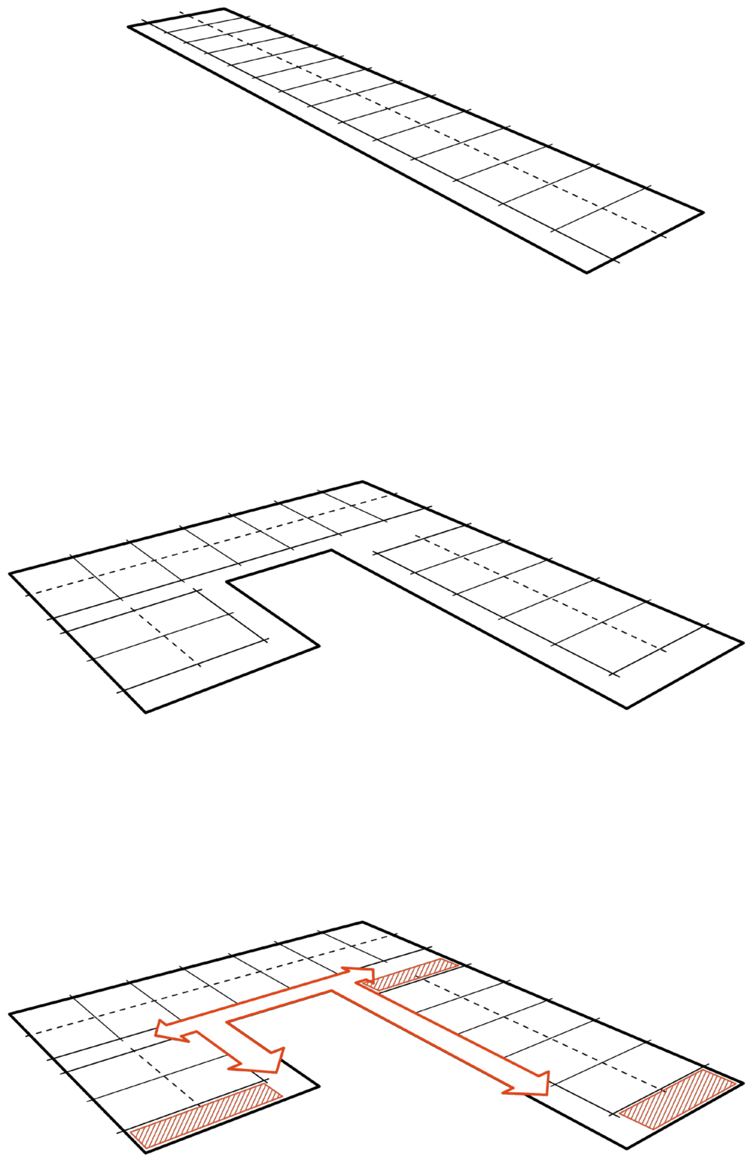


Fig. 54 | *Organizing Grid*

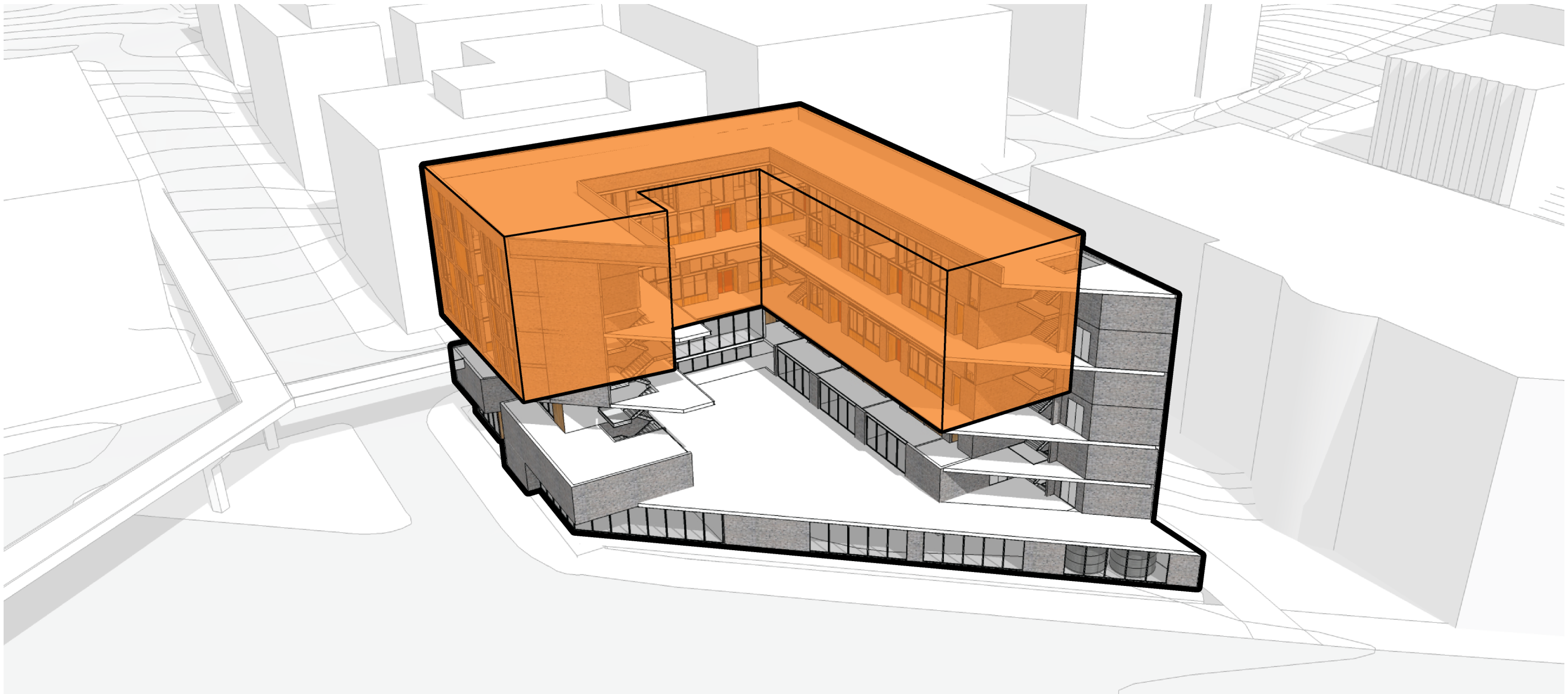


Fig. 55 | *Housing*

Housing

4 levels of housing units start on the fourth floor of the project. The housing strategy is developed from a 16 x 32 foot grid. one of the challenges with designing within a baugruppe is the highly individualized units often work in conflict to one another, challenging structure, circulation, etc. The grid acts as a framework, helping to coordinate some of the chaos that comes from designing for 30 unique clients in one project. The grid is then folded into a U-shape to fit within the property lines and open to the south. Circulation happens in exterior, single loaded corridors. Exterior corridors are meant to reduce cost by minimizing the square footage of conditioned space as well as increase social connection between neighbors. The corridors are set off from the building walls by two and half feet. This is meant to give a buffer between circulation and living space for privacy, while also creating a subtle light

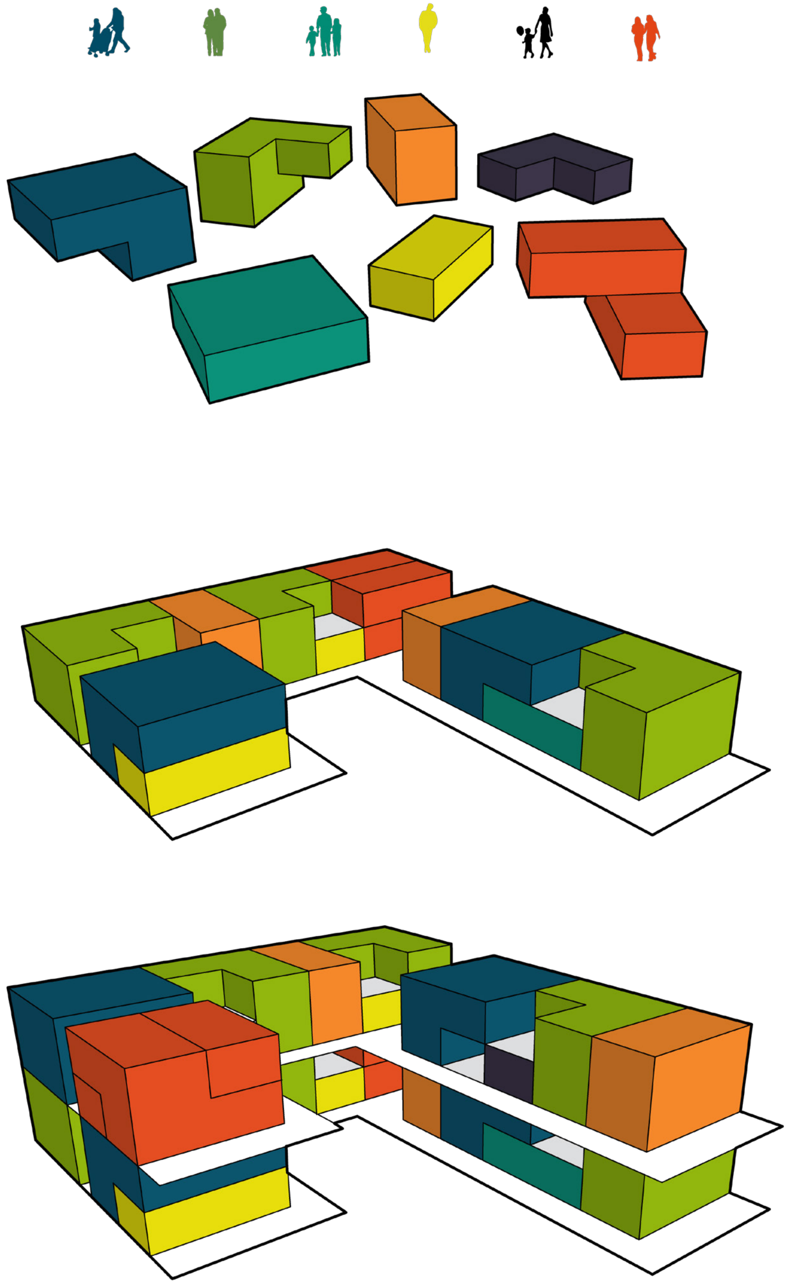


Fig. 56 | *Mixed Modules*

well for better daylighting to the units. Three circulation cores are established, two of which with elevators.

Various unit modules are developed to accommodate a variety of households. each module is based on the grid, Some are two story homes, while others are single story. The playfulness of the module diagram represents the effort to coordinate design within the baugruppe and make the process approachable to those that do not have a background in architecture.

Modules are arranged to create a dynamic mix of unit types. This would be workshopped during schematic design, with each member choosing a module that works for them, preferred location within the building, and then the architect orchestrating them in a sensible manner. This process would incorporate trade-offs and a series of compromises, but would overall be constructive to the project and community building. Strategic voids are created as shared outdoor space between adjacent units as the pieces come together. And then stacked, circulation happens on every other floor, allowing more privacy to the upper levels of the unit. Each unit has access to different qualities of light on two sides, facing out towards the neighborhood and inwards to the central court.

Operable screens are introduced on the courtyard side of the units to add privacy. The sliders are wood louvered screens that can either cover the window or pulled to the side in front of the brick. As opposed to interior blinds or curtains, the screens are meant to integrate the means of privacy into the privacy, denoting openness and closure into a dynamic elevation.

Fig. 57 | *Operable Facade*

Fig. 58 | *Perspective Rendering of West Thomas Street Elevation, Bridge Connection, and Public Square*

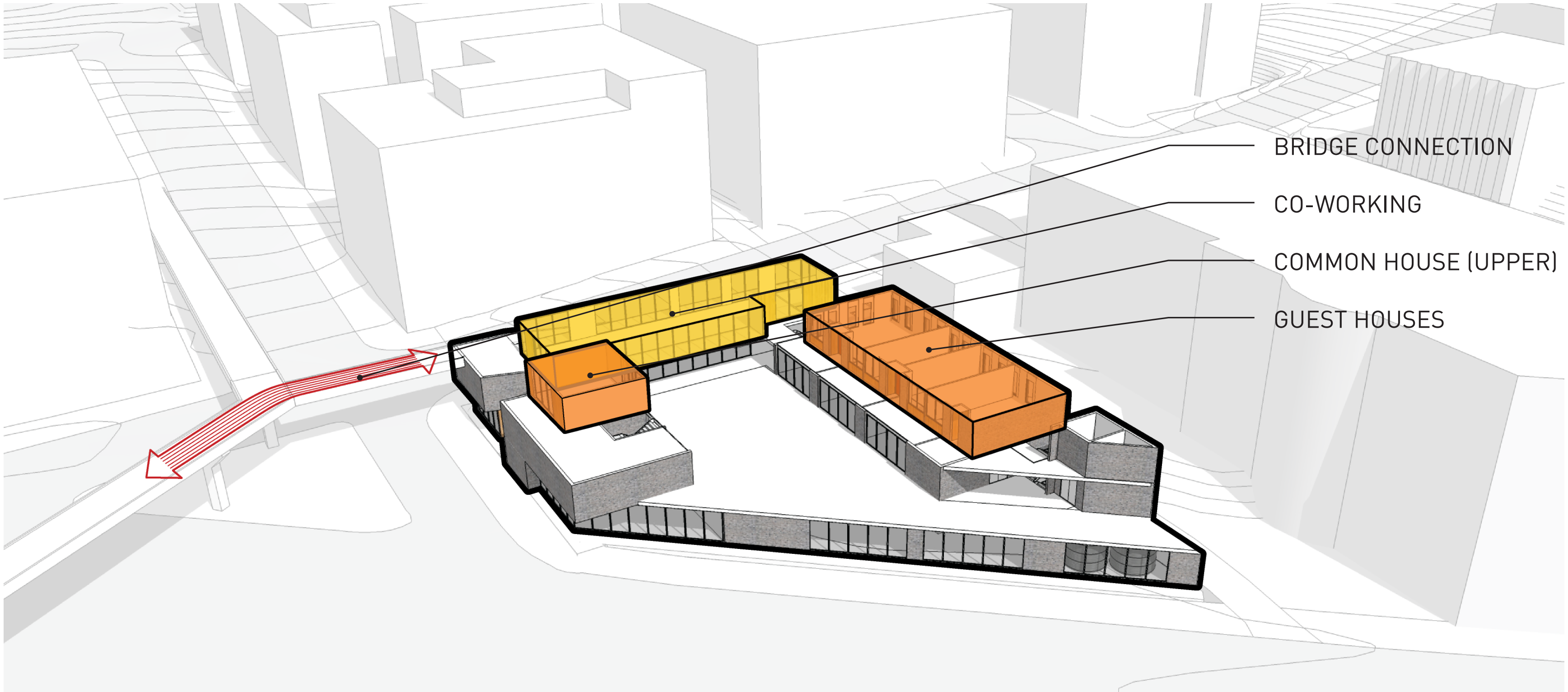


Fig. 59 | *Bridge Level*

Public Meets Private

An interstitial level were semi-public/private programming is developed between the private housing units above and the more public commercial elements below. At this level, program elements are integrated as the gray area where public and private interface.

Co-working

Shared office space that can serve not only the residents but also be an amenity for the neighborhood. Overlooking the courtyard while also having frontage and direct access to West Thomas street, the office space can be accessed by paid membership and produce revenue for the project.

Fig. 60 | *Perspective Rendering from Thomas Street Bridge, looking at the Greenhouse span along Elliot Avenue*

Guest Housing

Four guest houses that are shared by the residents provide ample space for when friends and family come by. The guest houses are managed on a time-share basis and are very common to baugruppe projects. When the rooms are vacant they can be rented on AirBNB to not only produce revenue but also to minimize unused space within the project.

Common House (Upper)

The common house is shared among the residents, providing a central space for social gathering or escape from the units. The upper level of the common house has a library, living/reading space, terrace, and direct access to the resident's growing level in the vertical greenhouse.

Bridge Connection

At this level, a connection to the Thomas Street Pedestrian bridge is established. The existing connection between the bridge and the neighborhood creates an awkward threshold as the east-west crossing turns and lands north-south. In addition, where the bridge currently lands is flanked by non-active entry plazas — creating an underwhelming gateway into Uptown. Being an important amenity for neighborhood, incorporating the bridge into the project will increase connectivity between the waterfront and neighborhood.

Part of creating an additional bridge connection is to vacate the short section of 3rd Avenue West — previously mentioned as a problematic for pedestrians. A street vacation at this location is already proposed by DPD in the Thomas "Green" Street concept plan. The proposal is in an effort to increase safety at the intersection of Thomas and 3rd Ave. A small piece of land where support columns for the bridge rest is currently owned by the city, and vacating the street would increase the size to become an appropriate size for a public square. Topography becomes virtually flat in this area and a public square would enhance wayfinding in the area and identity for the site, creating a node and gratious threshold into the neighborhood.

Fig. 61 | *Perspective Rendering of the Courtyard*

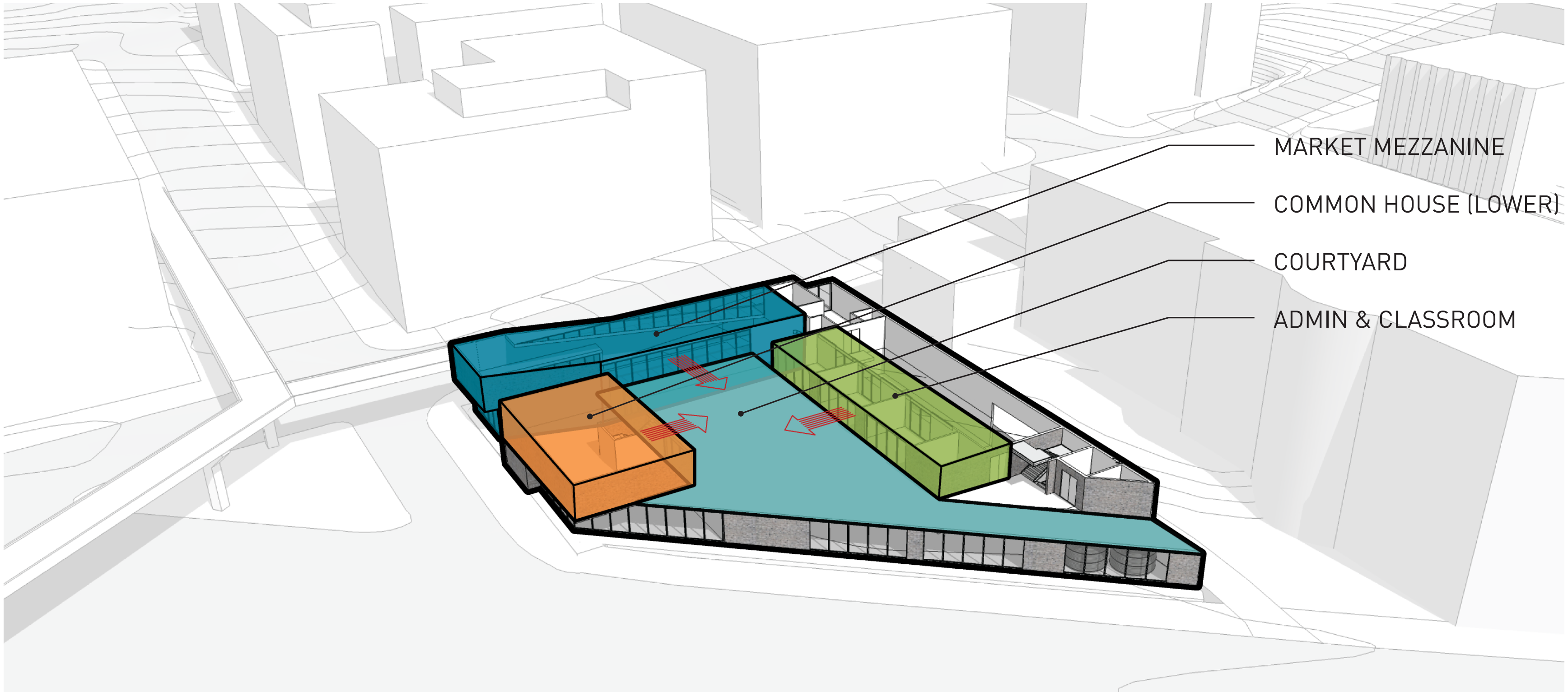


Fig. 62 | *Courtyard Level*

Courtyard Level

Generous in area as well as elevated a story above the western edge of the site,the courtyard is the central element of the project, being accessible not only as a shared outdoor space for the residents but also to the team members of the farm as well as the public. Due to the site's elevation change, the courtyard is at the elevation of the NE corner of the site, where the main entry lobby for the residents is located. The lobby is small, meant to offer covered access to the elevator and a secure place for mail and packages. The lobby has interior access to bike storage. In the absence of a parking garage, space is allotted to alternative modes of transporation. The bike "garage" is equipped with a repair station and also has exterior access to minimize outside elements being tracked into the lobby.

Fig. 63 | *Perspective Rendering of the Mezzanine*

The courtyard is landscaped with a central rain garden with wood decking walking paths. The decking is constructed of a harwood called *ipe* due to its aesthetic qualities and resistance to rot. The ipe slats are furred up to create an air cavity underneath where a waterproofing membrane keeps the level below dry, while transporting rainwater to a collection drain and into the below grade cistern.

Several program elements open up to the courtyard to help activate the space with different user groups. Nanawall door systems are used to increase connectivity between the spaces. A covered stair in the northeast corner becomes the main threshold into the courtyard

Admin and Classroom

Three offices used by the farm, market, and baugruppe open up to the courtyard on the west and overlook the loading and transport to the east. The classroom can host instructional coursework in hydroponic farming, helping to educate the community about this emerging technology or be utilized as a multi-purpose space that serves the residents or market for a variety of activities. tral space for social gathering or escape from the units. The upper level of the common house has a library, living/reading space, terrace, and direct access to the resident's growing level in the vertical greenhouse.

Market Mezzanine

A mezzanine level to the market with a coffee bar overlooks the market below. This space develops a direct connection to the courtyard for patrons of the market, while better utilizing the modest square footage of the market and narrow layout. The mezzanine looks across to the access ramp to the bridge. The creation of a visual and physical relationship to different program elements increases the dynamics of the market space while opening up a space that is partially subterranean due to the slope of the site.

Common House (Lower)

The common house opens up to the courtyard, allowing activities and social gathering to flow out into the outdoor space. Large shared spaces make up the common house program, with a community kitchen, dining area, game area, and common room.

Fig. 64 | *Section Perspective*

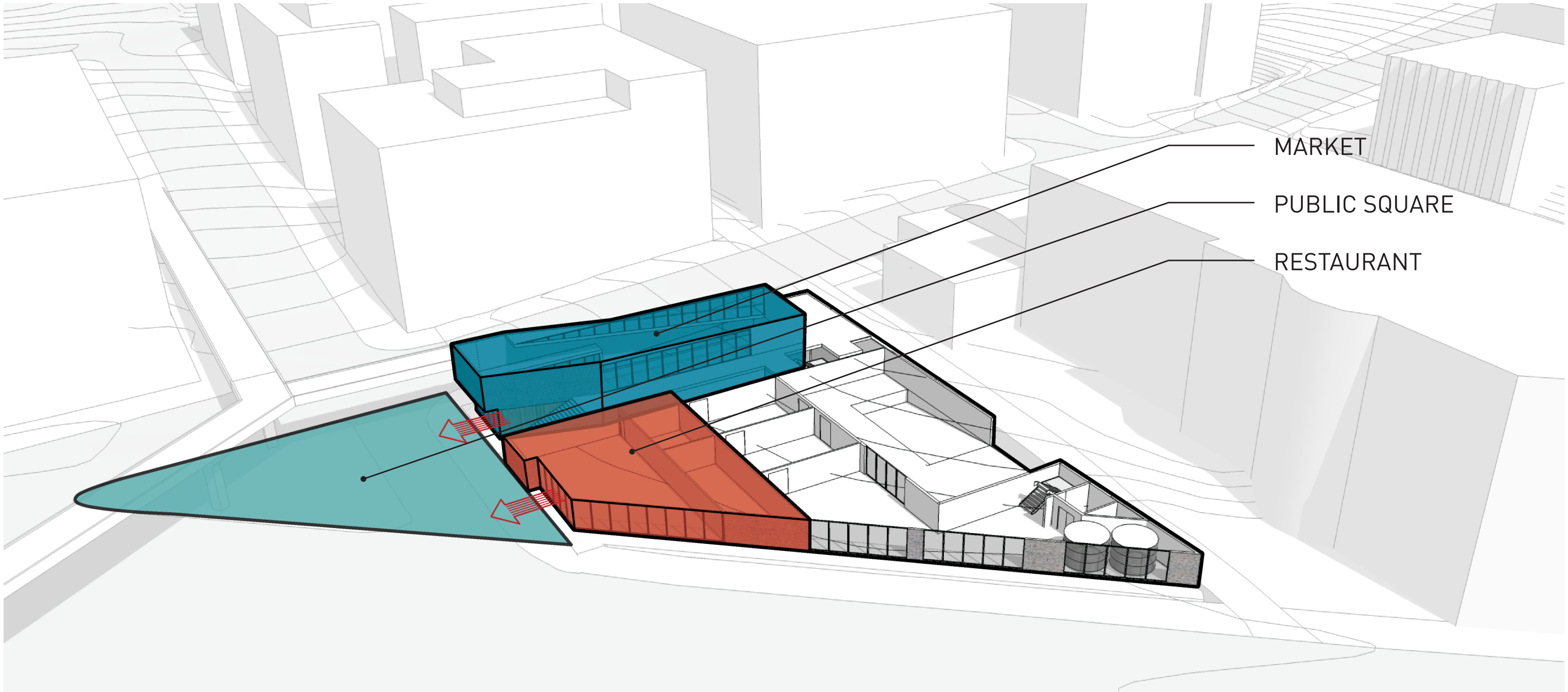


Fig. 65 | *Street Level*

Market

Opening up to the public square to activate the space is the main entrance to the market. The market is not only meant to sell the produce grown on site in the greenhouse, but is also dedicated to being a marketplace for other local food companies and farms. Having a market for these local businesses helps to aggregate marketing efforts and create a collaborative atmoshphere for the local food movement.

Restaurant

Also open to the public square is a restaurant, bringing in different users while extending time of use into a later part of the night. Seattle is well known for its food culture and restaurant scene. This is a "farm-to-table" establishment, with much of the food grown upstairs. The space is sized for a capacity of 92 guests at any given time.

FLOOR PLAN | LEVEL 1

1. Market
2. Restaurant
3. WC
4. Kitchen
5. Dry Storage
6. Cold Storage
7. Processing
8. Pallet Breakdown
9. Loading Dock

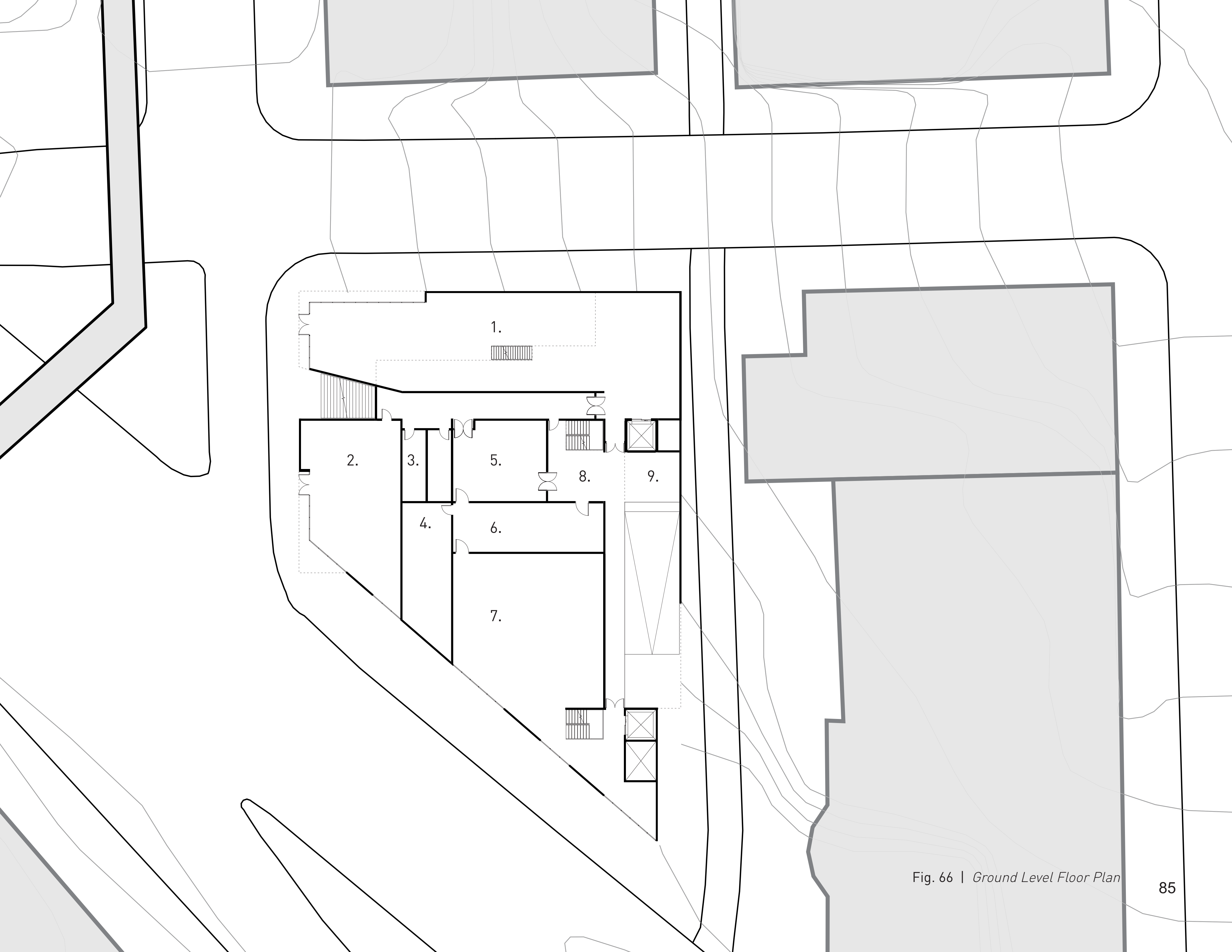
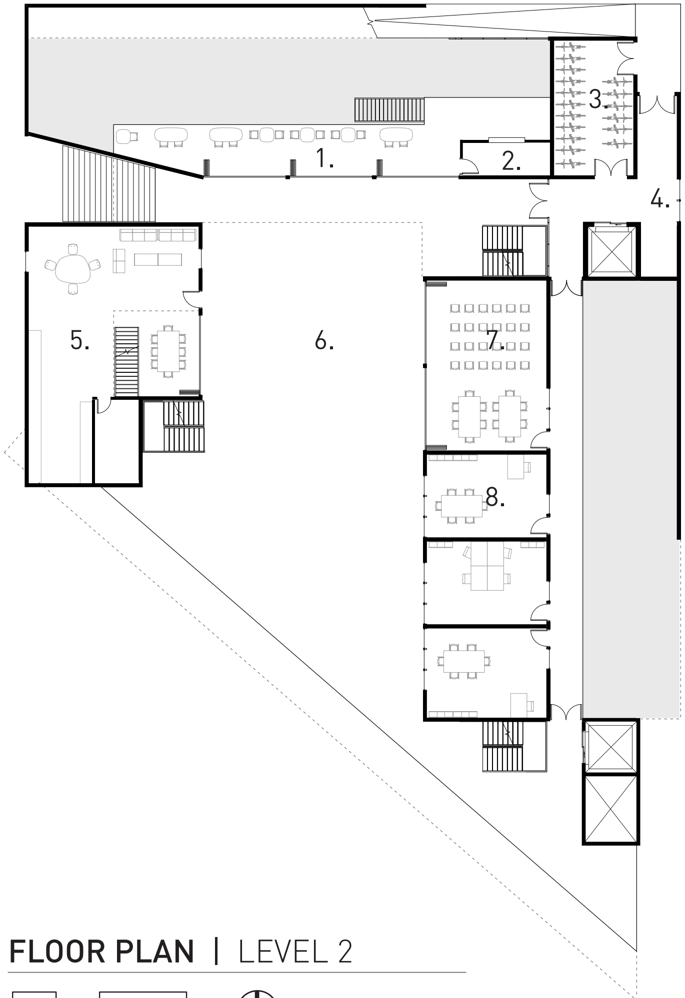


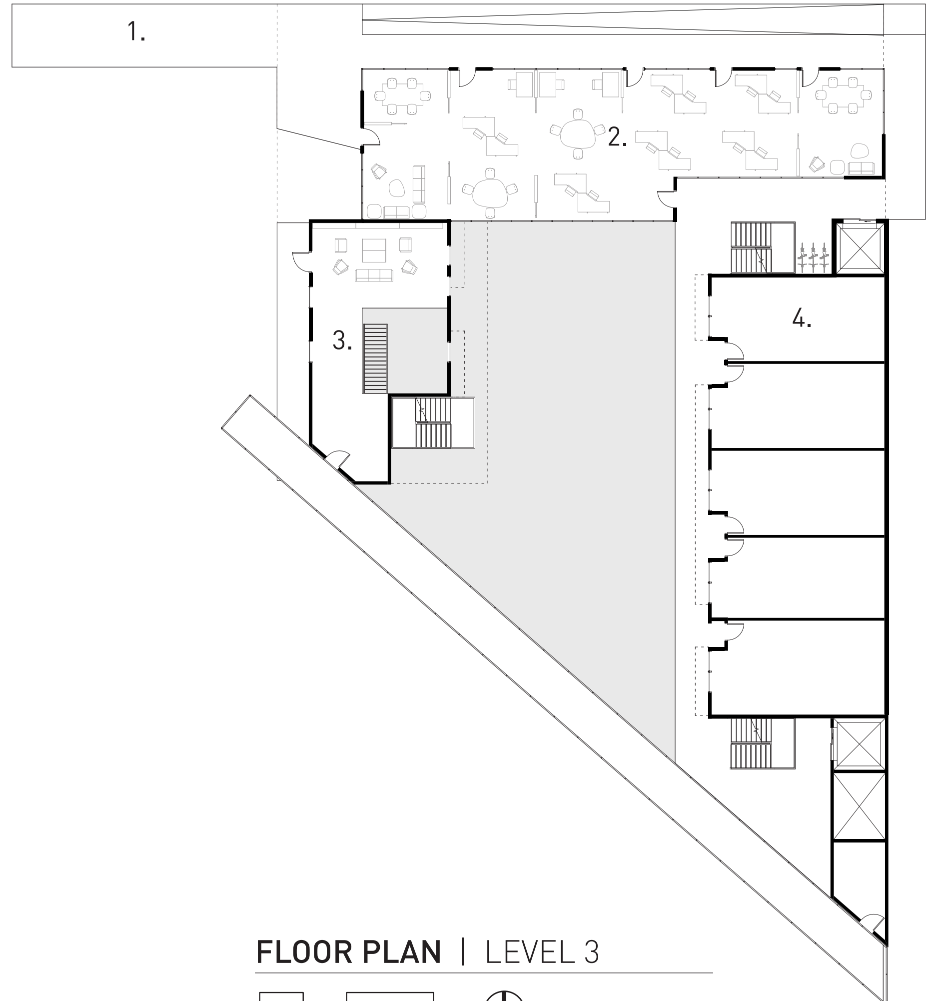
Fig. 66 | *Ground Level Floor Plan*



FLOOR PLAN | LEVEL 2

0 8 16 32 ft

1. Market Mezzanine
2. Coffee Bar
3. Bike Storage
4. Lobby
5. Common House
6. Courtyard
7. Classroom
8. Farm Offices

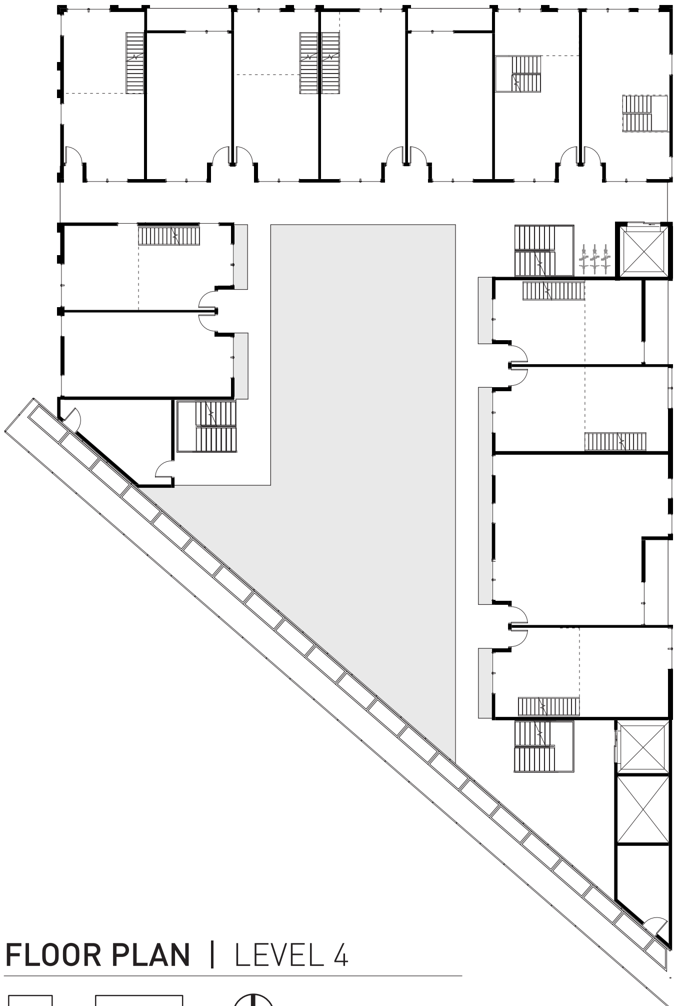


FLOOR PLAN | LEVEL 3

0 8 16 32 ft

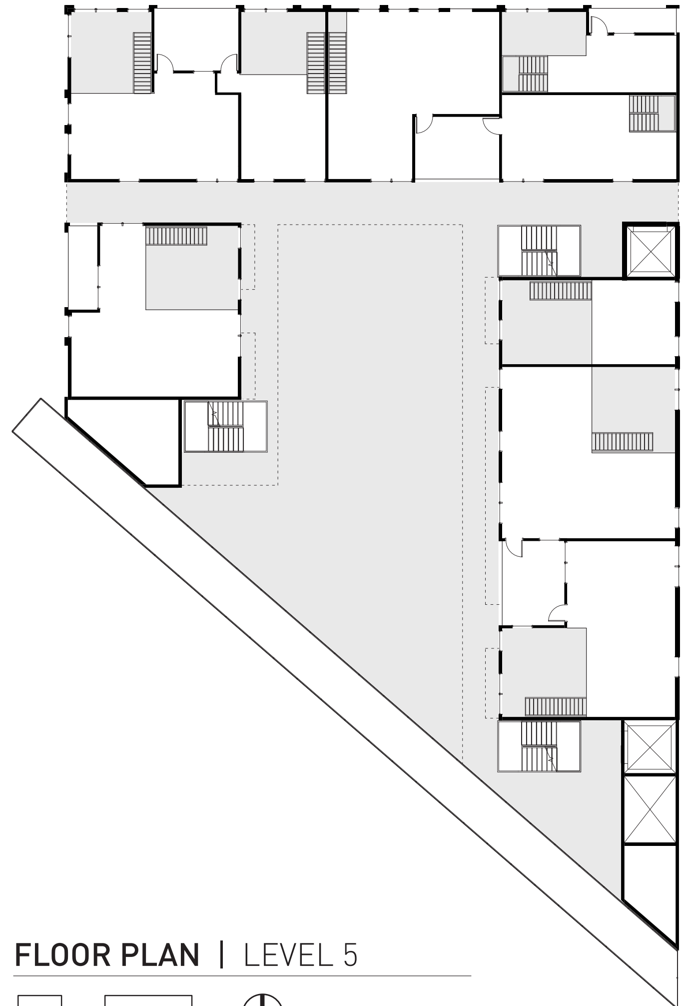
1. Bridge
2. Co-Working
3. Common House
4. Guest Rooms

Fig. 67-68 | *Floor Plans*



FLOOR PLAN | LEVEL 4

Residential Units (Lower)



FLOOR PLAN | LEVEL 5

Residential Units (Upper)

Note: Floor Plans 6 & 7 not shown. More residential units are located on these floors.

Fig. 69-70 | *Floor Plans*

5: [CONCLUSION]

Fig. 71 | *Section Perspective*

Devoid of any particular program or building type, this thesis began as an urban agriculture project focused on sustainable food systems in an age of rapid urban growth and industrial agriculture. During early program development, selecting housing was originally intended to re-connect where we live and where we grow in addition to the awareness that the majority of Seattle's development is mixed-use housing. After researching further, it became apparent that the rapid growth in Seattle is greatly effecting the cost of living, increasing rents and home values to unaffordable rates within its urban districts. The thesis then began to focus on the housing crisis, researching affordable housing in search of alternative models that could not only counter the current market rate development but also be a good option for BIA.

Discovering *baugruppen* as a viable housing model, began to steer the research and design into a specific direction, enriching the thesis beyond BIA by developing a new conceptual layer that offered a broader response to three key issues in housing policy: affordability, social cohesion, and individuality. By broadening the scope, the project became increasingly complex and challenging. For a project that started without any program, the program became the center piece that threaded together industrial, residential and commercial elements that engaged a diverse mix of users at different times of use. This evolution to the project added value to the thesis, guiding design decisions while at the same time steering away from a more infrastructural approach at the onset of the project.

Shortcomings in the project were found within the complicated issues around home finance in a capitalist economy. To get a project like this to move forward in the United States, land subsidies would have to be granted and banking options would need to be established. One of the main concerns is that without the city's involvement, a flagship project such as this would only be feasible by high-income residents who have the capital for investment. In Germany, *baugruppen* are often supported by either land subsidies or policies that give the group priority over developers — adding to the success of the movement. Yet, at a sensitive time for affordability in Seattle, it is possible for policies to begin to shift to open the market beyond conventional development models.

Similarly, the main challenge to BIA is financial feasibility and the need for initial capital investment. Building a greenhouse requires a large start-up cost in addition to substantial operational costs. As in the case of Gotham Greens, grants and outside investment are often needed as well as contractional agreements from vendors. Yet, a large majority of indoor farms in the United States are planning on expansion,[69] reflecting a promising future. Operational costs will reduce as technology becomes better and more accessible. With the growing awareness of the impacts from industrial agriculture, support of a more sustainable food system is gaining traction, prompting investment in the future of food.

Overall the project became a sucessful synthesis of unique program elements that worked well within its urban context. Beyond being a repsonse to housing and food insecurity, the thesis took on a challenging neighborhood full of difficult urban design questions and lots of attention from developers. Researching the rich history of Uptown inspired the project to be more than a building, but to engage with the site, community, and public realm.

69 Agrilyst, p. 34.

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