URBAN PRODUCTIVE LANDSCAPES: DESIGN STRATEGIES FOR CREATING SELF-SUSTAINING COMMUNITIES

BY

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THESIS

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ABSTRACT

A sustainable landscape thrives when resources are sourced from and returned to the community, creating a reciprocal relationship. This thesis explores whether the establishment of a closed-loop system sustains urban landscapes. As cities face transformative challenges from population growth and shifting demographics, the need for high-quality green spaces becomes increasingly important.

This thesis investigates the integration of these essential functions into everyday landscapes as a potential solution to urban sustainability challenges. Focusing on urban agriculture as a key component, the study proposes a design for cultivating specialty food crops within a closed-loop system. This system repurposes compost and waste, remediates soil, reduces impervious surfaces to regulate temperature, and enhances air and water quality, ultimately contributing to an improved quality of life for underserved neighborhoods.

The Hunter's Point neighborhood in San Francisco, California, serves as the testing ground for this proposal. Characterized by a predominantly low-income population and limited access to supermarkets, this community also benefits from existing recycling laws, providing an ideal environment to evaluate the viability and impact of closed-loop systems. By addressing environmental, social, and economic dimensions, this thesis demonstrates how integrating urban agriculture into multifunctional landscapes can promote resilience and equity in urban settings.

ACKNOWLEDGMENTS

This thesis is a reflection of the unwavering support I received from my committee- Professor Kelley Lemon, Professor David L hays and Professor Jack McCoy. Special thanks to Professor Kelley lemon and her Spring 2023 Design Workshop: Productive Landscapes Studio, which served as my inspiration for taking up this thesis.

I am grateful to all the faculty members of the Department of Landscape Architecture and Architecture for sharing their knowledge and valuable insights during all the review sessions. I owe an immense debt of gratitude to my parents, who supported my educational endeavors from the very beginning. I am thankful for my friends –Nawin Saravanan, Kavvya Ramarathnam, Rachitha Onkar, Raatan VS, Rajiv Ramachandran, Arvind Ganesan, Jarin Tumpa and Maija Mallula, who provided both distractions when needed and encouragement when it seemed impossible to continue. The discussions and unwavering support from my peers at the university have enriched my research experience, making this journey not only possible but also enjoyable.

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CHAPTER 1: INTRODUCTION

1.1.AIM OF THE THESIS

Urban land in the United States is projected to increase from 3.1% in 2000 to 8.1% in 2050, an area of 392,400 sq.km, which is larger than the state of Montana. By 2050, four states (Rhode Island, New Jersey, Massachusetts, and Connecticut) are projected to be more than one-half urban land. The total projected amount of US forestland estimated to be subsumed by urbanization between 2000 and 2050 is about 118,300 sq.km, an area approximately the size of Pennsylvania. Because of this urban growth, more regional planning and management may be needed to sustain ecosystem services required by a growing urban population.[1]

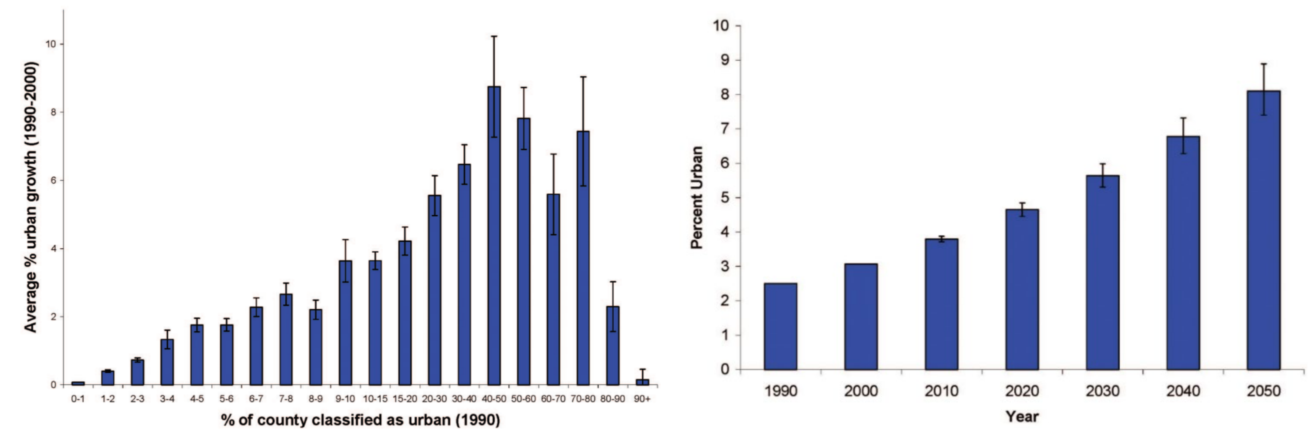

Fig 1.1: Urban Growth

Image source: Projected Urban Growth (2000 –2050), David J. Nowak and Jeffrey T. Walton

The challenge is, however, how to sustainably provide food for a world of ~9 billion people in 2050 with ~6.5 billion of these people living in urban areas without exacerbating the climate crisis.[2]
The notion that cities are centers of consumption, and landscapes are centers of extraction has created an ecologically disruptive, unidirectional flow of energy and resources in the metabolism of the biosphere.[3]

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[1] Nowak, D.J., and J.F. Dwyer. 2000. Understanding the benefits and costs of urban forest ecosystems. P. 11 25 in Urban and community forestry in the northeast, Kuser, J. (ed.). Plenum Publishing, New York.
[2] Lorenz, K., Lal, R. (2023). Challenges and Opportunities for the Global Food System. In: Organic Agriculture and Climate Change. Springer, Cham. https://doi.org/10.1007/978-3-031-17215-1_6
[3] Tan, L.M., Arbabi, H., Densley Tingley, D. et al. Mapping resource effectiveness across urban systems. npj Urban Sustain 1, 20 (2021). https://doi.org/10.1038/s42949-020-00009-3

Certain European cities like Amsterdam have started taking steps to create circular systems (see chapter 3) which they hope will provide solutions to many environmental, economic and geo - political challenges.

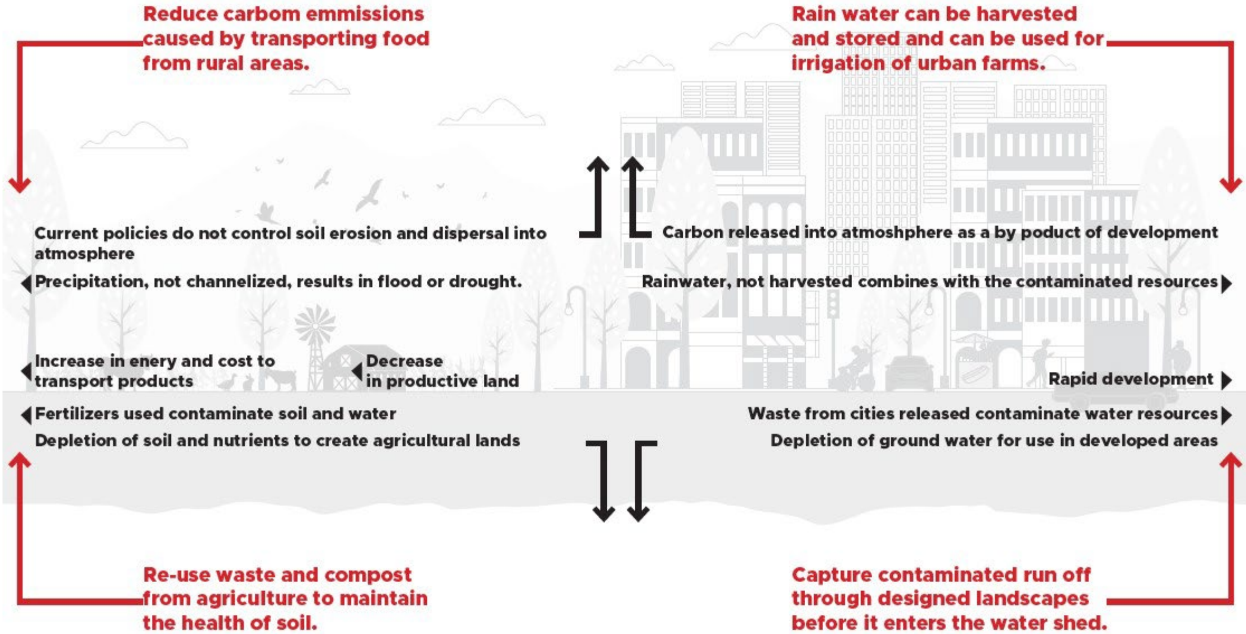

Fig 1.2: Flow of Resources

This image is a representation of the current unilateral flow of resources in a city and possible circularity that can be created to increase sustainability. There are various areas where this circular model can be applied. **My thesis aims to focus on Urban agriculture which can be a part of a sustainable food system by localizing food economies and increasing climate resilience.**

1.2.WHAT THE TERM URBAN MEANS

For this thesis, I will be considering two factors that categorize a place urban.

- The first one will be, according to the United States Census Bureau, a place is considered urban if it encompasses at least 2000 housing units and has a population of at least 5000 people at a census block or tract level. The nationwide average of people per housing unit is 2.5.[4]
- The second one would be Soil. Soil in urban areas is highly influenced by human activities. Urban soils often have a higher pH than other forest soils due to the presence of concrete and other building materials. Urban soil also tends to have higher concentrations of pollutants due

[4] https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.
html

to run off from roads and buildings.[5]

1.3.WHAT RESILIENCY IS

Urban resilience is the capacity of a city and its urban systems (social, economic, natural, human, technical, physical) to absorb strong perturbations, to reduce the impacts (changes, tensions, destruction or uncertainty) from a disturbance (shocks, disasters, changing weather, crises or disruptive events), to adapt to change and to improve systems that limit current or future adaptive capacity.[6]

1.4.WHAT URBAN AGRICULTURE IS

According to USDA, "Urban agriculture includes the cultivation, processing and distribution of agricultural products in urban and suburban areas. Community gardens, rooftop farms, hydroponic, aeroponic, and aquaponic facilities, and vertical production are all examples of urban agriculture. Tribal communities and small towns may also be included."
The 2018 Farm Bill (Agriculture Improvement Act of 2018, P.L. 115-334) refers to the urban farming demographic as urban, indoor, and other emerging agricultural production.[7]

Fig 1.3: Herbs

Image source: https://www.bonappetit.com/story/leafy-things-you-should-be-using-like-herbs

[5] https://websoilsurvey.nrcs.usda.gov/
[6] Paulo Jorge Gomes Ribeiro, Luís António Pena Jardim Gonçalves, Urban resilience: A conceptual framework, Sustainable Cities and Society, Volume 50, 2019, 101625, ISSN 2210-6707,
[7] 4.U.S. Census Bureau (2012) United States Summary: 2010 Population and Housing Unit Counts. 2010 Census of Population and Housing.

It's only since the industrial revolution that humans have separated food growing from where people live. People always raised food locally, close to home. **Producing food locally allows our communities to address urban issues like food desserts and insecurity** (see chapter 2).

1.5.TYPES OF URBAN AGRICULTURE

Urban agriculture is loosely defined as the production, distribution, and marketing of food and other products within the geographical limits of a metropolitan area. The key types of recognized urban farms are:[8]

1. Institutional Farms and Gardens

Typically linked with an institution (such as hospitals, churches, prisons, schools, public housing) whose primary mission is not large-scale food production, but instead to provide health, educational, and lifestyle opportunities.

2. Community Gardens

Usually located on publicly owned land or land trusts and managed by local resident volunteers. Community gardens mostly grow food, but some also grow flowers. Some community gardens provide space for community gatherings and events.

3. Community Farms

Communal growing spaces operated by a nonprofit organization that engages the surrounding community in food production as well as social and educational programming.

4. Commercial Farms

Some for-profit farms exist in urban areas, although they tend to be small and often produce niche products. Some small urban commercial farms focus on non-traditional growing techniques like vertical or soilless farming.

1.6.CUBA AS AN EXAMPLE

When Cuba found itself abruptly cut off from trade with the USSR in 1989, the country entered an economic crisis, prompting the government to engage in creative and innovative approaches to urban food production.[9] Havana has since managed to produce approximately half of its fresh vegetables right within the city, harnessing a network of community gardens, balconies, and rooftops. These

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[8] USDA website-urban agriculture

[9] Clouse, Carey. Farming Cuba: Urban Agriculture from the Ground Up. New York: Princeton Architectural Press, 2014

urban gardens not only serve as a local food source but also generate opportunities for employment, contribute to an enhanced urban climate, and provide an aesthetic uplift to the city.

Cuba—an island not only physically but also economically severed from its neighbors—was forced to develop a way to feed its population of 10.5 million people, 69% of whom lived in cities, without the imports of staple grains and agricultural technology that its entire food system had come to depend on.[10]

This period of isolation transformed the country— socially, politically, and spatially. Faced with extreme rations, Cuba's urban population took to the vacant urban land to produce their own food. The acute food shortages pushed the government to allow individuals to grow food on government owned urban land, and in 1993 Castro responded to even more severe U.S. sanctions with the Third Agrarian Reform Law, which allowed 70% of Cuba's agricultural land to be transferred to individuals and cooperatives through usufruct rights.[11] Agriculture systems developed during this period were devoid of pesticides and fertilizers by necessity, and therefore Cuba's emerging farming practices were organic by default. The Cuban Special Period represents the largest attempted conversion from conventional to alternative, semi-organic, agriculture in the world's history.[12]

Many urban residents also spoke of how they love the proximity, assurance of quality and low price of food grown on organopónicos. Within the Cuban system of urban agriculture today, land used for farming is government-owned and often near high-density development. These farms provide aesthetic respite from a dusty, decaying urban fabric. Food is sold from market stalls directly on the farm, and residents rely on this relatively inexpensive source of fresh produce.[13]

Urban agriculture in Cuba was motivated and enabled by the extreme extent of their food crisis, the strength and power of the centralized government, and both vacancy and low land values in urban settings.[14]

The severity of the food shortages seen during the Special Period ensured an engaged citizenship behind government-led Urban Agriculture (UA) initiatives, and the government was equally

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[10] Holt-Giménez, E. & Shattuck, A. "Food crises, food regimes and food movements: rumblings of reform or tides of transformation?" J. Peasant Stud. 2011; 38, 109–144.

[11] Schultz, Rainer. "Food Sovereignty and Cooperatives in Cuba's Socialism." Socialism and Democracy 2012; 26(3): 117-138.

[12] Rosset, Peter and Medea Benjamin, ed. The Greening of the Revolution: Cuba's Experiment with Organic Agriculture. New York: Talman Co, 1994.

[13] Parraga, Marianna and Alexandra Ulmer, "Venezuela's energy woes spread to its closest ally: Cuba." Reuters (July 8, 2016).

[14] Schultz, Rainer. "Food Sovereignty and Cooperatives in Cuba's Socialism." Socialism and Democracy 2012; 26(3): 117-138.

supportive of individual farming efforts. The dire necessity of urban farming during this time is largely responsible for the pervasive and entrenched system of UA seen today.[15]

the unique strength and reach of the central government in Cuba cannot be separated from the success of the urban agriculture program. All the sites of urban agriculture observed were on government land. The legal framework of usufruct rights allowed individuals and groups to use government land for farming initiatives over long-term lease periods.[16]

Fig 1.4: Urban Farms in Cuba

Image source: Andy Cook, nearly 8,000 parcels, or small lot gardens, are found in Havana today.
https://www.architectural-review.com/essays/cubas-urban-farming-revolution-how-to-create-self-sufficient-cities

[15] Clouse, Carey. Farming Cuba: Urban Agriculture from the Ground Up. New York: Princeton Architectural Press, 2014.

[16] Schultz, Rainer. "Food Sovereignty and Cooperatives in Cuba's Socialism." Socialism and Democracy 2012; 26(3): 117-138.

Fig 1.5: Urban Farms in Cuba

Image source: Andy Cook, reusing soda bottles for watering devices and using permaculture techniques for animal husbandry on his rooftop, this El Cerro farmer tends to more than one hundred rabbits. https://www.architectural-review.com/essays/cubas-urban-farming-revolution-how-to-create-self-sufficient-cities

UA practices developed in Cuba that have the potential to be employed elsewhere to improve food security in advance of crisis. The cases explored in this study indicate that government support for urban farming practices is essential for ensuring adequate land access and effective affordability of produce. To this end, governments in other nations could subsidize urban farming practices in the face of food crisis, including providing seeds and public land to support the practice. Additionally, the on-site vending so pervasive in the Cuban system demonstrates an effective method of integrating an urban farm into city fabric. This market strategy also ensures that time, cost, and energy used in the transportation of food to citizen is minimized—an essential feature of the Cuban system that ensures its capacity to function in the face of threats to the nation's food system or economy. Additionally, the model of placing urban farms within dense urban populations, like housing developments, presents a large potential for successful replication. This spatial overlap places the affordable, fresh produce within the range of many people, who are generally of low income and therefore sensitive to food insecurity.

1.7.ADVANTAGES OF URBAN AGRICULTURE

By producing food on unused land in cities, urban agriculture can reduce the amount of land needed for rural agriculture.[17] When agriculture takes advantage of unused space in cities, it can directly reduce carbon emissions since food grown in or near cities travel shorter distances. In areas with long supply chains or where foods are transported by planes, growing food in local, urban gardens can replace transported foods and reduce transportation-related emissions.[18] Urban agriculture also stores carbon, both in soil and vegetation.[19]

Robust urban agriculture systems can also help to reduce disaster risk.[20] As climate change effects increase, food security will be affected by drought, flooding, wildfire, and extreme storms. There is the potential for urban agriculture to build local resilience by providing access to local foods.[21] Also, urban agriculture is inherently diverse – individual farms grow many types of crops, different farms grow different varietals of the same crop, and farms located throughout a city can experience different localized weather patterns.[22] If crops in one area of a city or certain types of crops are damaged by an extreme weather event, other crops or other local farms potentially can supplement that loss.

Urban agriculture can help make cities more equitable.[23] Researchers found that historical "redlining" of minority neighborhoods in more than 100 American cities has placed a heavier burden on residents from extreme heat than other communities, according to the findings published in the journal Climate.[24] Urban agriculture can increase food access and green spaces in parts of the city that are historically disadvantaged. Urban agriculture near disadvantaged communities can provide a type of green space that can reduce the effects of climate change for nearby residents. UA projects
occupy a vital place in the fight against community food insecurity in disadvantaged inner-city

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[17] Lovell, Sarah Taylor. 2010. "Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States" Sustainability 2, no. 8: 2499-2522. https://doi.org/10.3390/su2082499

[18] Gwan-Gyu Lee, Hyun-Woo Lee, Jung-Hwan Lee, Greenhouse gas emission reduction effect in the transportation sector by urban agriculture in Seoul, Korea, Landscape and Urban Planning,

[19] United States Department of Agriculture, Climate Hubs.

[20] Marielle Dubbeling, René van Veenhuizen and Jess Halliday, "Urban agriculture as a climate change and disaster risk reduction strategy", Field Actions Science Reports, Special Issue 20 | 2019, 32-39.

[21] Gulyas, Boglarka Z., and Jill L. Edmondson. 2021. "Increasing City Resilience through Urban Agriculture: Challenges and Solutions in the Global North" Sustainability 13, no. 3: 1465. https://doi.org/10.3390/su13031465

[22] https://www.cocorahs.org/

[23] United States Department of Agriculture - https://www.climatehubs.usda.gov/hubs/international/about.

[24] https://www.scientificamerican.com/article/past-racist-redlining-practices-increased-climate-burden-on-minority-neighborhoods/

neighborhoods in cities like Philadelphia.[25]

Urban areas experience the heat island effect in greater concentrations, where certain parts of cities are warmer than other parts of cities and cities are warmer than surrounding rural areas.[26] In urban areas buildings, roads and other infrastructure absorb and re-emit the sun's heat much more than natural landscapes. These pockets where the concentration of manmade infrastructure is higher become heat islands. As urban populations grow, cities can consider strategically placing urban agriculture plots to reduce heat island effects.

The diversity of crop types and farm locations in urban agriculture has benefits for biodiversity.[27] urban green spaces such as UA can bring diverse green infrastructure back into the urban system, providing vegetative structure and biodiversity for ecosystem function and services across fragmented habitats and spatial scales.[28] UA may be especially important for bio diversity conservation in cities because vegetative structural complexity in simplified landscapes (cities) contributes disproportionally more to conservation than in more natural landscapes.[29] UA provides many opportunities for revegetating the landscape at the local scale within a vegetatively depauperate urbanized landscape. Plant diversity attracts a diversity of animals, which would otherwise not be present without urban agriculture.

Urban agriculture can increase local food security in the face of climate change, making it an important component of land-use planning.[30] Robust local and urban agriculture systems are key parts of a sustainable food system that will help to make food supplies more resilient to climate change. Urban agriculture has the potential to benefit cities environmentally and socially.

1.8.EFFECTS OF URBANIZATION

Although urban regions currently cover only a very limited part of the earth's land surface, they have marked effects on environmental, social, and economic conditions at both local and global scales. Some of which are:

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[25] Meenar, M. R., & Hoover, B. M. (2012). Community food security via urban agriculture: Understanding people, place, economy, and accessibility from a food justice perspective. Journal of Agriculture, Food Systems, and Community Development, 3(1), 143–160. http://dx.doi.org/10.5304/jafscd.2012.031.013

[26] https://www.epa.gov/heatislands/learn-about-heat-islands

[27] Brenda B. Lin, Stacy M. Philpott, Shalene Jha, The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps, Basic and Applied Ecology,

[28] Lin, B.B., & Fuller, R.A. (2013). Sharing or sparing? How should we grow the world's cities? Journal of Applied Ecology,50(5),1161–1168.

[29] Tscharntke, T., etal. (2012). Landscape moderation of biodiversity patterns and processes–Eight hypotheses. BiologicalReviews,87(3),661–685.

[30] Eigenbrod, C., Gruda, N. Urban vegetable for food security in cities. A review. Agron. Sustain. Dev. 35, 483–498 (2015). https://doi.org/10.1007/s13593-014-0273-y

- Urbanization involves the transformation of natural landscapes into built environments. This process leads to land use changes, including the conversion of green spaces and natural habitats into infrastructure and buildings.[31]
- Urban areas often experience the urban heat island effect in higher concentrations because they are made from surfaces that absorb and retain significantly more heat. This phenomenon has implications for local climate and energy consumption.[32]
- Urbanization can exacerbate social inequalities, with disparities in access to resources, services, and opportunities often observed within cities.[33]
- Urban areas are major consumers of resources, including energy, water, and materials. This high level of resource consumption contributes to global environmental challenges and can impact ecosystems beyond city boundaries.[34]
- Urban transportation systems, often characterized by high levels of motorized vehicles, contribute to air pollution and greenhouse gas emissions. This has implications for global climate change.[35]
- The effects of urbanization are interconnected across environmental, social, and economic dimensions. Changes in one aspect can have cascading effects on the others, highlighting the complexity of urban systems.[36]
- It is estimated that 83% of the U.S. population lives in urban areas, up from 64% in 1950. By 2050, 89% of the U.S. population and 68% of the world population is projected to live in urban areas.[37]

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[31] Angel, S., Parent, J., & Civco, D. L. (2012). The fragmentation of urban landscapes: Global evidence of a key attribute of the spatial structure of cities, 1990–2000. Environment and Urbanization 24(1): 249–283.
[32] Yang, Li, Feng Qian, De-Xuan Song, and Ke-Jia Zheng. 2016. “Research on Urban Heat-Island Effect.” Procedia Engineering 169:11–18. https://doi.org/10.1016/j.proeng.2016.10.002.
[33] de Snyder, V Nelly Salgado et al. “Social conditions and urban health inequities: realities, challenges and opportunities to transform the urban landscape through research and action.” Journal of urban health : bulletin of the New York Academy of Medicine vol. 88,6 (2011): 1183-93. doi:10.1007/s11524-011-9609-y
[34] https://unhabitat.org/topic/urban-energy
[35] https://www.epa.gov/transportation-air-pollution-and-climate-change/carbon-pollution-transportation
[36] Croci, Edoardo, and Benedetta Lucchitta, eds. Nature-Based Solutions for More Sustainable Cities: A Framework Approach for Planning and Evaluation. First edition. Bingley, U.K: Emerald Publishing Limited, 2022. Print.
[37] United Nations (UN) Population Division (2018) World Urbanization Prospects: The 2018 Revision.

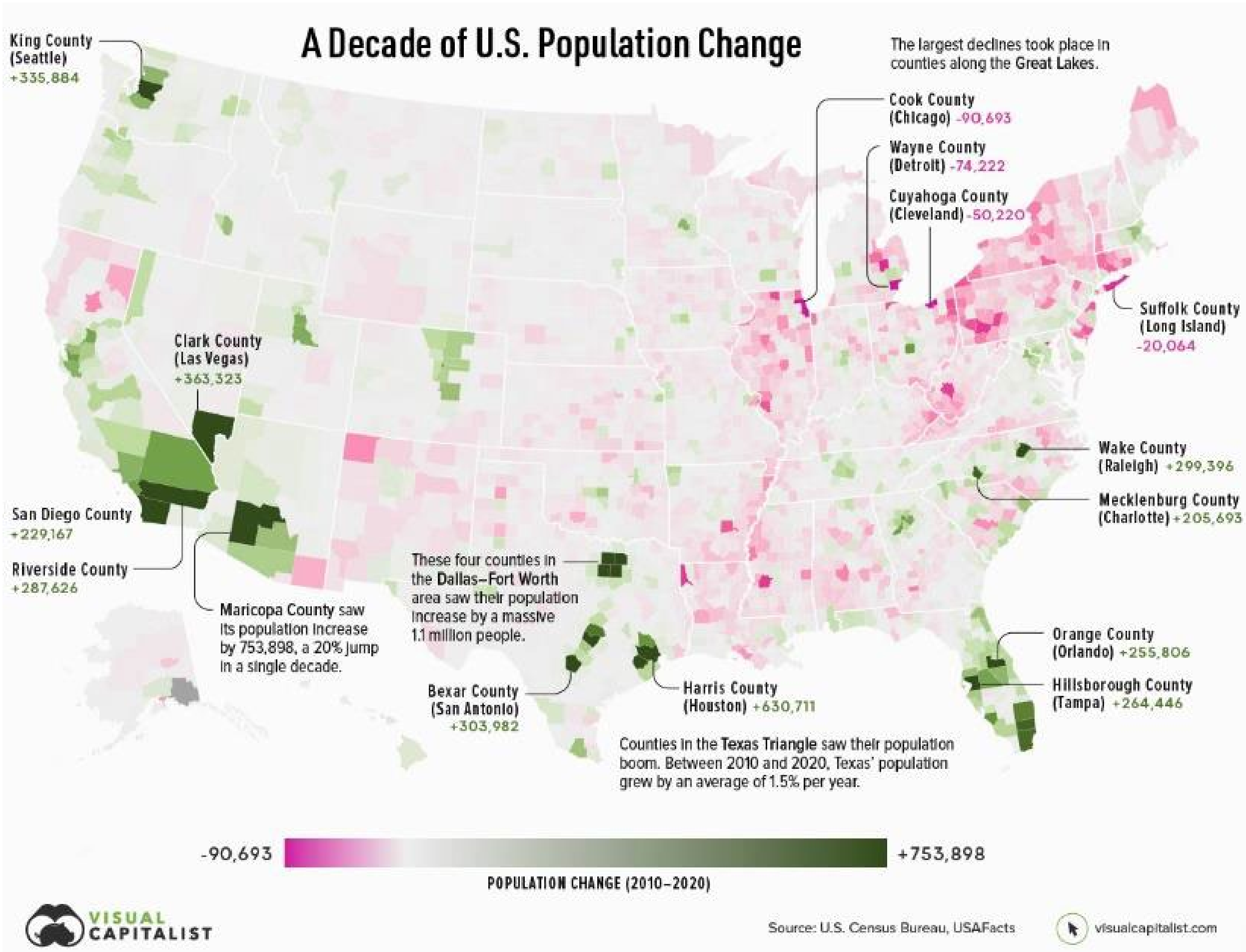

Fig 1.6: Change in US Population

Image source: https://www.visualcapitalist.com/mapping-a-decade-of-us-population-growth

The increase in urban population has significantly impacted on the environmental quality and overall livability of cities, presenting a host of new challenges that must be addressed to strengthen the resilience of urban centers.[38] One approach to enhancing urban resilience is the promotion of multifunctional urban areas. **This thesis delves into the concept of developing productive landscapes for production of crops for consumption from a neighborhood planning perspective**

- **To test sustainable food loops that transition from a linear model of resource flow to a circular model,**
- **To create accessible food production spaces that are inclusive,**

[38] https://unhabitat.org/wcr/

- **Propose decentralized production and distribution systems as a step towards a resilient and sustainable city**,
- **By integrating food production and its related activity in federally owned land, the Naval shipyard here, to ensure sustainability.**

Productive landscapes require land, but in return it will enrich the city. Land in cities must be allocated, reclaimed or recycled. Productive landscapes can take any shape and occupy any shape in the city, starting with space on wide pavements. In 2005, a vision for integrating Continuous Productive Urban Landscapes (CPULs) into existing and future cities were proposed by André Viljoen, Katrin Bohn and Joe Howe (see chapter 1.8).

For this thesis, the focus will be on preserving and converting open/vacant/abandoned spaces within neighborhoods, similar to the concept of CPULs, into productive areas capable of providing and serving the community. This approach offers the opportunity to repurpose underutilized and vacant land parcels within the city into productive spaces, effectively integrating food production with sustainable landscape development.

All U.S. urban areas have some quantity of Vacant Urban Area (VUA), but for areas that have experienced decentralization, deindustrialization and population decline over the past few decades, the situation has been considered more acute.[39] While vacant land can be classified as a multitude of types (e.g. brownfields, greenfield, unused land, and derelict sites), Bowman and Pagano defined it as publicly and privately-owned unused or abandoned land, land that once had structures on it, and/or land that supports structures that have been abandoned, derelict, boarded up, partially destroyed or razed.[40]

Contamination or environmental concerns may render certain lots unsuitable for immediate development.[41] Remediation efforts or regulatory obstacles can delay or prevent construction. Urban farming in cities is currently predominantly situated in neighborhoods with the financial capacity to cover maintenance and operational costs, often in less densely populated areas.[42] In highly populated neighborhoods, access to urban farming is limited to affluent individuals who can afford to lease a

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[39] Goldstein, Jensen, & Reiskin, 2001; Hollander, 2010; Hollander & Németh, 2011

[40] Bowman, A. O.'. M., & Pagano, M. A. (2000). Transforming America's cities: Policies and conditions of vacant land. Urban Affairs Review, 35(4), 559–581. http://dx.doi.org/ 10.1177/10780870022184534.

[41] Ferronato, Navarro, and Vincenzo Torretta. "Waste Mismanagement in Developing Countries: A Review of Global Issues." International journal of environmental research and public health vol. 16,6 1060. 24 Mar. 2019, doi:10.3390/ijerph16061060

[42] Syngellakis, S., and J. L. Miralles i García, eds. "Urban Agriculture and City Sustainability." Southampton: WIT Press, 2019. Print.

plot in a nearby community farm, if one exists.[43] Underserved communities, which would benefit the most from such initiatives, often lack accessibility to urban farming opportunities.[44] The reason being several including, limited land for cultivation, lack of funding to start and maintain a farm and sometimes community resistance to new initiatives.[45] Underserved communities, according to FEMA (The Federal Emergency Management Agency) Groups that have limited or no access to resources or that are otherwise disenfranchised. These groups may include people who are socioeconomically disadvantaged; people with limited English proficiency; geographically isolated or educationally disenfranchised people; people of color as well as those of ethnic and national origin minorities; women and children; individuals with disabilities and others with access and functional needs; and seniors.[46]

[43] L. Powell et al., "Food Store Availability and Neighborhood Characteristics in the United States," American Journal of Preventive Medicine 44 no. 3 (2007): 189–95.
[44] Rosan, Christina, and Hamil Pearsall. Growing a Sustainable City? The Question of Urban Agriculture. Toronto; University of Toronto Press, 2017. Print.
[45]https://www.ers.usda.gov/amber-waves/2010/march/access-to-affordable-nutritious-food-is-limited-in-food-deserts/
[46] https://www.fema.gov/about/glossary

1.9.EXISTING LITREATURE INTENDED TO CONTRIBUTE TO THE ONGOING DEBATE ABOUT THE FUTURE SHAPE OF CITIES.

1. CONTINIOUS PRODUCTIVE URBAN LANDSCAPES

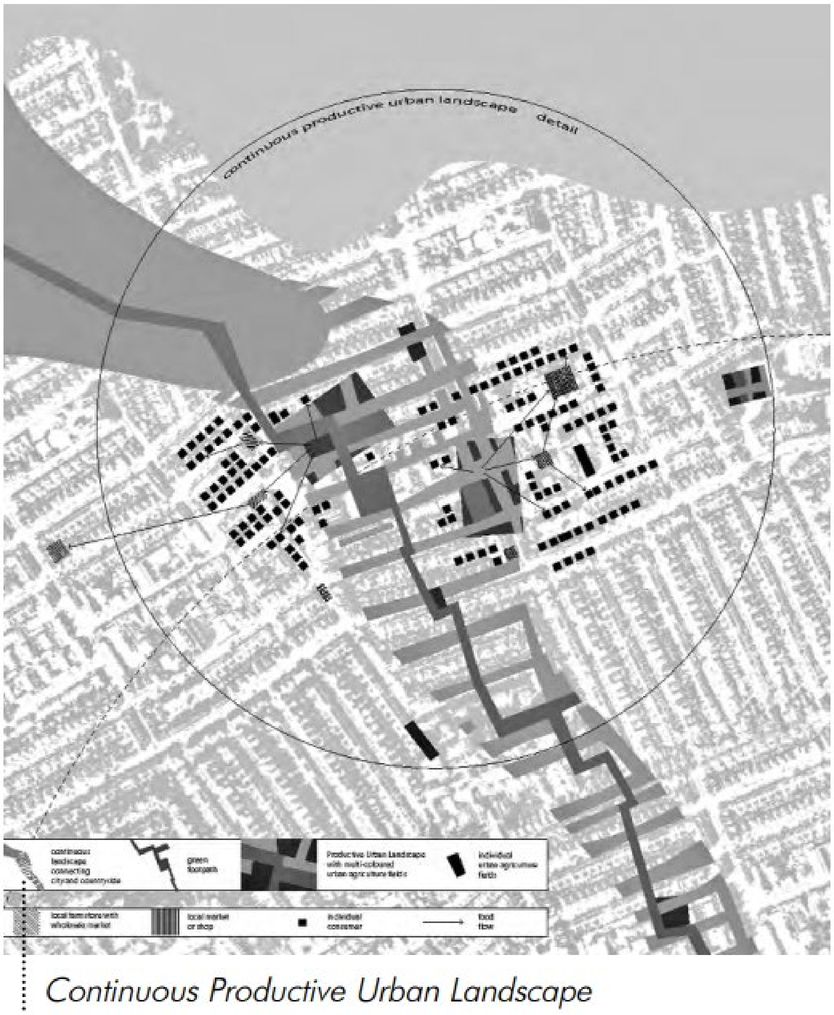

Fig 1.7: CPUL

Image source: https://library.uniteddiversity.coop/Food/Continuous_Productive_Urban_Landscapes.pdf

In 2005 a vision and strategy for the 21st century city that will be green, a healthy place for all and will generate zero net pollution was developed and published as a book called **CONTINUOUS PRODUCTIVE URBAN LANDSCAPES: DESIGNING URBAN AGRICULTURE FOR SUSTAINABLE CITIES** by André Viljoen, Katrin Bohn and Joe Howe. This book is a 21st century breakthrough in defining an urban design/planning conceptual approach to reincorporating a productive landscape, including agriculture, into the human settlement (CPULs). A vision for integrating Continuous Productive Urban Landscapes (CPULs) into existing and future cities. CPULs were treated as urban spaces combining agricultural and other landscape elements within a strategy of continuous, open space linkages. Urban agriculture within CPULs, integrated into individual cities, can contribute to more sustainable food production and open space management.[47]

Examples of what was proposed in London

Fig 1.8: CPUL

Image source: https://library.uniteddiversity.coop/Food/Continuous_Productive_Urban_Landscapes.pdf

Image showing how parts of parks may be given over to urban agriculture in a CPUL without compromising other uses and CPUL proposal for south London.

The conclusion to this initial research was that urban agriculture could make a significant contribution to fruit and vegetable requirements, and that a case could be made for considering it as an essential element of sustainable infrastructure in existing and developing cities. This infrastructure would best be located within corridors of open space, forming a coherent overall landscape strategy, defined by us as a Continuous Productive Urban Landscape (CPUL).[48]

[47] Viljoen, André., Katrin. Bohn, and J. (Joe) Howe. Continuous Productive Urban Landscapes : Designing Urban Agriculture for Sustainable Cities. Oxford ; Architectural Press, 2005. Print.

[48] Viljoen, André., Katrin. Bohn, and J. (Joe) Howe. Continuous Productive Urban Landscapes : Designing Urban Agriculture for Sustainable Cities. Oxford ; Architectural Press, 2005. Print.

2. FROM ECO CITIES TO LIVING MACHINES

Eco machines was first developed by John Todd in 1974 under the name Living machines in New Alchemy Institute, perform ecological sewage treatment by mimicking and accelerating the natural purification process of wetlands. Eco machines are cost effective methods to treat water from communities and can be incorporated into several small-scale projects. Their aesthetic as productive water features offer opportunities to integrate them indoors and outdoors.

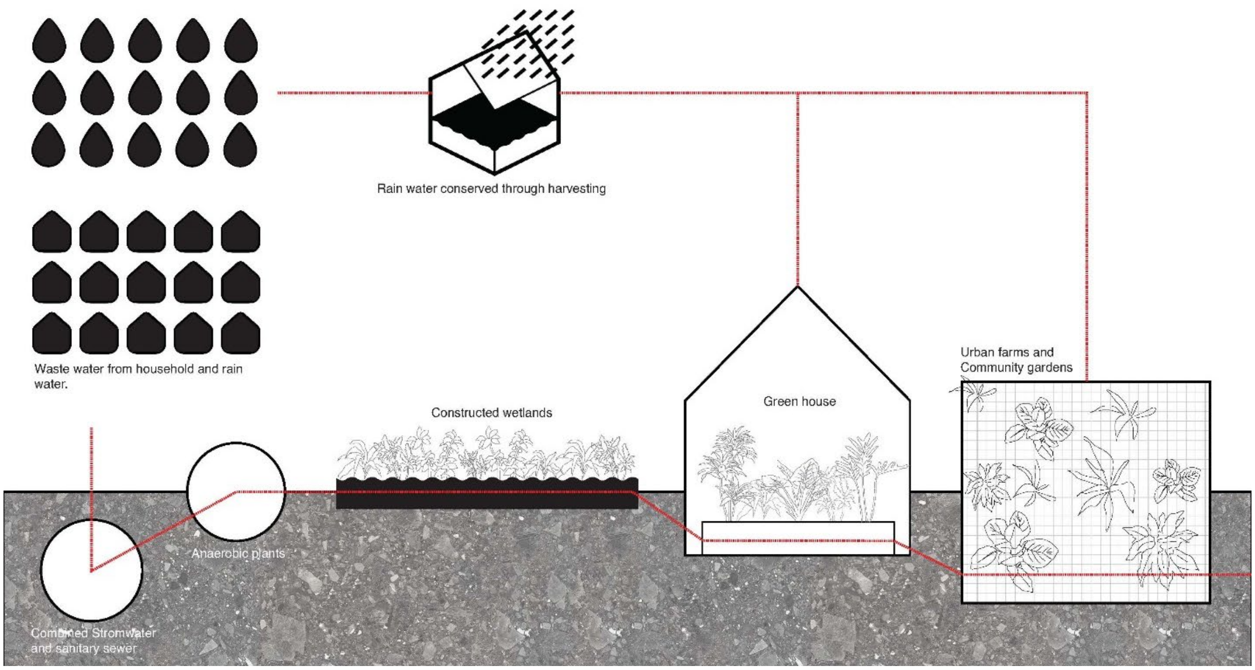

Fig 1.9: A take on how the concepts of living machines can be modified to suit today's needs

A combination of these concepts to create sustainable spaces for food production within the urban areas not only underscores the social, economic, and environmental advantages of implementing such spaces but also highlights their essential role in advancing the well-being and quality of life for residents in a resilient city. On a broader scale, the proposed system paves the way for the establishment of productive and green spaces in any neighborhood, with the aim of integrating this concept into the urban planning policies of cities. This will ensure the sustainability of our cities and their overall landscapes.[49]

[49] Todd, Nancy Jack. From Eco-Cities to Living Machines: Principles of Ecological Design. Berkeley, Calif: North Atlantic Books, 1994. Print.

CHAPTER 2: FARMS, FOOD DESERTS AND FOOD INSECURITY

2.1.CONVENTIONAL FARMS

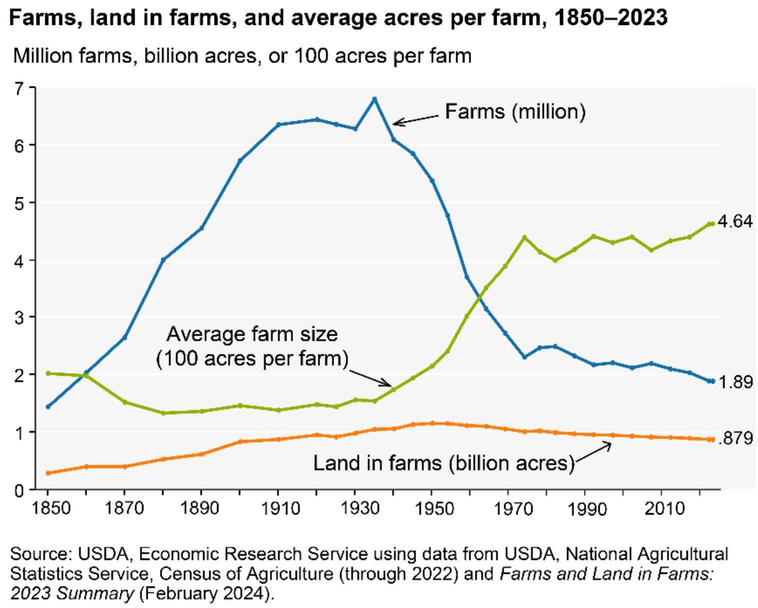

Fig 2.1: Decrease in Farmland

Image source: United States Department of Agriculture

In the most recent survey, there were 1.89 million U.S. farms in 2023, down 7 percent from the 2.04 million found in the 2017 Census of Agriculture. Similarly, acres of land in farms continued a downward trend with 879 million acres in 2023, down from 900 million acres in 2017.

There are two main categories of crops grown in the U.S. and around the world: specialty crops and commodity crops. Specialty crops are diverse in flavor, color and nutrient content, and they are the backbone of cuisines all over the world. Commodity crops, on the other hand, are indistinguishable from each other and are usually grown for processing.[50]

So why does this distinction matter? It's a matter of the numbers. Almost half of the world's arable land and land in the USA are utilized to grow commodity crops.[51] While these crops contribute to the global economy in several ways, they require a lot of manufacturing energy to be effectively metabolized by our bodies - making them an inherently less sustainable crop. They also incur many

[50] https://planteddetroit.com/blogs/our-blog/specialty-crops-vs-commodity-crops?srsltid=AfmBOorbC7lgOS-BcDuW7PBTZKvnZLUpquUtorfWXhCKjk0rZjJi5iTU

[51] United States Department of Agriculture

more food miles being shipped from field to processor to food manufacturer to distributor to grocery store, before finally coming to rest in your home kitchen.[52]

Globally, just four crops – soybeans, wheat, rice and corn – are grown on almost half the world's agricultural lands. In the U.S. farms producing commodity crops far outnumber those producing specialty crops.[53]

2.2.URBAN AGRICULTURE IN THE PRESENT

Urban agriculture is a widely proposed strategy to make cities and urban food systems more sustainable, healthy, and just. Despite strong evidence of social and nutritional benefits from UA, environmental claims are not well supported, particularly how the environmental footprint of UA compares to conventional agriculture. As interest in Urban Farming increases, it is important to ensure that it is beneficial for the people and the planet.

The graphs below are the results of a study conducted by the University of Michigan, Ann Arbor.[54] 73 sites in France, Germany, Poland, the United Kingdom, and the United States, was studied to arrive at the results. The carbon footprint across the life cycle of producing food at three types of low-tech UA: urban farms (professionally managed, focused on food production), individual gardens (small plots managed by single gardeners) and collective gardens (communal spaces managed by groups of gardeners) was studied. This revealed that UA has higher GHGs per serving of fruit or vegetable than conventional agriculture, irrespective of country.

[52] Farm Bureau of the USA

[53] https://www.foodindustry.com/articles/whats-the-difference-between-specialty-crops-and-commodity-crops/#google_vignette

[54] Hawes, J.K., Goldstein, B.P., Newell, J.P. et al. Comparing the carbon footprints of urban and conventional agriculture. Nat Cities 1, 164–173 (2024). https://doi.org/10.1038/s44284-023-00023-3

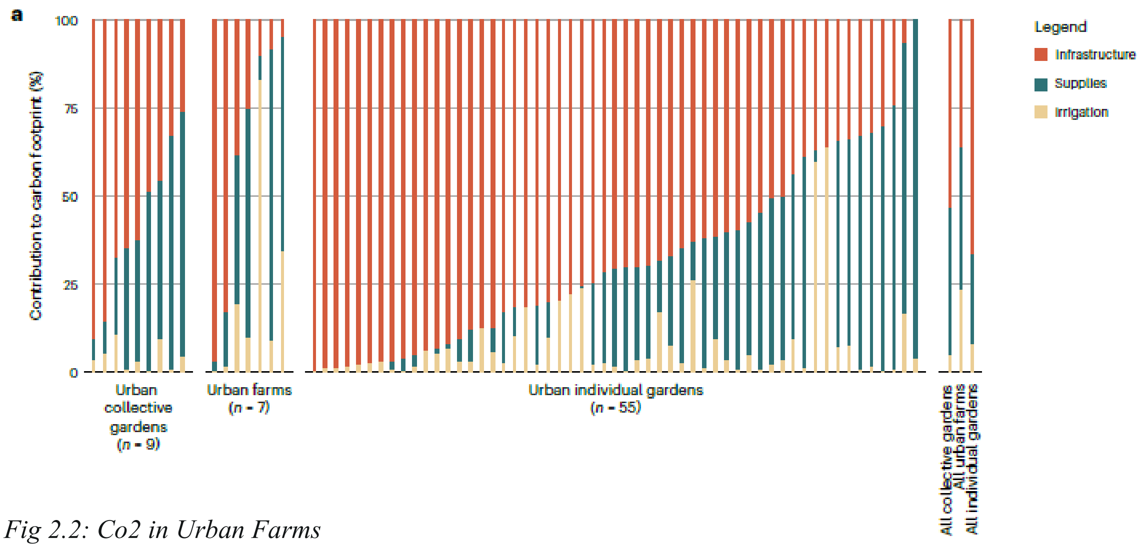

Fig 2.2: Co2 in Urban Farms

Image source: https://css.umich.edu/publications/research-publications/comparing-carbon-footprints-urban-and-conventional-agriculture

The graph represents the contributions of infrastructure, supplies and irrigation to GHG impacts. Supplies include fertilizer, compost, gasoline, weed block textile and so on. Irrigation is blue water used on food crops. Each column is an individual urban farm or garden.

The black lines show the median infrastructure GHG impacts per serving of food produced at three types of UA space as a function of farm lifetime. The dashed lines show GHG impacts per serving using conventional agriculture. Urban farms amortize infrastructure investments after only three years. Individual gardens take decades, and collective gardens never break even.[55]

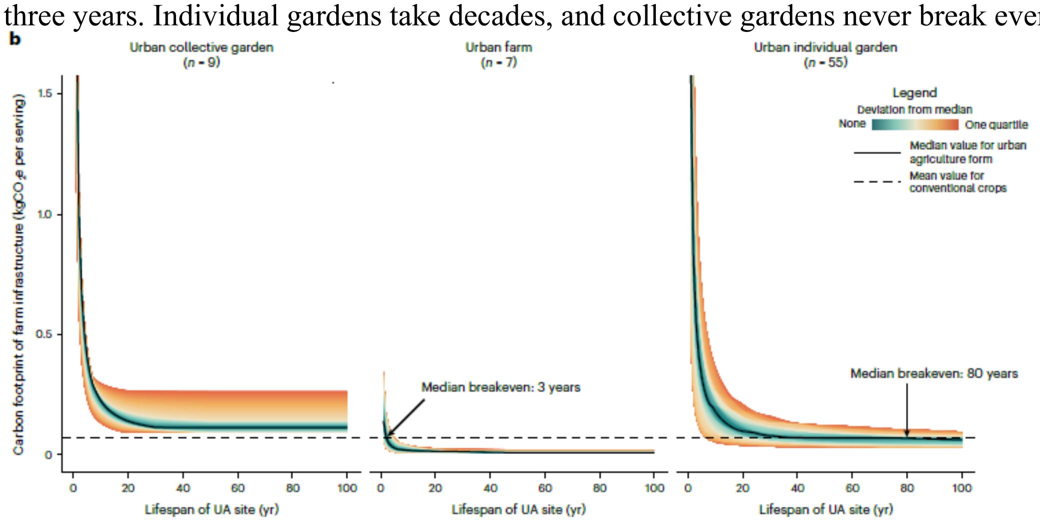

Fig 2.3: Co2 in Urban Farms

Image source: https://css.umich.edu/publications/research-publications/comparing-carbon-footprints-urban-and-conventional-agriculture

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[55] Hawes, J.K., Goldstein, B.P., Newell, J.P. et al. Comparing the carbon footprints of urban and conventional agriculture. Nat Cities 1, 164–173 (2024). https://doi.org/10.1038/s44284-023-00023-3

a. Contributions of infrastructure, supplies and irrigation to GHG impacts.

b. The black lines show the median infrastructure GHG impacts per serving of food produced at three types of UA space as a function of farm lifetime.

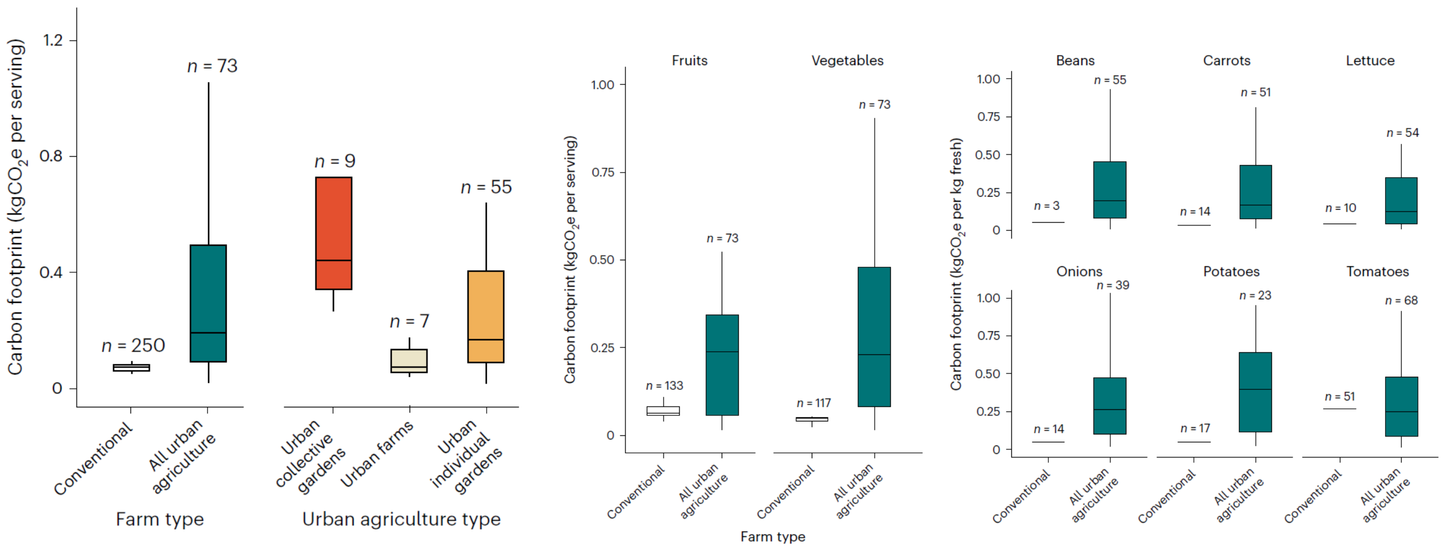

Fig 2.4: Co2 in Urban Farms

Image source: https://css.umich.edu/publications/research-publications/comparing-carbon-footprints-urban-and-conventional-agriculture

a. The carbon footprint of conventional versus urban agriculture.

b. GHG emissions by farm type and product. Impacts per serving of food and of crop.

What then makes urban farms climate friendly? What was the reason for such high carbon emissions?

- Infrastructure was the largest driver of carbon emissions - 63% hence, UA sites should preserve infrastructure as long as possible.
- Sites should leverage urban waste streams as inputs. Upcycling refuses from the urban environment can cut about 52% of carbon emissions.
- Sites should invest in social benefits; increasing social benefits can reduce impacts allocated to food.

2.3.FOOD DESERTS IN THE USA

More than 53 million or 17% of Americans were considered low-income and had little to no access to supermarkets or similar large food stores, according to 2019 data from the US Department of Agriculture (USDA).[56]

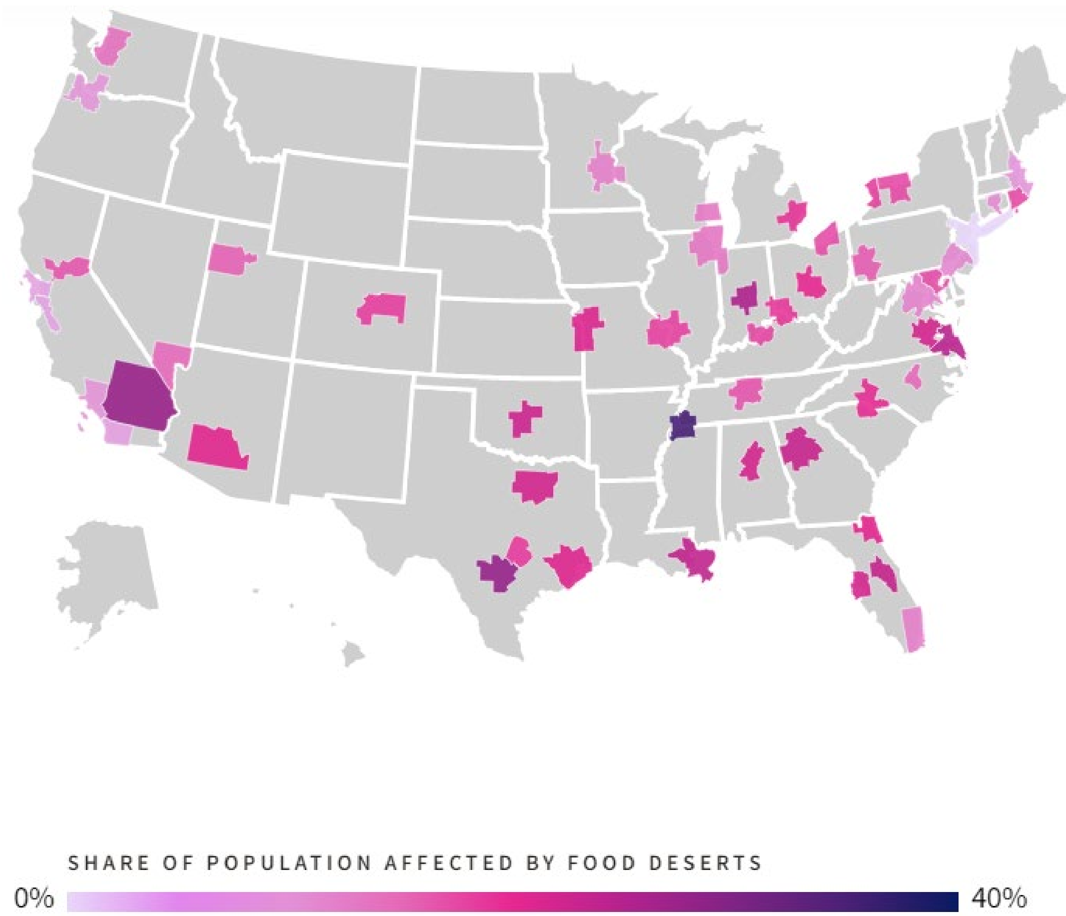

Fig 2.5: Food Deserts in USA

Image source: https://www.ers.usda.gov/data-products/food-access-research-atlas/

[56] Berg, Nathan, and James Murdoch. 2008. "Access to Grocery Stores in Dallas," International Journal of Behavioral and Healthcare Research Vol. 1(1): pp. 22-37.

2.4.HOW ARE FOOD DESERTS DEFINED IN THE USA

The USDA defines food deserts as an area where low-income people do not have easy access to large food retailers. These food deserts particularly impact urban areas. Ninety-six percent of people in a food desert, 51.7 million, lived in urban areas in 2019.[57]

Food deserts in the Bay Area

At least 889 neighborhoods in the Bay Area are considered to have "low food access." Of those urban areas, 600 are found in the San Francisco metro area, while another 289 food deserts exist around San Jose.[58]

The map represents areas in San Francisco that had low access to food in 2019.

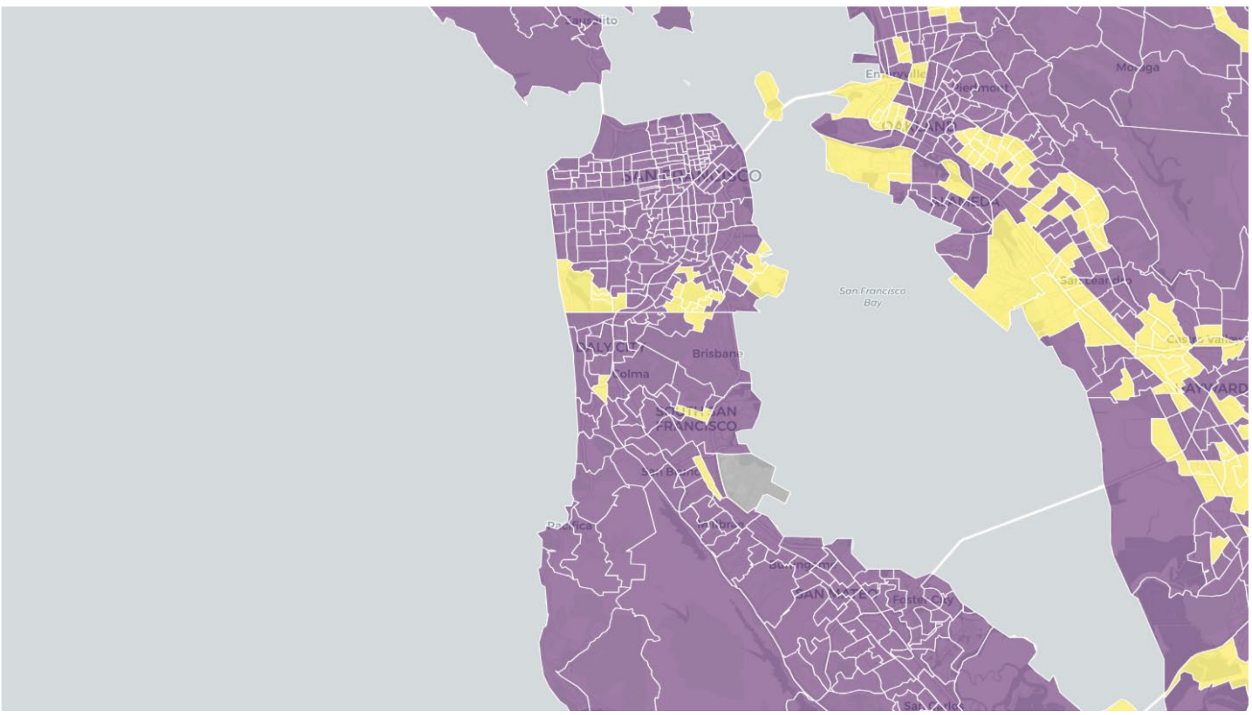

Fig 2.6: Food Deserts in Bay Area

Image source: https://abc7news.com/food-desert-bay-area-deserts-pantry-near-me-alameda-bank/11254529/

The USDA considers a tract low access if at least 500 people or a third of the population lives more than a half mile away from the nearest food retailer in urban tracts or more than 10 miles away in rural tracts.[59] Types of food retailers considered in the count exclude convenience stores and smaller food sellers.

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[57] U.S. Department of Agriculture. 2009. Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences—Report to Congress, AP-036, USDA, Economic Research Service. Available at: http://www.ers.usda.gov/Publications/AP/AP036/.

[58] https://www.usda.gov/

[59] https://www.usda.gov/

About a third of people in food deserts, 17.2 million people, live more than a mile away from the nearest urban food store or at least 20 miles from the nearest rural food retailer. Six percent of Americans are in these more extreme food deserts. Urban residents account for 16.9 million of those people.[60]

low-income (LI): poverty rate of 20% or greater, or median family income at or below 80% of the statewide or metropolitan area median family income[61]

low-access (LA): a low-income tract with at least 500 people or 33% of the tract's population living more than 1 mile (urban areas) or more than 10 miles (rural areas) from the nearest supermarket or grocery store. (USDA LA data is also available assuming different measures of distance, ranging 0.5 miles to 20 miles.)[62]

An example of LI and LA in San Francisco.

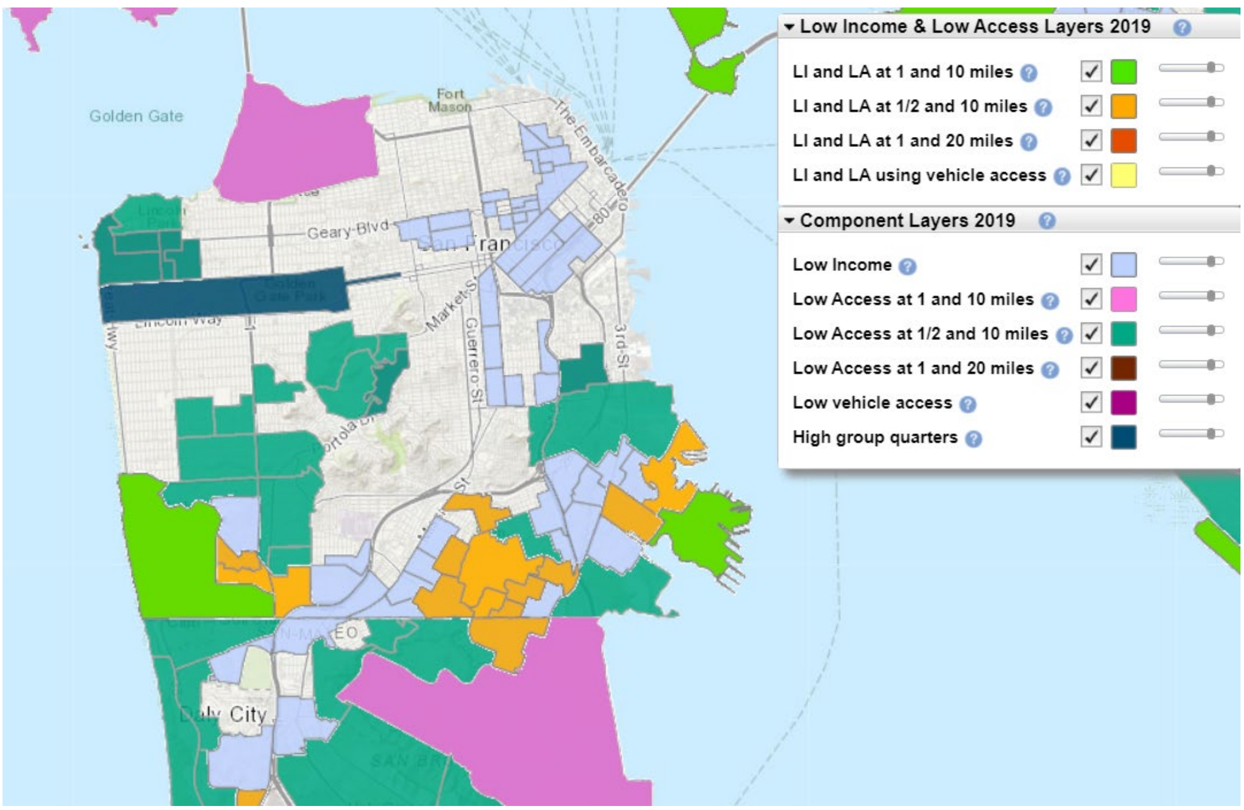

Fig 2.7: LI and LA in SFO

Image source: https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/

[60] U.S. Department of Agriculture. 2009. Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences—Report to Congress, AP-036, USDA, Economic Research Service. Available at: http://www.ers.usda.gov/Publications/AP/AP036/.

[61] https://crsreports.congress.gov/

[62] https://crsreports.congress.gov/

CHAPTER 3: RESEARCH QUESTION

3.1.RESEARCH STATEMENT

A sustainable landscape emerges when resources are drawn from the community and reciprocated. Does the establishment of a closed loop ensure not only endurance but also the evolution of a landscape? As cities undergo significant changes due to population increase shift, quality green spaces are important. In the dense urban fabric, there is limited room for green infrastructure, while the need persists for activities such as food cultivation, stormwater management, household wastewater treatment, temperature regulation, carbon emissions sequestration, and improvement of air and water quality. Could the integration of these functions and systems into everyday landscapes provide a viable solution?

This thesis examines urban agriculture as one element of developing a resilient urban landscape, by implementing a design that allows for the cultivation of specialty food crops in a "loop" system that recycles compost and waste, remediates soil, improves air and water quality, regulates temperature through reduced impervious surfaces, and leads to a better quality of life for underserved neighborhoods and communities. The proposal uses the Hunter's Point neighborhood in San Francisco, California as a testing ground for which to develop these ideas. Hunters Point is a community where:

- **A significant share of the population is low income and lives farther than 5 miles from the nearest supermarket.**
- **There are recycling laws to promote sustainability which is important for testing the success of these loop systems.**

CHAPTER 4: CASE STUDIES

4.1.GLOBAL BEST PRACTICE: CIRCULAR AMSTERDAM

This example of Amsterdam's sustainability policy highlights the critical role of strong local government support in ensuring its success. The City of Amsterdam has set out more than 70 actions that they will plan and carry out in the coming 4 years in partnership with all Amsterdammers. A separate budget has been allocated to do this every year as they are determined to achieve 100% circularity by 2050. In the United States, currently, San Francisco is widely recognized as a leading city in urban sustainability pioneering innovative approaches like mandatory residential composting and green waste recycling programs making it the perfect testing ground for such initiatives.

As a pillar of Amsterdam's sustainability policy, creating a circular economy was high on the municipality's agenda. The ability to identify and implement circular solutions at the city level was to lead to job creation, a cleaner environment, new or rejuvenated industries, and competitiveness in global markets. The circular economy provides solutions for many environmental, economic and geo-political challenges that cities worldwide are facing.[63] A circle scan was done in four phases. In phase 1, the main material and energy flows as well as the employment levels in the economic sectors in the region were analyzed, creating a solid base for phase 2. In phase 2, a comprehensive analysis of the value chains that connect multiple sectors within Amsterdam was conducted. Phase 3 explored the two chains in an ideal circular future. This future vision provides a view of how the chains (and their interactions with other chains) can be set up to be more effective. In phase 4, an action agenda and roadmap were drawn to kick-start relevant circular projects, and potential barriers were identified.[64]

The future vision and roadmap were developed for two chains

- **Construction chain**
- **Organic residual streams chain**

and the impact that the implementation of these would have on the economy and the use of materials.

[63] Accenture (2014). Circular Advantage Innovative Business Models and Technologies to Create Value in a World without Limits to Growth

[64] Amsterdam Smart City (2015). Buiksloterham: living lab voor circulaire gebiedsontwikkeling. http://amsterdamsmartcity.com/news/detail/id/448/slug/buiksloterham-lab-for-circular-area-development?lang=nl

1.Construction chain

In an ideal circular construction chain, the buildings are designed in such a way that materials will have the longest possible lifespan through reuse or repurposing.[65] The introduction of a material passport is a concrete measure that can be of great help in stimulating reuse by increasing transparency to develop a business case and enabling reallocation of materials. Furthermore, chain cooperation and supply chain financing is especially important since it contributes to a longer term maintenance and use that does justice to the useful life of buildings. As a result, economic, environmental and social performance improves.

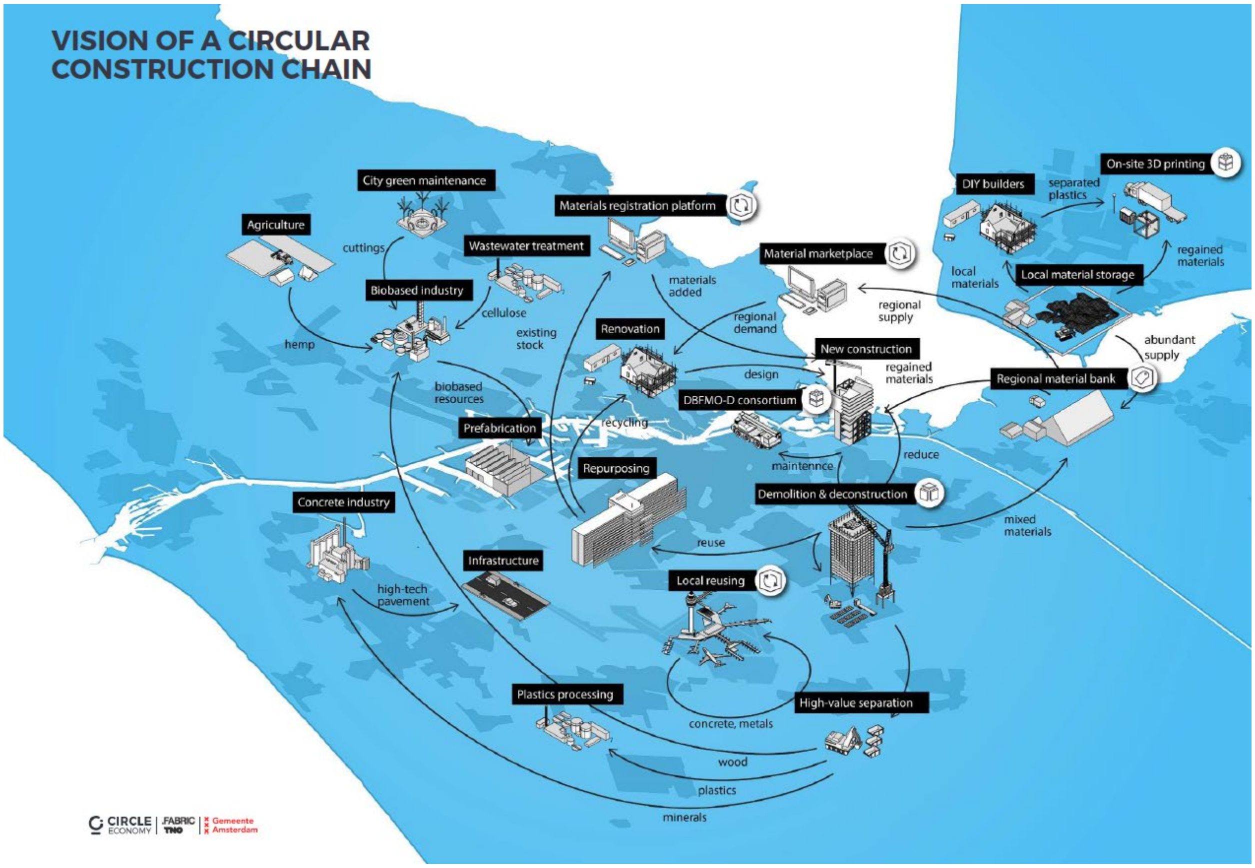

Fig 4.1: Circular Amsterdam-Construction chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

[65] Buildings (2009). The Challenges and Benefits of Mixed-Use Facilities. http://www.buildings.com/article-details/articleid/9004/title/the-challenges-and-benefits-of-mixed-use-facilities.aspx

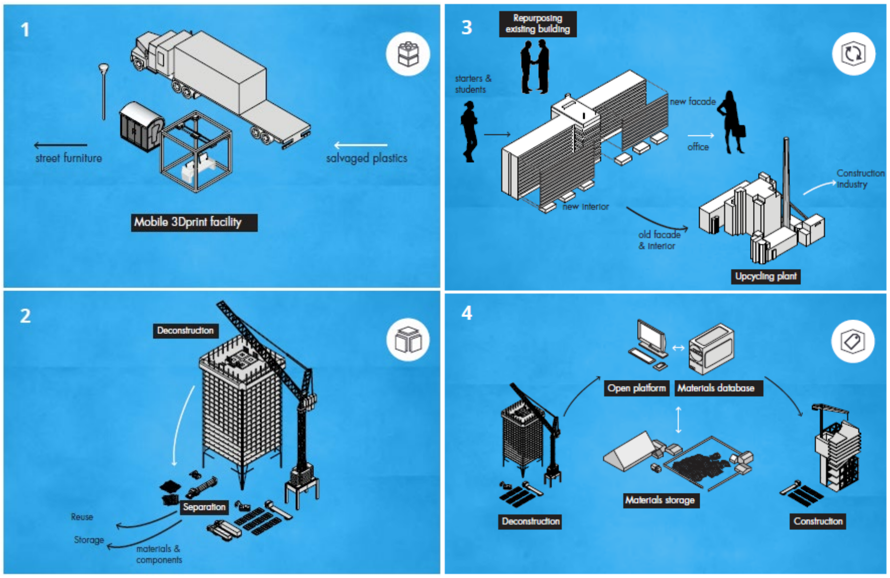

Fig 4.2: Circular Amsterdam-Construction chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

From the vision described for the construction chain, they developed strategies and action items which enable the municipality to close the material cycles in the construction chain.

1. Smart design Smart design of buildings so that they are better equipped when their purpose changes and so that materials can be reused.

2. Dismantling and separation Efficient dismantling and separation of waste streams to enable high value reuse.

3. High-value recycling, high-value recovery and reuse of materials and components.

4. Marketplace and resource bank the exchange of resources between market players to enable the reuse of materials in new buildings.

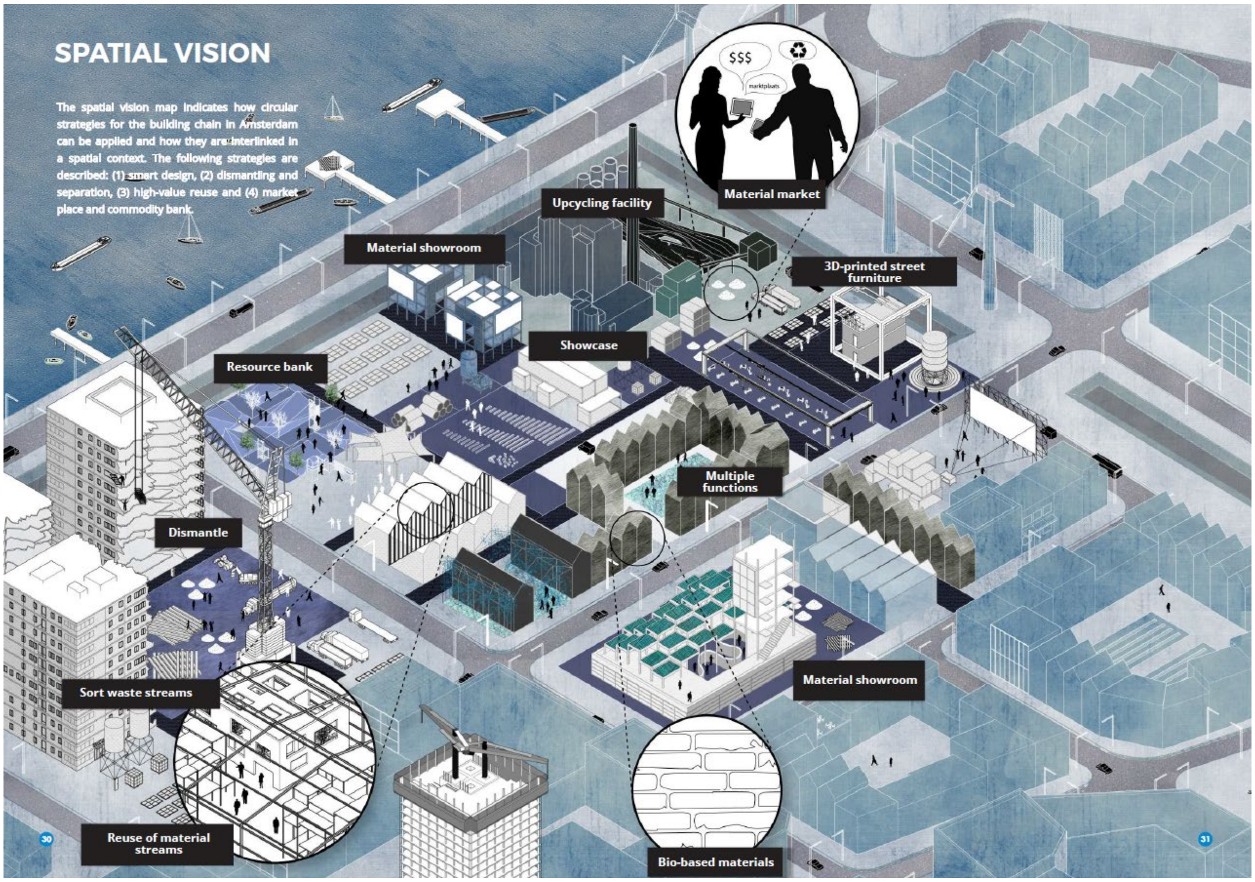

Fig 4.3: Circular Amsterdam-Construction chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

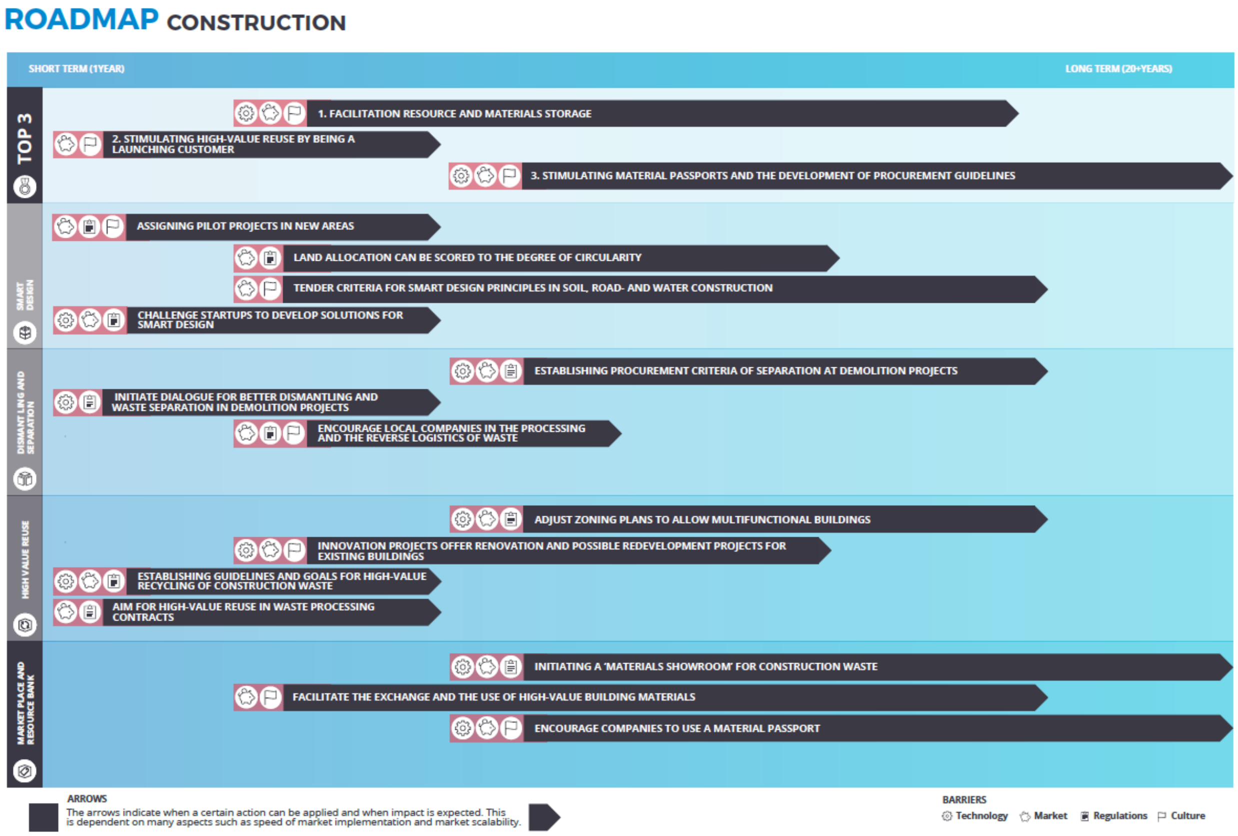

Fig 4.4: Circular Amsterdam-Construction chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

The goals and objectives of building a circular Amsterdam aligns with the United Nations Sustainable Development Goals.

In 2015, the city commissioned an economic scan to understand the flow of materials and the potential economic and environmental benefits of keeping these materials in higher value uses.[66] This resulted in job creation, lower greenhouse gas emissions and waste disposal. This scan laid a roadmap for practical implementation of circularity in the city and the region.[67]

2. Organic residual streams chain

In the ideal circular future of organic residual streams in Amsterdam, organic flows such as food and water of the highest quality are delivered to consumers. Organic residues are recovered in a high value manner and reused in innovative applications. Core to this circular vision is integrated food

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[66] Schoenborn, J. (2012). A Case Study Approach to Identifying the Constraints and Barriers to Design Innovation for Modular Construction. http://scholar.lib.vt.edu/theses/available/etd-05082012-010848/unrestricted/Schoenborn_JM_T_2012.pdf

[67] Bastein, A.G.T.M., Jacco Verstraeten-Jochemsen, Elmer Rietveld, Maria Hauck, Edgar Frijters, Olv Klijn and B. Driessen. "Circular Amsterdam. A vision and action agenda for the city and metropolitan area." (2016).

production, food processing and biological processes, where nutrients and water flows are efficiently directed, and residual flows are valorized. This leads to a more varied chain of organic residual streams that requires less energy, nutrients, water and resources and achieves significant economic, environmental and social benefits.[68]

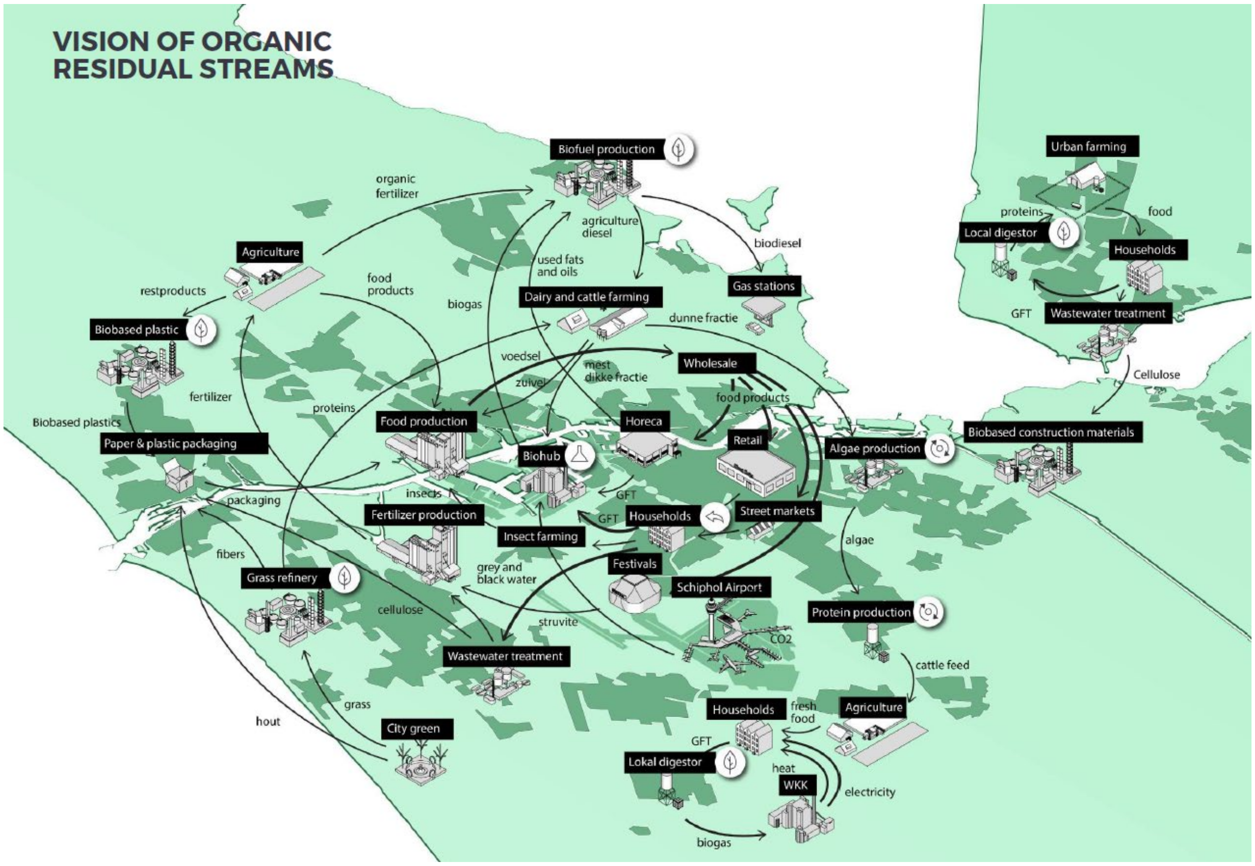

Fig 4.5: Circular Amsterdam-Organic Residual chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

This image is an example of Amsterdam, one of the first cities in the world to adapt this approach. In a circular future, consumers have easy access to local food sources. Local, cooperative farms and breeders in the vicinity of cities will ensure the direct supply of fresh seasonal produce to consumers. The food chain will, therefore, be shorter, with more interaction between local growers and citizens resulting in a greater sense of community. By using underutilized city, roof and community spaces in a smart way for urban agriculture and city gardens, consumers get much easier and closer access to fresh food.[69]

[68] Circle Economy (2014a). Circle Scan: Current state and future vision Agri & Food Sector. https://www.rabobank.com/en/images/03-07_CE_Rabobank_AgriFood_Circle_Scan.pdf
[69] Jansma et al. (2015). Urban agriculture and local food production: feeding our cities future. https://www.wageningenur.nl/upload_mm/3/0/d/bd72e939-609f-4cb3-afa9-c8c4c61aa26e_UrbanAgriculture_small.pdf

Spurred by a culture of production, consumption and disposal, resources flow in and out of a city in an exploitative and unsustainable linear model.[70] The constant extraction, processing, and waste produces a host of environmental and human injustices, resulting in the dramatic reshaping of our planet due to global climate change. The circular economic model offers an alternative to this "take, make, waste" system. The circular economic model is regenerative and restorative by design, keeping resources in use at their highest value for as long as possible. This model builds upon three core principles:

- design out waste and pollution.
- keep products and materials in use for as long as possible and
- regenerate our natural systems to improve the environment.

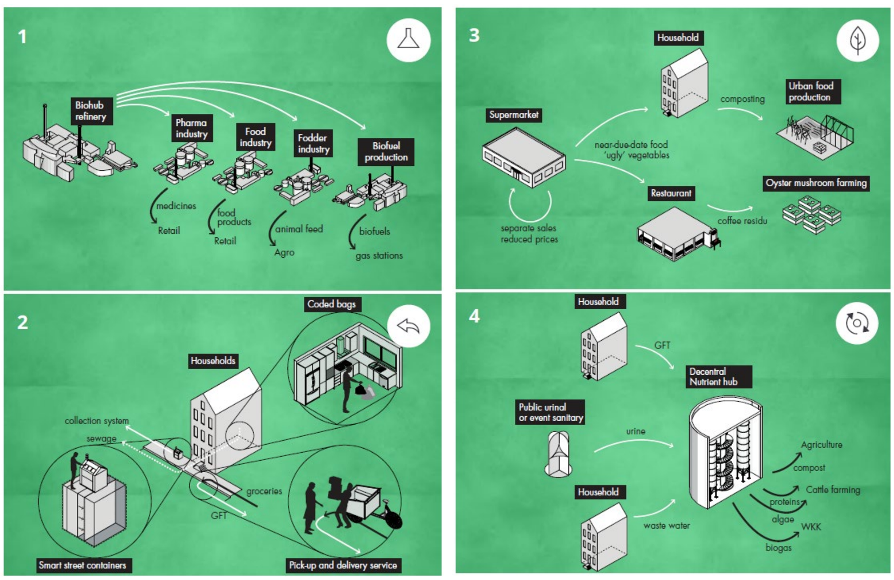

Fig 4.6: Circular Amsterdam-Organic Residual chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

From the described vision for high-value recycling of organic residual streams, they developed strategies and action items, such as land allocation and purchasing, to close material cycles in the organic residual streams chain.

The strategies are:

1. Central bio-refinery hub
2. Waste separation and return logistics
3. Cascading of organic flows

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[70] Circle Economy (2014a). Circle Scan: Current state and future vision Agri & Food Sector. https://www.rabobank.com/en/images/03-07_CE_Rabobank_AgriFood_Circle_Scan.pdf

4. Recovering nutrients

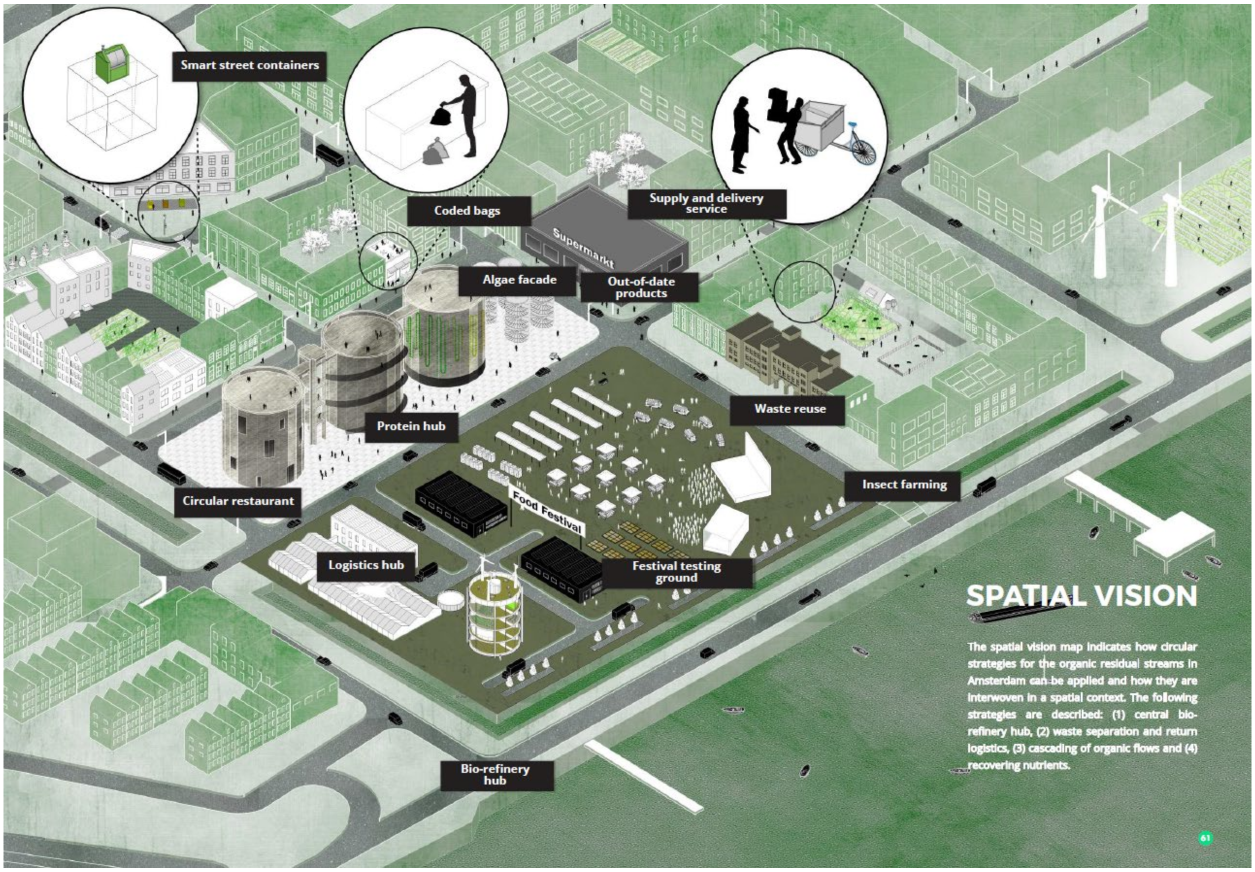

Fig 4.7: Circular Amsterdam-Organic Residual chain

Image source: https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam

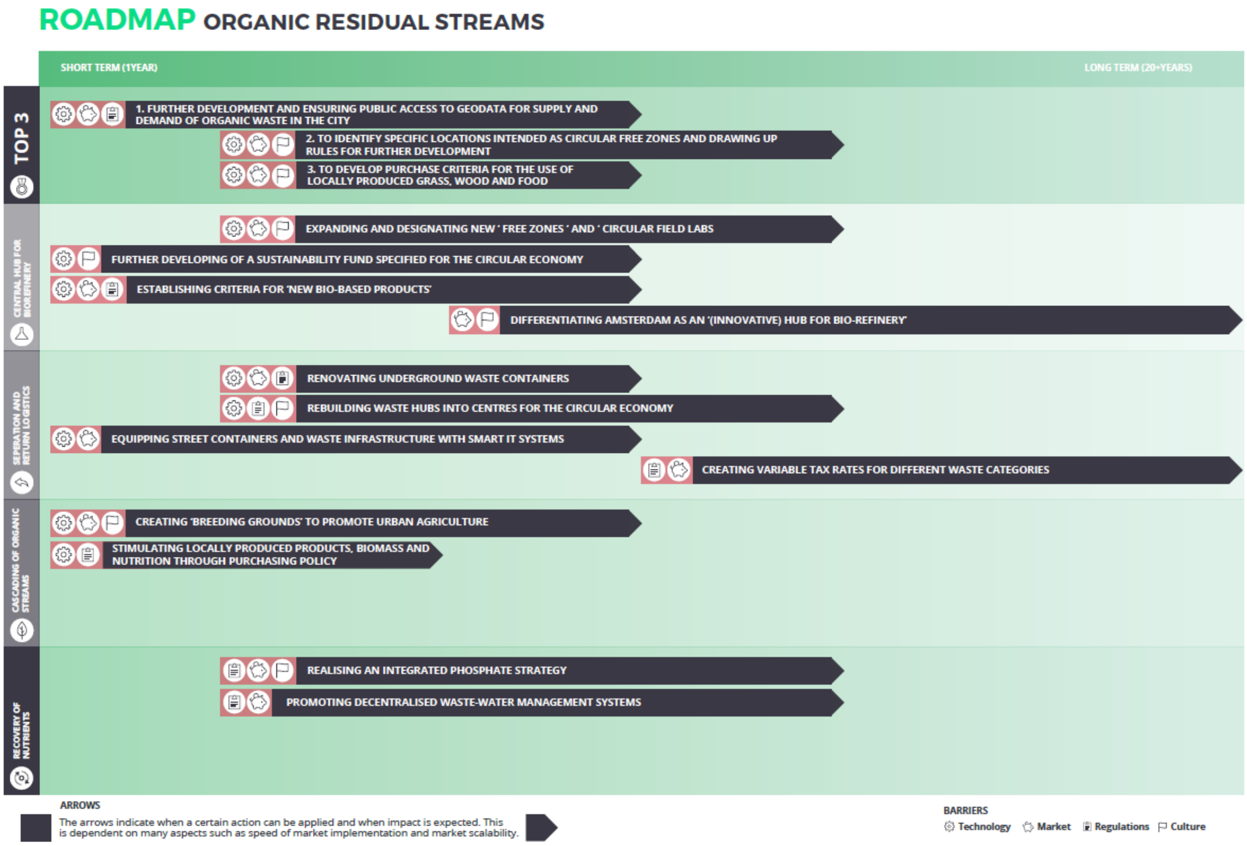

Fig 4.8: Circular Amsterdam-Organic Residual chain

Image source: *https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam*

The roadmap and action agenda presented in this Quick Scan offer a starting point, giving concrete direction to the ambition, vision and agenda on the theme of a circular economy for two specific value chains – construction and organic residual streams. This was presented to the municipality, which can focus on expanding the details of these plans as a next step. Stakeholders, both within the government and in the market, will need to be engaged to act on the proposed directions.

4.2.SUSTAINABLE DEVELOPMENT GOALS BY UNITED NATIONS

The goals and objectives of building a circular city align well with the sustainable development goals by united nations to create sustainable and resilient cities. The circular approach is meant to increase the efficiency and effectiveness of city assets and products by extending their components utilization and lifetime.[71]

[71] https://sdgs.un.org/goals

The SDGs are a set of 17 Goals developed and unanimously adopted by all 193 member countries of the United Nations, to be achieved by 2030.

Fig 4.9: UN Goals

Image source: https://sdgs.un.org/goals

4.3.SAN FRANCISCO CIVIC CENTER

Civic Center Historic District comprises a roughly 58-acre and 15-block part of San Francisco that has multiple historic designations. It was designated locally as a San Francisco Landmark District in December 1994. Most of the city's major government and cultural institutions are in the Civic Center Historic District including City Hall, San Francisco Public Library and the War Memorial Complex.[72]

The proposal for the Civic Center addresses the following goals:

- Goal 6: Clean water and sanitation
- Goal 7: Affordable and clean energy
- Goal 11: Sustainable city and communities
- Goal 13: Climate action

[72] https://generalplan.sfplanning.org/index.htm

Fig 4.10: San Francisco Civic Center

1. Water[73]

Existing water system

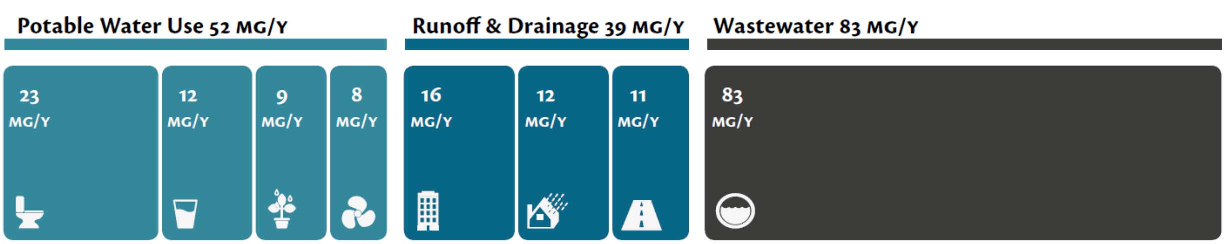

Fig 4.11: San Francisco Civic Center existing water use

- Potable water supplies are delivered to the Civic Center via the Hetch Hetchy Regional Water System (160 miles east of San Francisco), and only used once.
- The sewer system is a combined sewer system, where wastewater from buildings, stormwater from streets and rainwater from roofs are all conveyed to the treatment system without being used.

[73] Murphy, Nathan. Bay Bridge. Digital image. Flickr. Flickr. Web. 12 JUN 2015. <https://www.flickr.com/photos/atomicllc/9454103828>.

- Currently, water is supplied to a variety of end uses and wastewater is removed via the combined sewer system.

Proposed water system

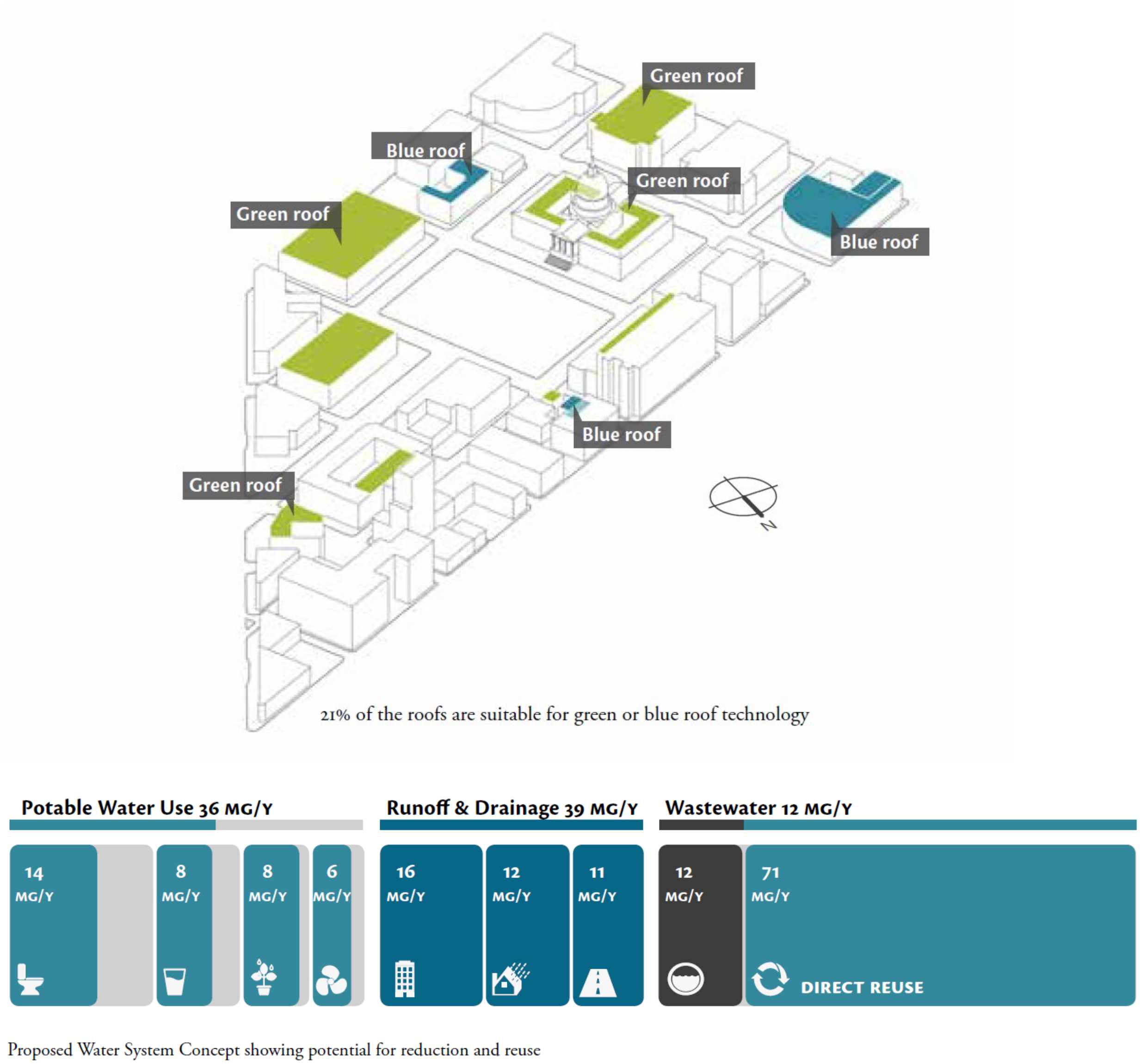

Fig 4.12: San Francisco Civic Center proposed water use
Image source: https://sdgs.un.org/goals

- Manage stormwater within the district
- Minimize potable water demand and replace with onsite recycled water
- Treat wastewater as a valuable resource.

The existing water system in the neighborhood is portable water delivered from 160 miles away and used only once. The sewer system is a combined sewer system, where wastewater from buildings, stormwater from streets and rainwater from roofs are all conveyed to the treatment system without being used. The strategies that were proposed to Achieve Long Term Vision were:[74]

- Utilize green and blue roofs to minimize roof runoff.
- Implement green streets to reduce flows to the combined sewer.
- Manage additional stormwater in open spaces such as a newly created park within Fulton Street.
- Treat on-site wastewater for potable reuse by using technology.

2. Energy

Fig 4.13: San Francisco Civic Center solar roof

Existing energy system

- Most of the energy is generated outside of the district.
- There is a large reliance on fossil fuels to energize the power and gas grids.
- Knowledge and control over energy production methods and materials is not possible.
- No integration of local sustainable energy feedstocks.
- Power supply is susceptible to significant interruptions during natural disasters.

[74] SFPUC. Accessed November 9, 2024. https://www.sfpuc.gov/sites/default/files/about-us/policies-reports/CivicCenterSustainableDistrictPlan.pdf.

PROPOSED ENERGY PORTFOLIO

	Contribution (%)	Energy (MW)	
Biomass Thermal Conversion	50%	2.0	60 tons/day of biomass, plastic, paper, etc.
Future Solar and Wind Energy	25%	1.0	Approximately 2 acres roof area and ½ acre of pedestrian rain and shade covers
Existing Solar Energy Installed	10%	0.4	0.65 acres of roof area for solar
Heat Energy Recovery Loops	12.5%	0.5	Sewer heat and flue mining, combined heat and power, passive solar
Anaerobic Digestion	2.5%	0.1	Wastewater energy potential for 0.5 M people
Total	**100%**	**4.0 MW**	

Fig 4.14: San Francisco Civic Center proposed energy use

Proposed energy system

- Create efficient systems and management strategies to reduce demand.
- Retrofit buildings with advanced energy controls.
- Provide building occupants with education and continuous feedback.

The current power system in the Civic Centre[75] is typical of large cities where electrical energy and natural gas are supplied for heating water and running electrical equipment and devices. Electrical energy is, for the most part, produced outside of San Francisco and delivered via electrical transmission lines to substations throughout the city. The strategies that were proposed to achieve the long-term vision are:

1. Create efficient systems and management strategies to reduce demand.
2. Retrofit buildings with advanced energy controls.
3. Provide building occupants with education and continuous feedback.

SFPUC has been performing extensive energy efficiency evaluations and retrofits for 11 of the buildings in the area. These investments, retrofits and educational efforts have increased the efficiency of the buildings by approximately 20%. This has reduced the annual energy consumed by about 4.5 MWh while shaving peak demand by 834 kW.[76]

[75] SFPUC Stock Photos. City Hall South Side Roof Solar Installation. 2015.
[76] SFPUC. Accessed November 9, 2024. https://www.sfpuc.gov/sites/default/files/about-us/policies-reports/CivicCenterSustainableDistrictPlan.pdf.

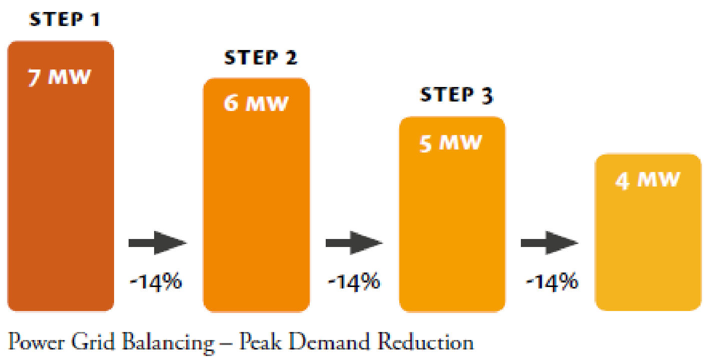

Fig 4.15: San Francisco Civic Center proposed energy use

The graph above shows how demand can be reduced during peak hours by power grid balancing, creating solar field in stages over roof tops over a period.

3. Sustainable Utilities District

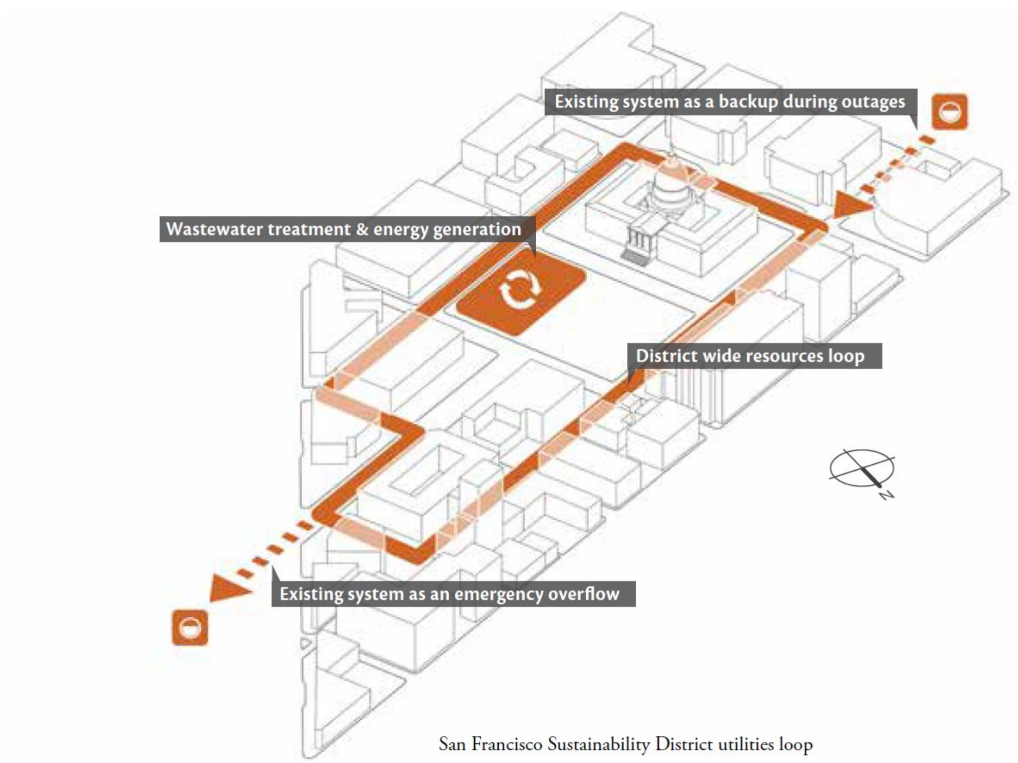

Fig 4.16: San Francisco Civic Center flow of resources

The District Plan looks at sustainability first in terms of the environmental impacts of the utilities that provide energy, water, wastewater, stormwater and solid waste services for the buildings and the public realm within the district. The idea to achieve sustainability was through decentralization, where production, consumption and management of resources can happen in small scale at parts of neighborhood rather than one large scale model.

Objectives created:

- Zero Water – Replace the use of imported potable water with local water resources.
- Zero Wastewater – Treat and use wastewater and manage stormwater onsite.
- Zero Energy – Achieve net-zero imported energy use and carbon emissions through conservation and onsite generation from renewable, local resources.

The advantages of decentralized treatment and supply systems over centralized systems are: Decentralized systems allow for efficiencies that would not be possible in a large-scale system. Decentralized systems provide opportunities for reduction in infrastructure costs. Costly upgrades to the existing utility system can sometimes be avoided by the installation of smaller, localized schemes. Decentralized systems make users more aware of environmental impacts and local resources are more visible and therefore more likely to trigger a local response.[77]

4. Climate action

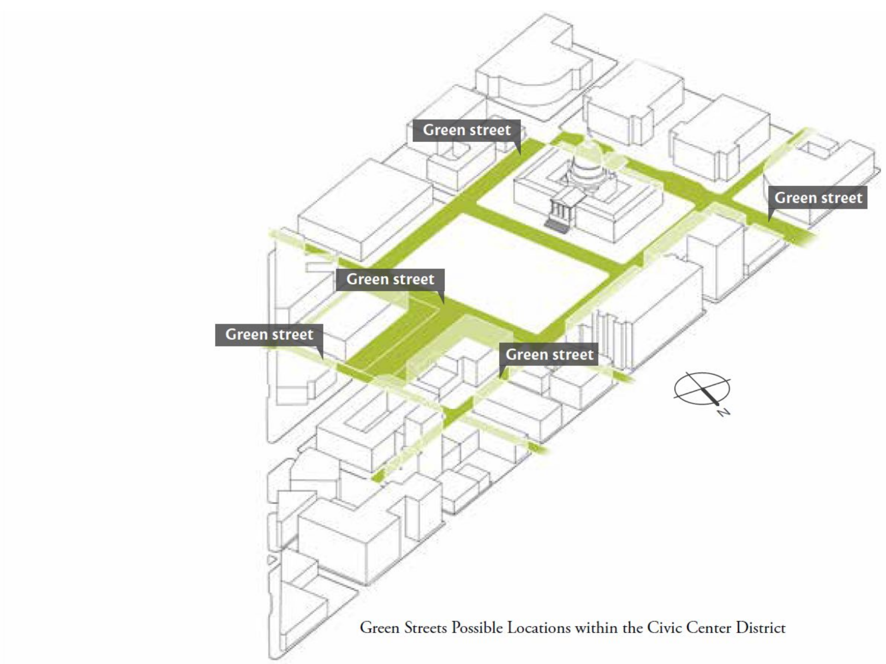

Fig 4.17: San Francisco Civic Center climate action

Proposed ideas

- Maintain the District's wide-open spaces and expansive character.

[77] SFPUC. Accessed November 9, 2024. https://www.sfpuc.gov/sites/default/files/about-us/policies-reports/CivicCenterSustainableDistrictPlan.pdf.

- Utilize green infrastructure improvements as a catalyst to bring nature to the district.
- Transform the Fulton Street corridor into an urban green space.
- Engage visitors with a daylit reach of Hayes Creek.
- Weaving in visible stormwater management systems, energy production, and resource conservation.
- Incorporate opportunities for urban agriculture.

The Civic Center Sustainable Utility District is also intended to serve as model for potential future sustainability improvements elsewhere in San Francisco and beyond. In this way, the impact of actions taken in the Civic Center area can have an even greater impact on how our society addresses and adapts to global climate change.[78]

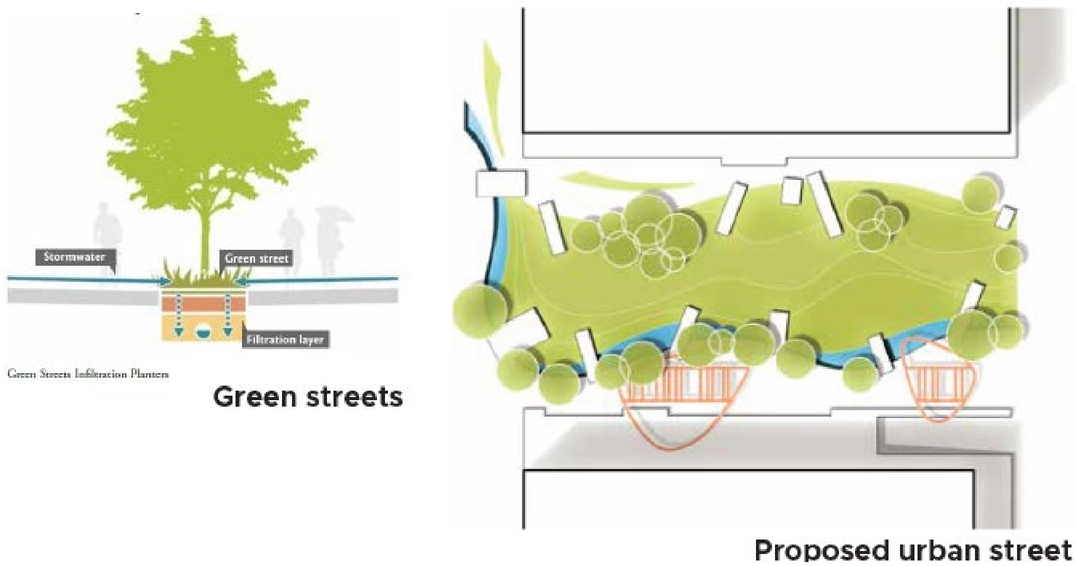

Fig 4.18: San Francisco Civic Center green streets

4.4.MODEL SPACES BY SPUR REGIONAL AND AECOM

Fifty years from now, everyone can find a place to live in the San Francisco Bay Area. The proposal values long-time residents and welcome newcomers from around the world. The proposal aims to protect what is precious and still find ways to grow. To grow by making great places for people to live and work.[79]

[78] Gollings, John. Central Dandenong Lonsdale Street Redesign and Upgrade. Digital image. BKK Architects. Black Kosloff Knott Pty Ltd. Web. 12 JUN 2015

[79] Model Places: Envisioning a future Bay Area with room and opportunity for everyone, SPUR Report September 21, 2020

In this proposal, San Francisco Bay Area Planning and Urban Research Association (SPUR) and Architecture, Engineering, Construction, Operations, and Management (AECOM) have come together to envision a Bay Area where: Everyone is housed and has access to quality public amenities.

- People of color are safe and welcome in streets and public spaces.
- Commuters have time for family and community life.
- Elders get out and about with family and friends, aging in community.
- Kids walk to school together, expanding their sense of self and sense of place.
- Teens set off on bikes or on foot to creeks, lakes, beaches and parks.
- All kinds of families, in all types of homes, live in community together.

Today, the Bay Area is home to 7.6 million people, in 2.8 million housing units and 3.7 million jobs. But over the next 50 years, these numbers are expected to increase by as many as 4 million people and 2 million jobs.[80]

The six Model Places described here demonstrate that, if each place does its part, the Bay Area has plenty of room to grow while preserving open space and addressing its protracted housing shortage. This report also shows how accommodating new growth can enable existing areas to become better places for people, retaining many of their essential qualities while supporting diversity and inclusion, public health, green mobility and community life. [81]

Model Spaces - Industrial spaces

This place type represents the lowest density among areas with jobs and includes land used for transportation and utility infrastructure. It is most often found along the bay's edge, where it was built on filled Baylands near the highway and freight rail infrastructure. As a result, it tends to occupy low-lying areas that will be subject to regular or permanent flooding with sea level rise.

[80] Model Places: Envisioning a future Bay Area with room and opportunity for everyone, SPUR Report September 21, 2020

[81] Model Places: Envisioning a future Bay Area with room and opportunity for everyone, SPUR Report September 21, 2020

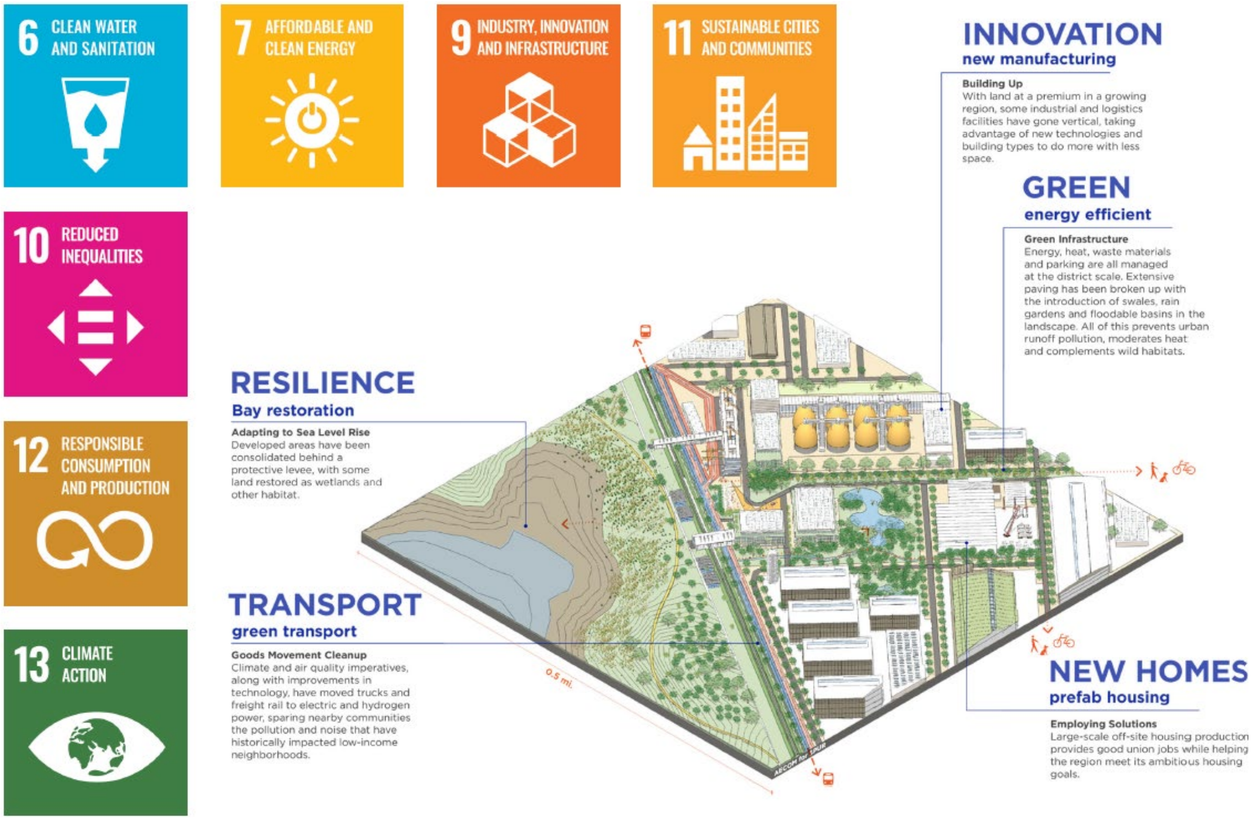

Fig 4.19: Model Spaces Industrial zones

Assets of the existing space

- Source of low- and middle-skilled jobs
- Abundant, underutilized, flexible and often affordable land
- Large lots often under single ownership
- Wide range of economic and logistical support functions

Challenges

- Low densities
- Often vulnerable to coastal / groundwater flooding and sea level rise
- Car-dependent; not served by transit
- Very limited amenities and services
- Large, paved areas that produce heat and stormwater runoff
- Environmental pollution

Proposals for the industrial zones in the bay area

- To address pressure from both climate hazards and conversion to other uses, industrial land will need to get smarter, denser and greener.

- Stormwater management through green infrastructure.
- Parking and transportation demand management (TDM) at the district scale.
- Green energy production and resilient micro-grid distribution.
- District heating, cooling and cogeneration.
- Solid waste composting and recycling.
- Scalable solar energy production on industrial buildings through third-party providers.
- Green stormwater management through landscaping, swales and infiltration basins that capture runoff from the large impermeable surfaces.

Model Spaces – Dense Urban spaces

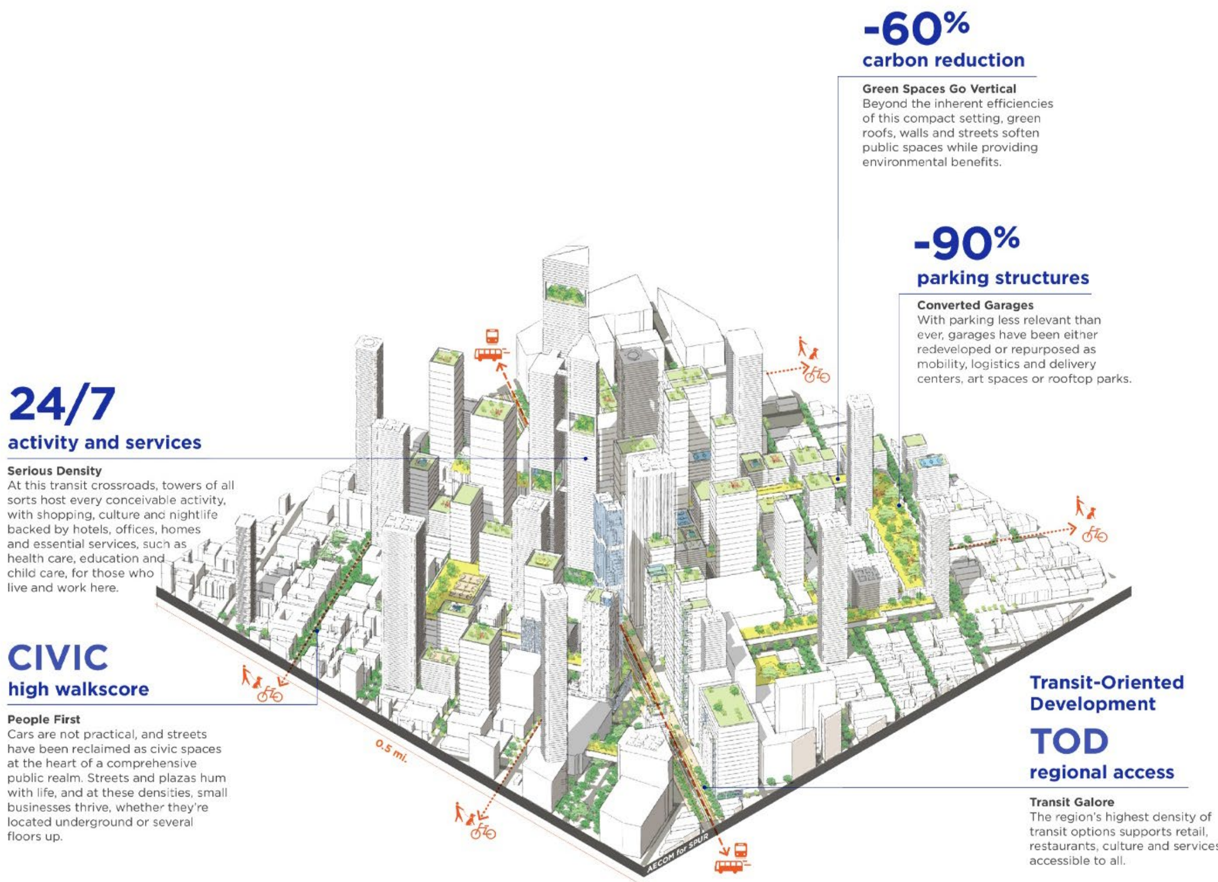

Fig 4.20: Model Spaces Dense urban spaces

Model Spaces – Cul-de-Sac Suburbs

While the quiet character remains, retirees, young adults and others have moved into a diversified housing stock, and basic services are available within a short walk or bike trip. New forms of transportation provide real alternatives to the car, while paths and greenways connect to a regional trail network for both commuting and exploring outdoors. Kids and seniors are out on local streets, which have been reclaimed as green spaces.

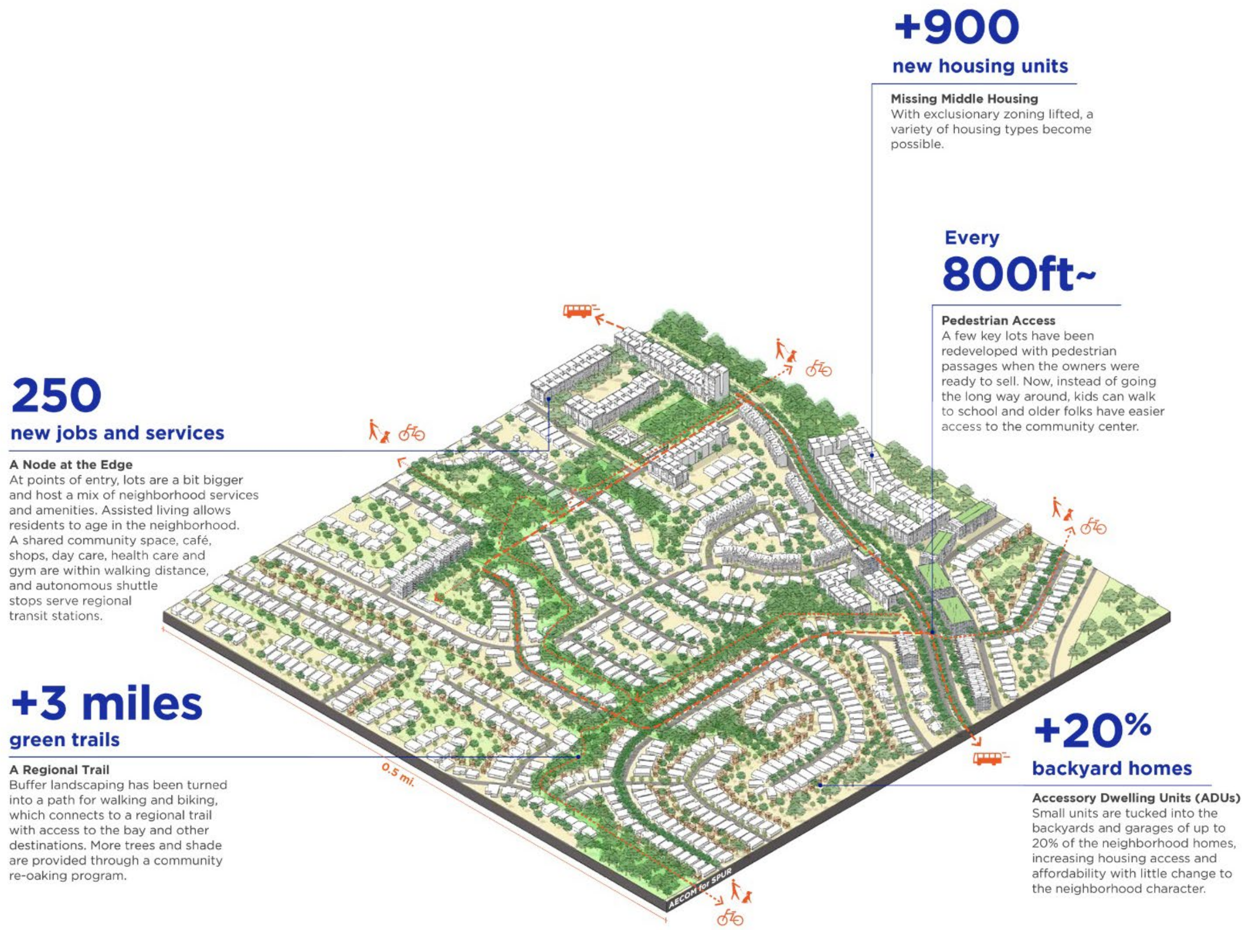

Fig 4.21: Model Spaces cul de sac

Model Spaces – Urban Neighborhood spaces

Communities are supported with the services and infrastructure they need, especially those whose residents are most vulnerable and at risk. Street designed for people, not cars, encourage walking, biking and other alternatives to the automobile. Public space is oriented towards the community, with funds from new development leveraged to support community selected projects and improvements. Development focuses on key corridors and routes to allow for rail and bus connectivity, enabling easy access to jobs and the rest of the Bay Area.

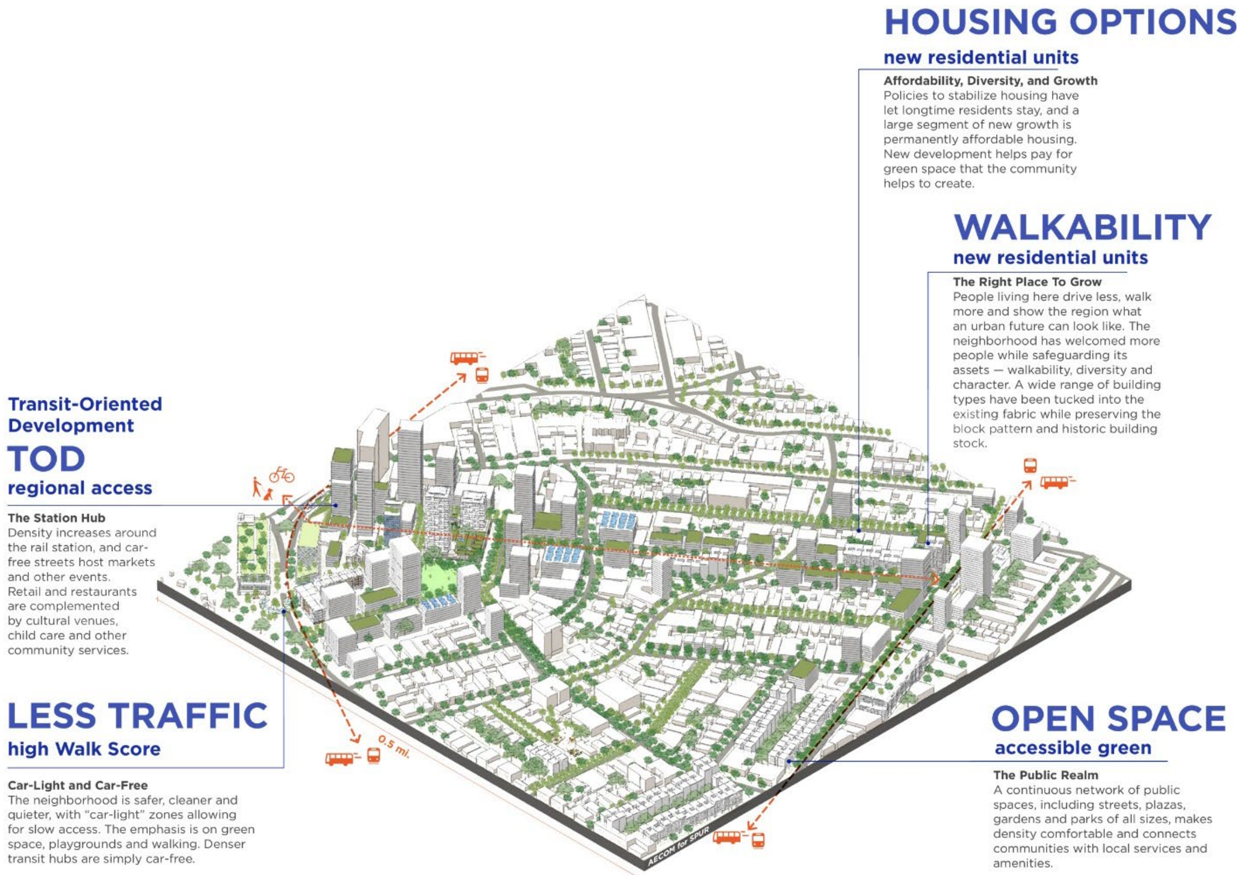

Fig 4.22: Model Spaces urban neighborhood

Model Spaces – Small Lot and Streetcar Suburbs

Fifty years from now, a small lot and streetcar suburbs welcome many more residents into a wider range of housing types, local services, transit options and open space. Small parcels and walkable blocks provide an ideal framework for a community built densely enough to meet basic needs on foot and bike. These areas still provide abundant green space while retaining the traditional fabric of some of the best periods of Bay Area development.[82]

[82] Model Places: Envisioning a future Bay Area with room and opportunity for everyone, SPUR Report September 21, 2020

Fig 4.23: Model Spaces suburbs

Model Spaces – Office Parks

Office parks retain the flexible, low-cost office buildings that businesses rely on, but add in complementary new uses and activities that enhance their economic and environmental performance. A variety of housing types introduce evening and weekend populations, allowing new amenities to thrive. Dining and services cluster near shuttle stops, serving both workers and residents and eventually justifying rapid transit links to the regional network. Parking, once the predominant land use, is gradually relocated to the outskirts while large, contiguous parcels allow for district-level, optimal environmental systems.[83]

[83] Model Places: Envisioning a future Bay Area with room and opportunity for everyone, SPUR Report September 21, 2020

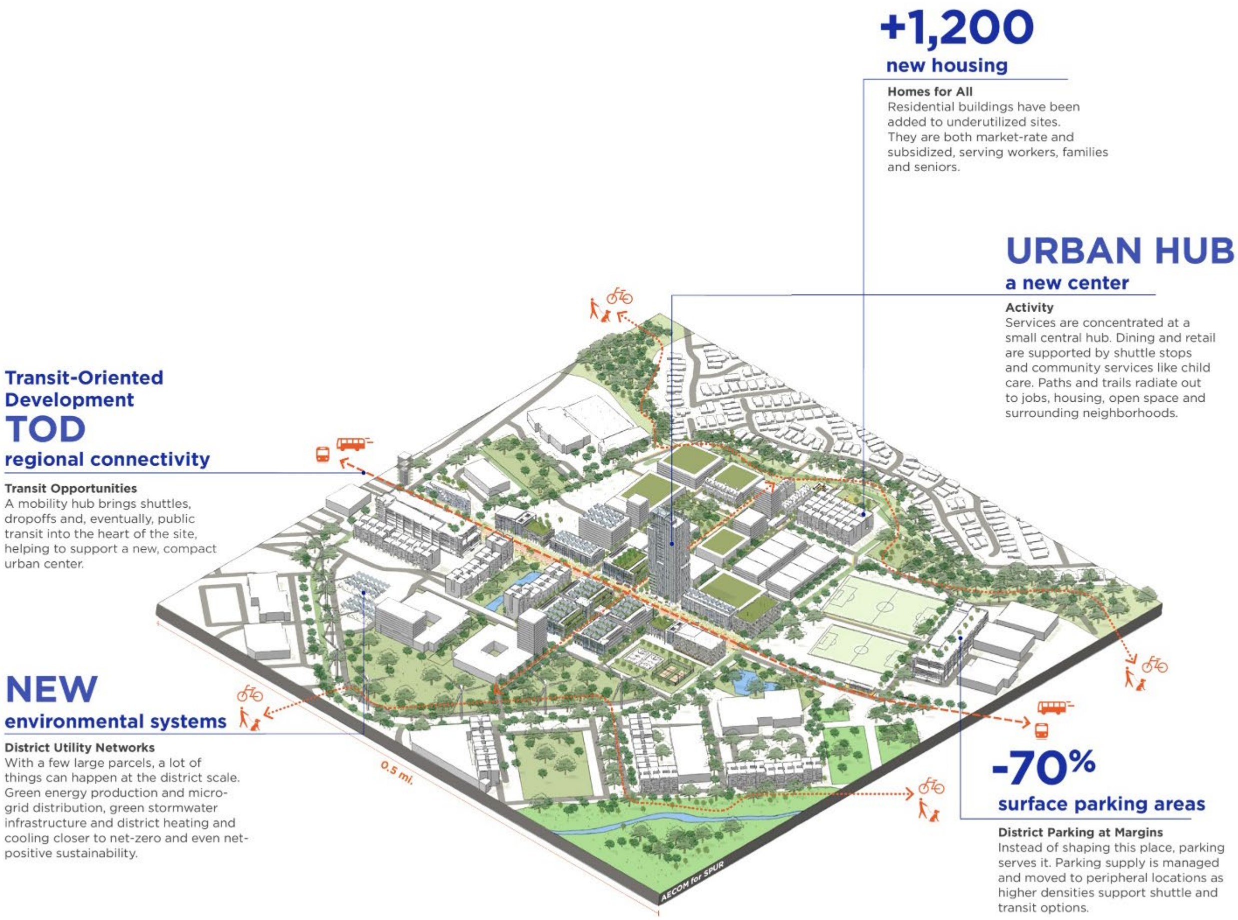

Fig 4.24: Model Spaces office spaces

CHAPTER 5: SAN FRANCISCO AS A CASE STUDY

5.1.THE CITY

San Francisco is one of the most innovative cities in the world in implementing new comprehensive approaches to urban sustainability. From its groundbreaking zero waste strategies such as the residential compost and green waste recycling program, to its energy efficiency and renewable energy programs, the city has been a leader in designing and implementing programs that work.

Fig 5.1: San Francisco
Image source: Google maps

5.2.INACCESSIBILITY TO FOOD IN SAN FRANCISCO

According to a report from San Francisco Health Improvement Partnership in 2019, Food Security, Healthy Eating, Active Living, Inadequate nutrition and a lack of physical activity contribute to 9 of the leading 15 causes of premature death in San Francisco. According to the San Francisco Food Bank, roughly one in five San Franciscans each day has no reliable source of fresh foods and must rely on food from soup kitchens, food pantries, or other community resources that have become a structural part of the city's food system.[84] Outside of these limited options, San Franciscans have limited means to purchase fresh, healthy foods.

Fig 5.2: Food Insecurity

A. Tracts in which at least 500 people or 33% of the population live farther than 1 mile from the nearest supermarket.

B. Tracts in which at least 500 people or 33% of the population live farther than 5 miles from the nearest supermarket.

C. Low-income tracts where a significant share of the population live farther than 1 mile from the nearest supermarket.

D. Low-income tracts where a significant share of the population live farther than 5 miles from the nearest supermarket.

[84] https://www.sfmfoodbank.org/fast-facts/

At least 889 neighborhoods in the Bay Area are considered to have “low food access.” Of those urban areas, 600 are found in the San Francisco metro area, while another 289 food deserts exist around San Jose.[85]

5.3.FOOD INSECURITY IN SAN FRANCISCO

- 50% of low-income residents surveyed in San Francisco report food insecurity.
- 20-30% of Black/African American and Latinx pregnant women are food insecure.
- 616, the number of people waiting for enrollment at a food pantry.

The USDA has designated ***Oceanview, Merced, Ingleside, Bayview Hunters Point, Visitation Valley, and Treasure Island Neighborhoods*** as areas of low food access.[86]

According to a report from San Francisco Health Improvement Partnership in 2019, Food Security, Healthy Eating, Active Living, Inadequate nutrition and a lack of physical activity contribute to 9 of the leading 15 causes of premature death in San Francisco.[87]

According to the San Francisco Food Bank, roughly one in five San Franciscans each day has no reliable source of fresh foods and must rely on food from soup kitchens, food pantries, or other Community resources have become a structural part of the city’s food system.[88] Outside of these limited options, San Franciscans have limited means to purchase fresh, healthy foods.

5.4.FOOD INSECURITY BY RACE

- 1 in 8 Californians currently struggle with food insecurity (defined by the California Association of Food Banks as the “occasional or constant lack of access to the food one needs for a healthy, active life”
- And this is even though California produces nearly half of the nation’s fruits and vegetables.
- While there is no shortage of good food, the downstream effects of inequitable distribution and consumer access and affordability impact on the qualities and quantities of available food, especially for lower income populations.[89]

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[85] https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/
[86] https://www.sf.gov/departments/department-public-health
[87] https://www.sfmfoodbank.org/
[88] https://www.sfmfoodbank.org/
[89] https://www.cafoodbanks.org/food-insecurity-data/

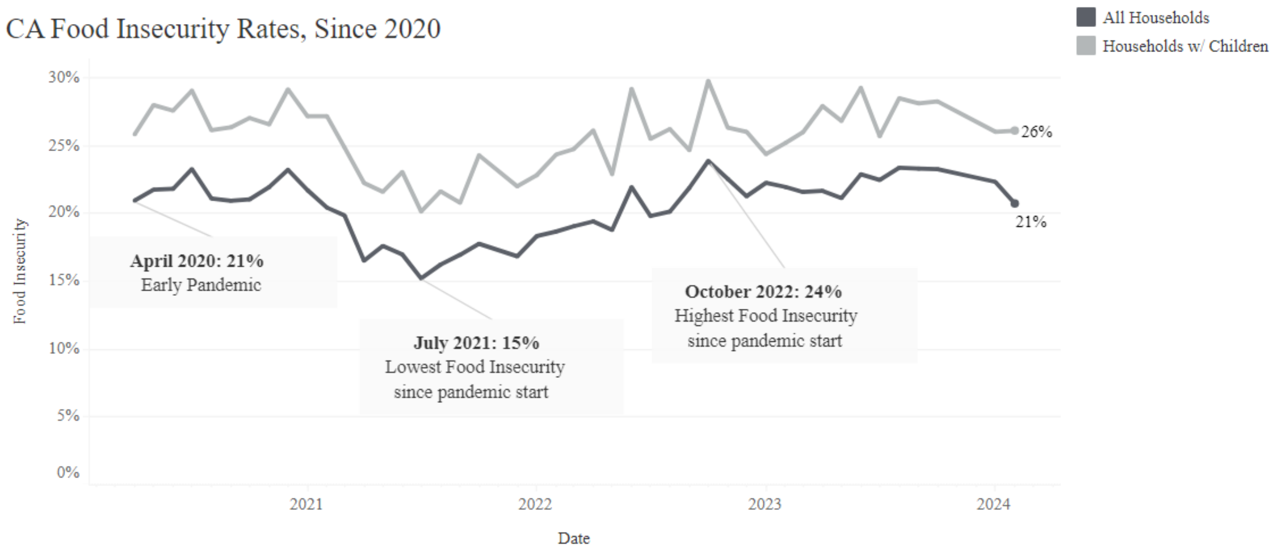


Fig 5.3: Food Insecurity

Image source: https://www.cafoodbanks.org/food-insecurity-data/

Although California produces nearly half of the nation's fruits and vegetables, in 8 Californians currently struggle with food insecurity. This is because of inequitable distribution, consumer access and affordability. The price of groceries in California costs $30 more per week than other states. This specifically impacts the lower income population.[90]

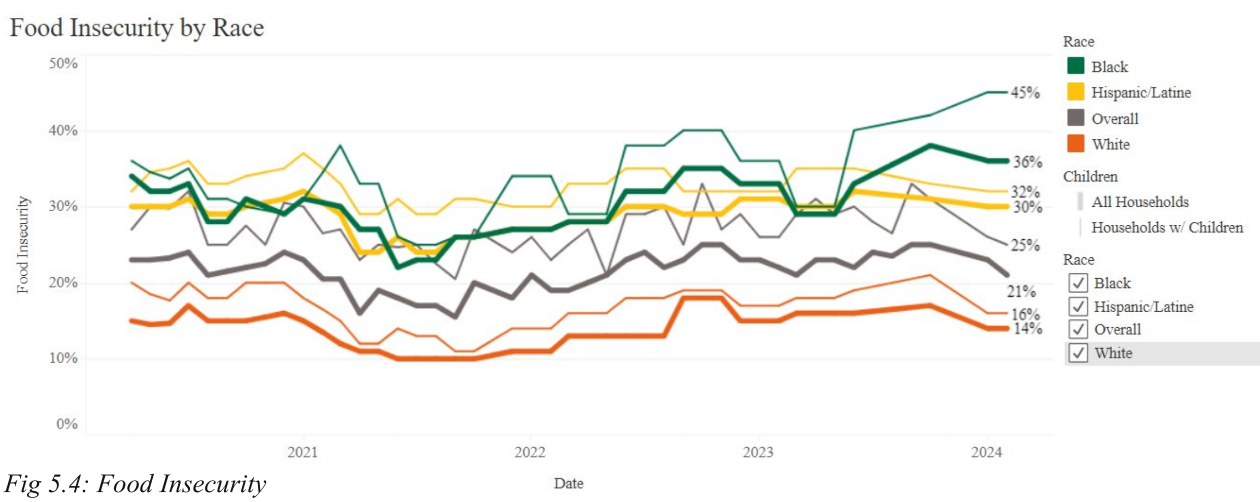


Fig 5.4: Food Insecurity

Image source: https://www.cafoodbanks.org/food-insecurity-data/

[90] https://www.cafoodbanks.org/food-insecurity-data/

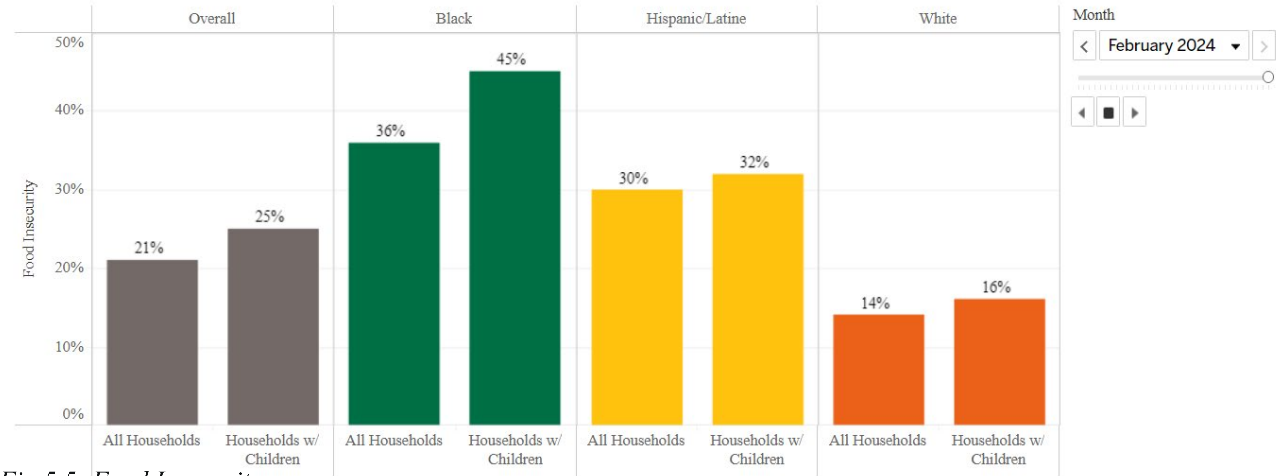


Fig 5.5: Food Insecurity

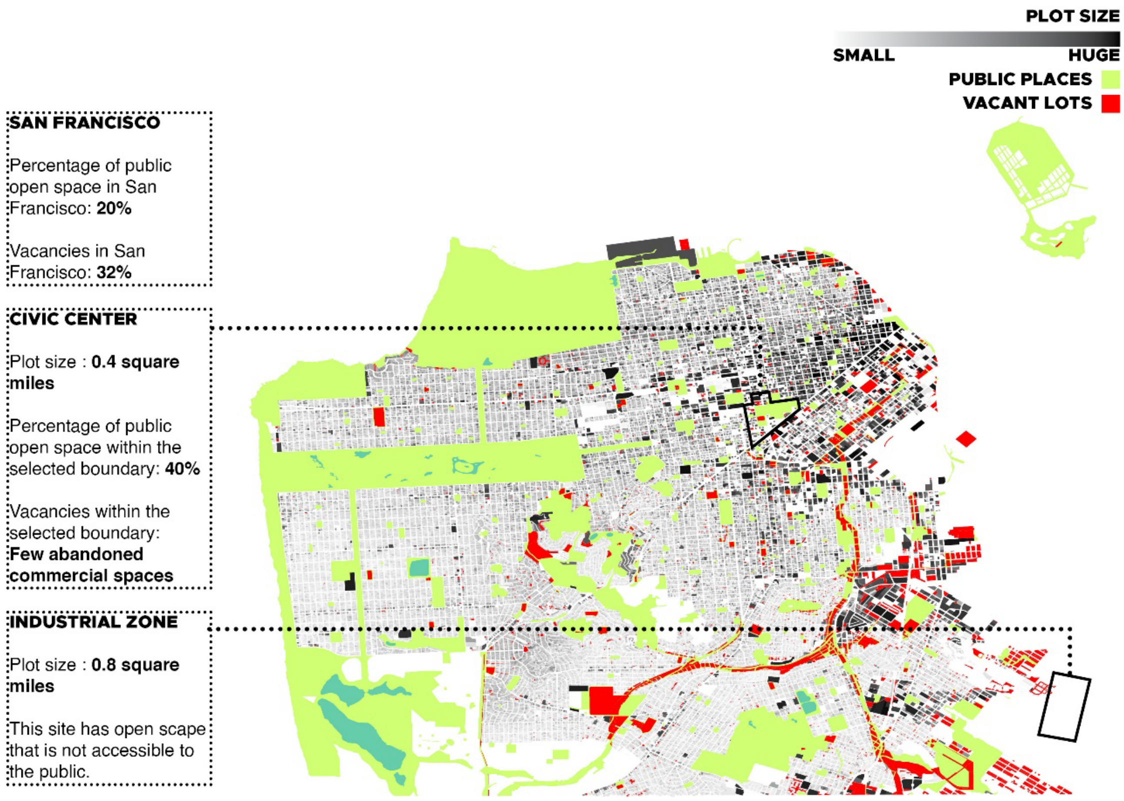
Image source: https://www.cafoodbanks.org/food-insecurity-data/

Out of the 26% of the population that lives in food deserts, at least 45% are households with children of the African American communities are food insecure in California as of February 2024, according to California Food Banks.[91]

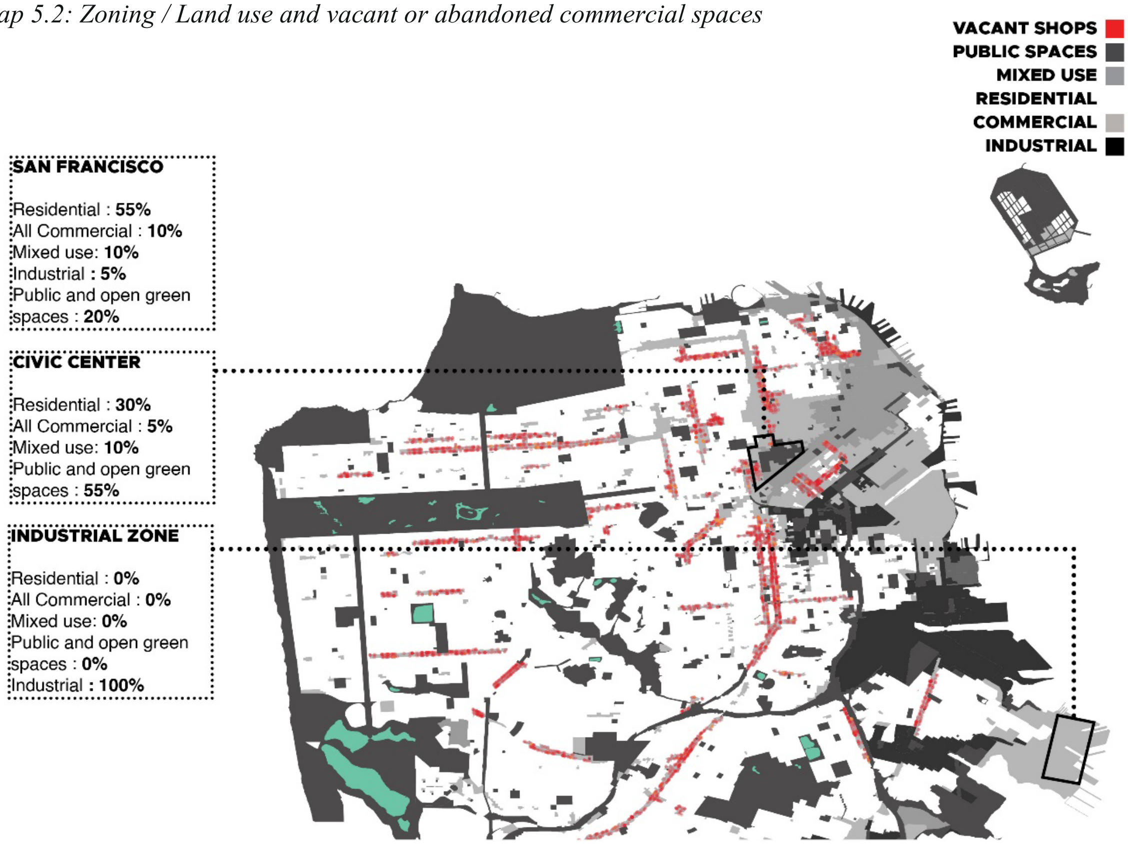
5.5.MAPS OF SAN FRANCISCO

[91] https://www.cafoodbanks.org/food-insecurity-data/

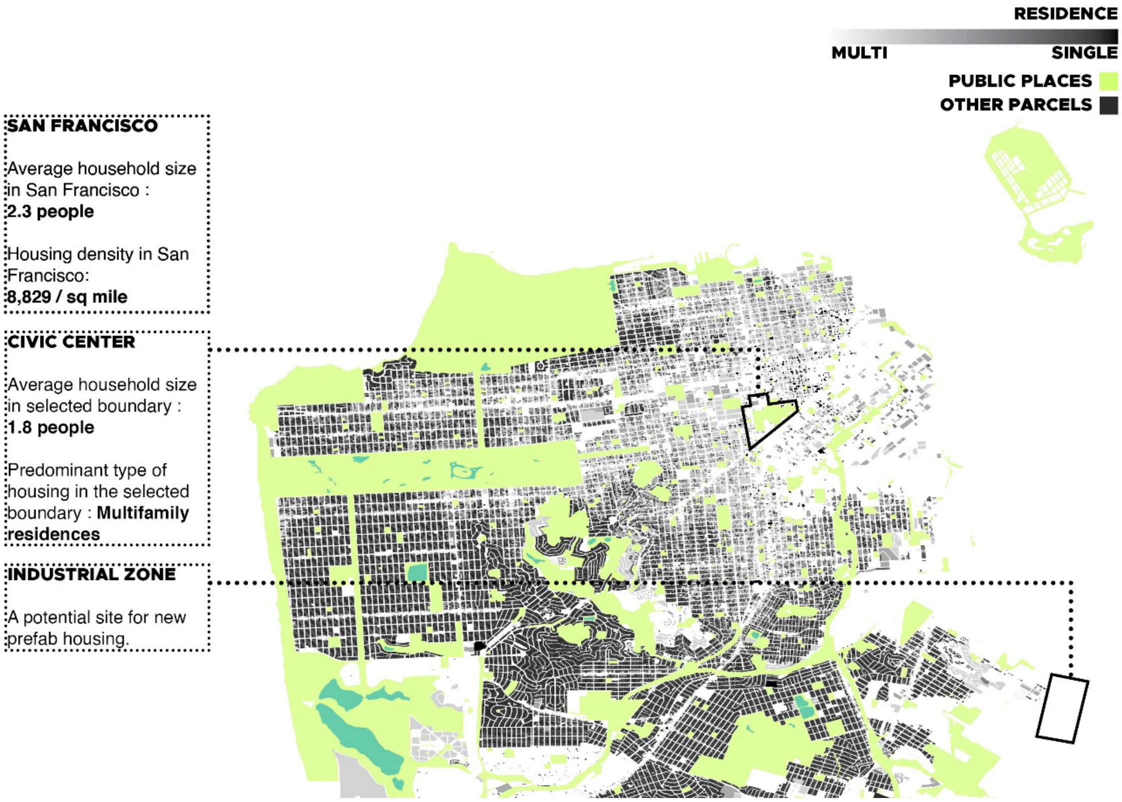
Map 5.1: Size of plots and vacant lots within the city



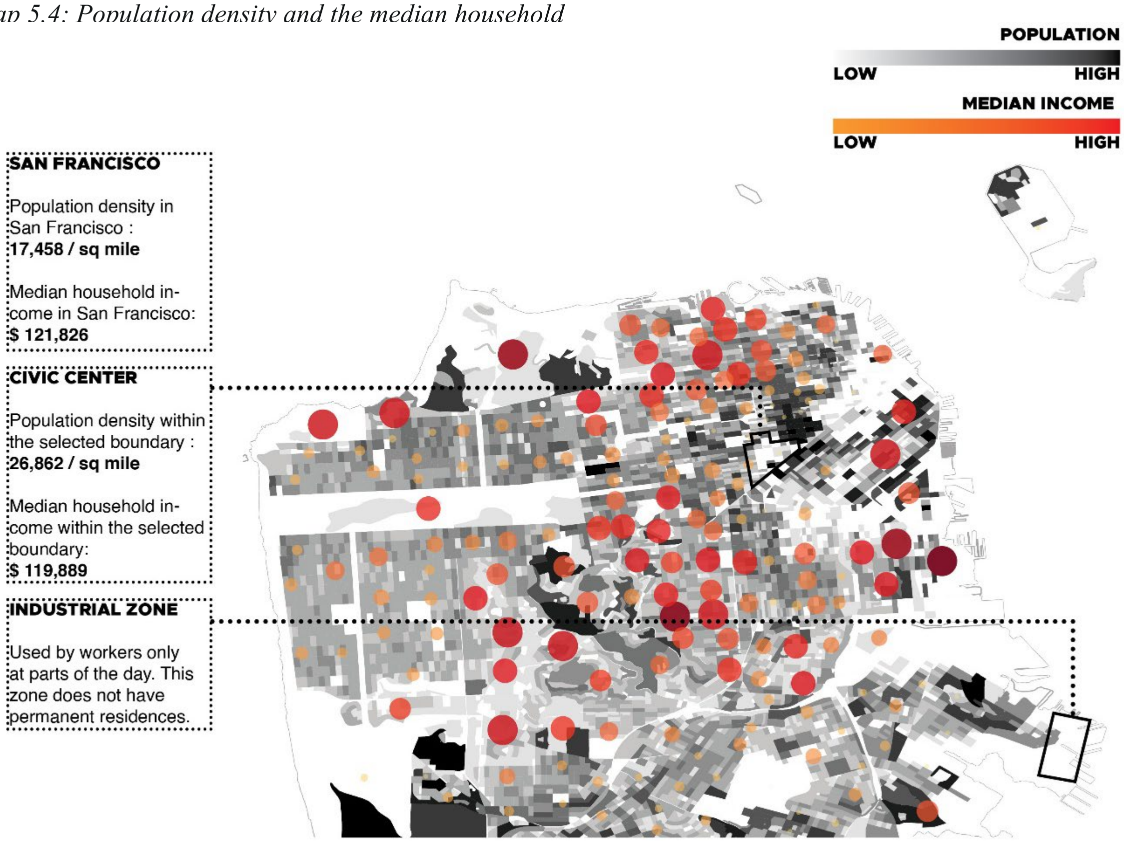
Map 5.2: Zoning / Land use and vacant or abandoned commercial spaces



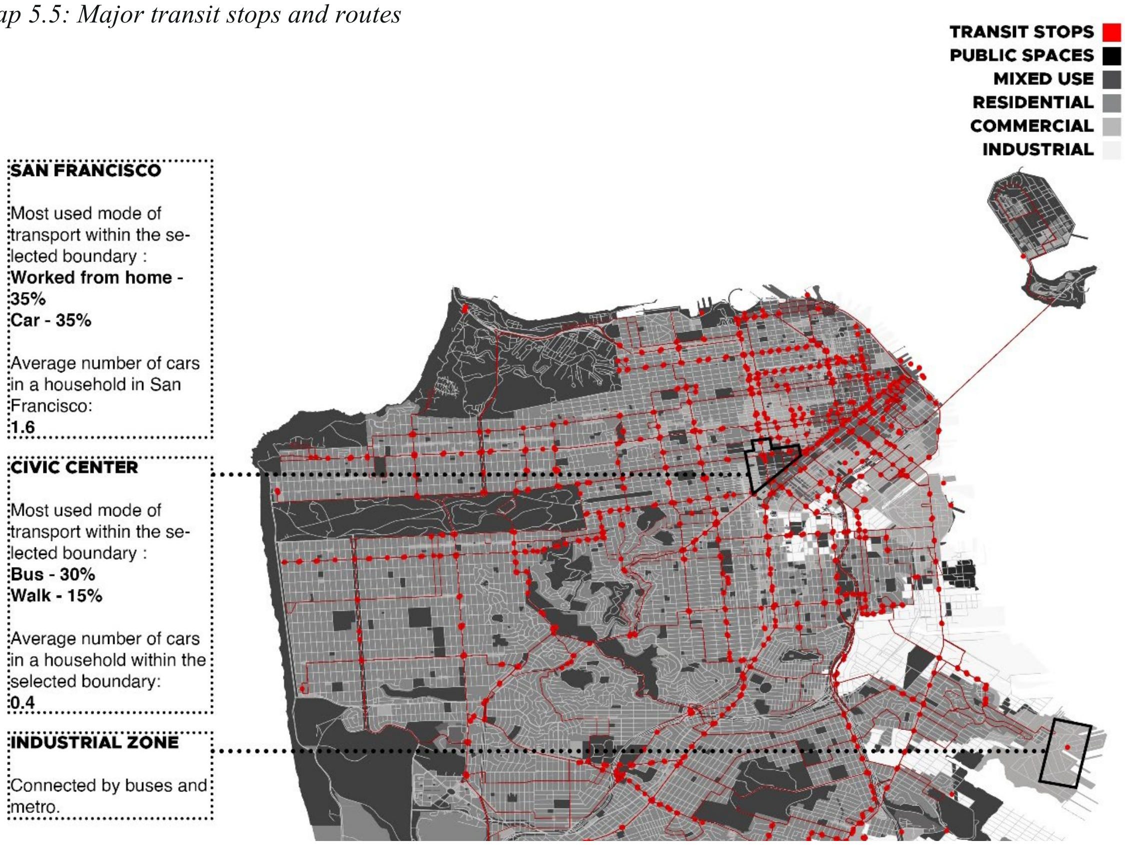
Map 5.3: Types of Residences and open green spaces



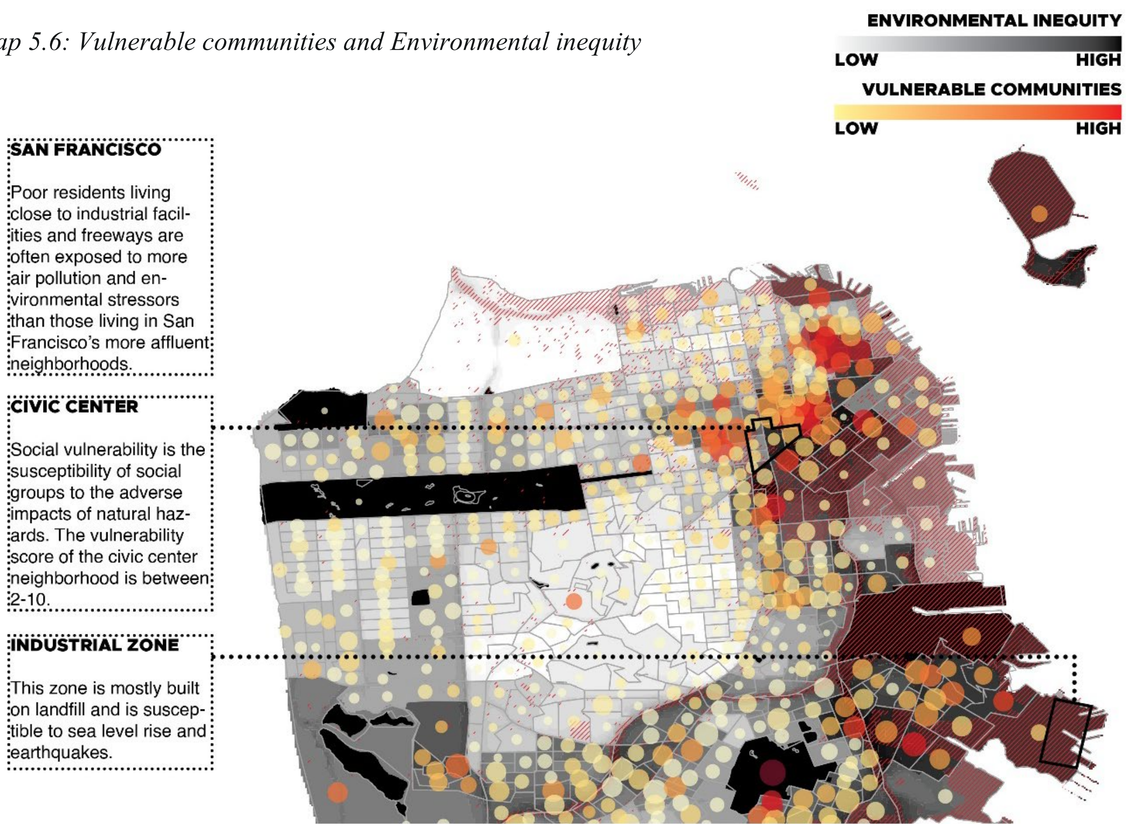
Map 5.4: Population density and the median household



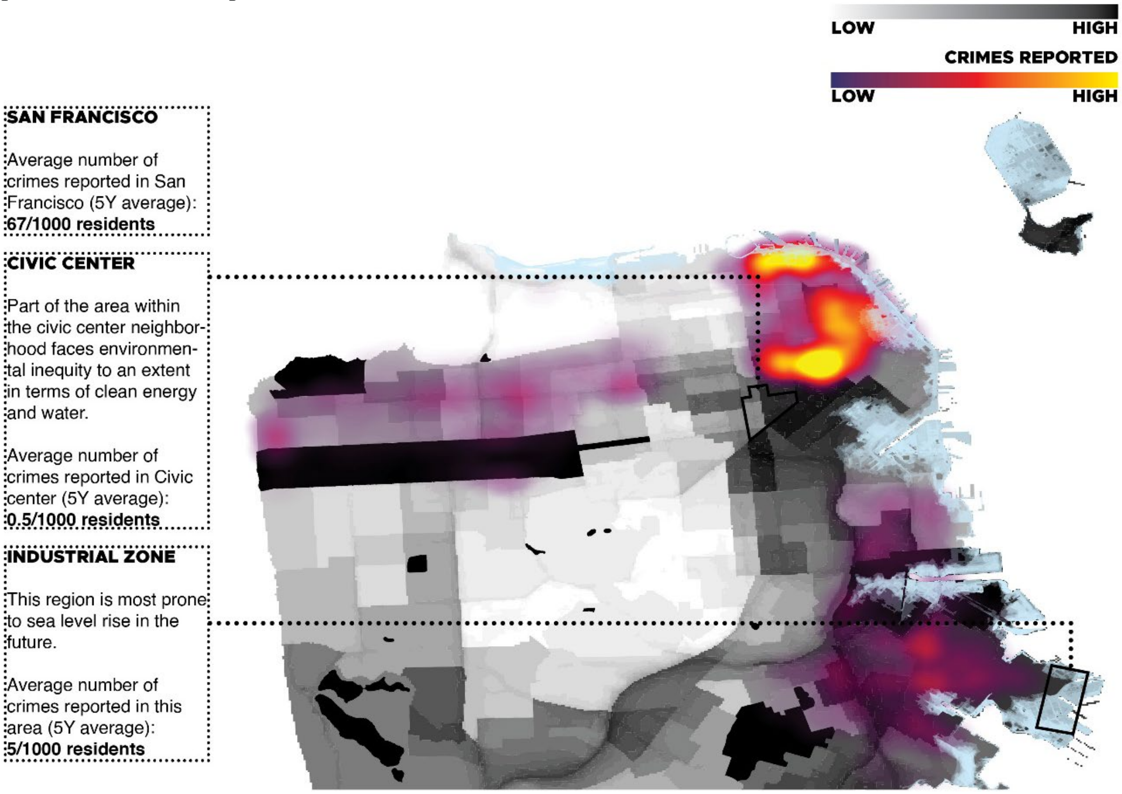
Map 5.5: Major transit stops and routes



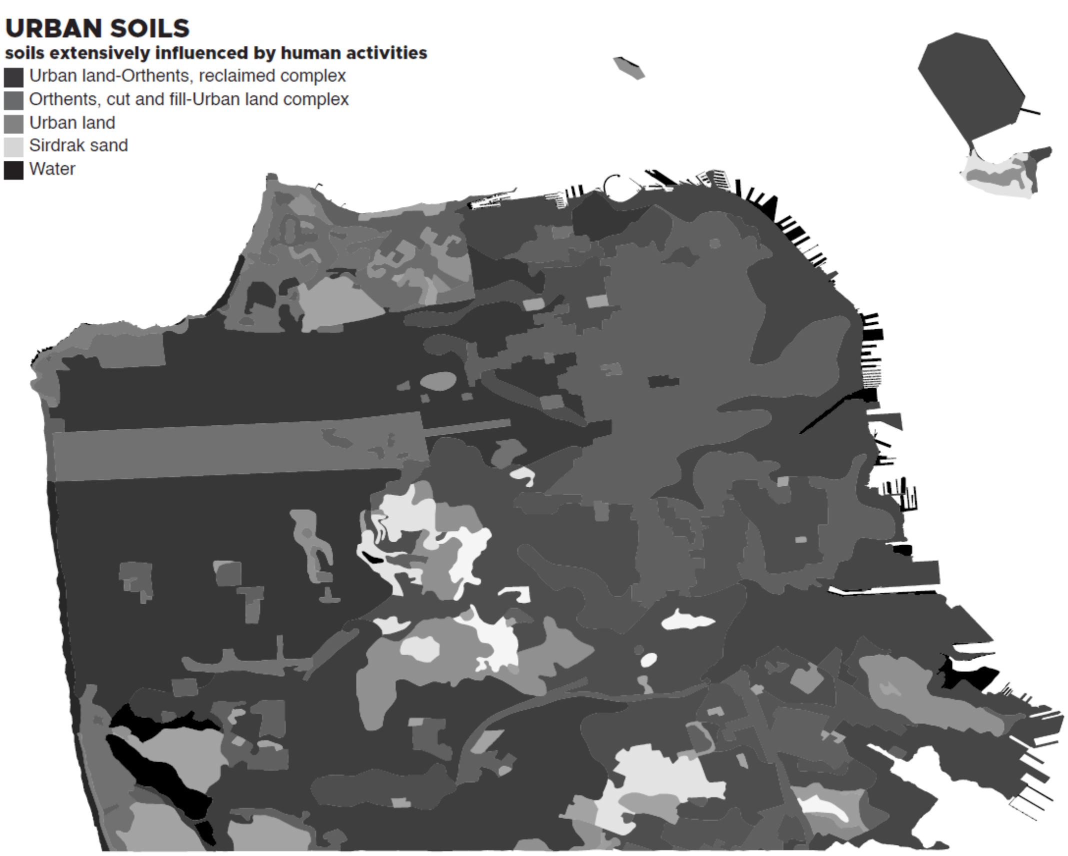
Map 5.6: Vulnerable communities and Environmental inequity



Map 5.7: Crime heat map



Map 5.8: Soil map



4.5.THE JOURNEY OF FOOD

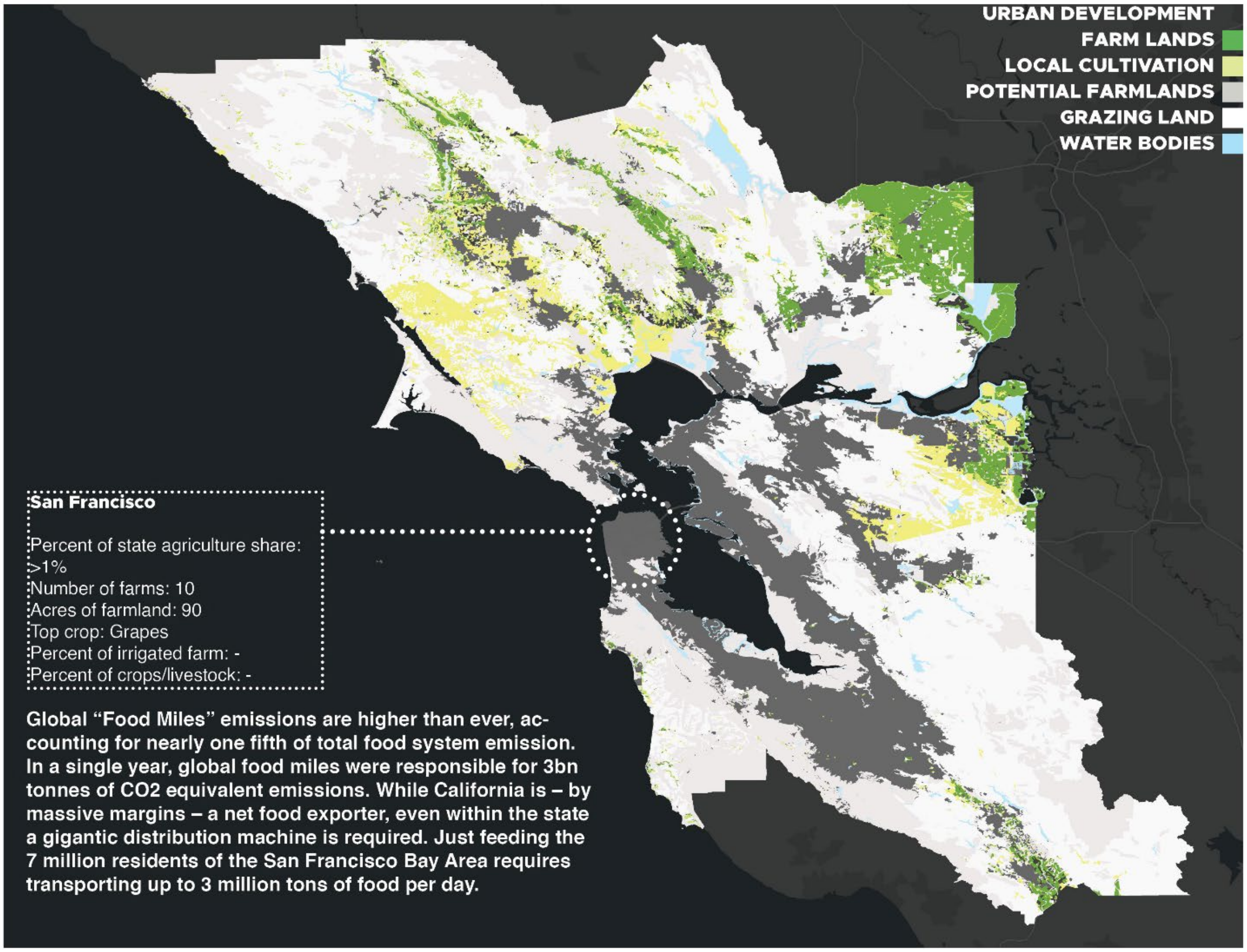


Fig 5.6: Food Miles in Bay area

It is estimated that the meals in the United States travel about 1,500 miles to get from farm to plate. While California is – by massive margins – a net food exporter, even within the state a gigantic distribution machine is required. Just feeding the 7 million residents of the San Francisco Bay Area requires transporting up to 3 million tons of food per day.[92]

[92] https://foodwise.org/learn/how-far-does-your-food-travel-to-get-to-your-plate/

5.6.THE JOURNEY OF WASTE

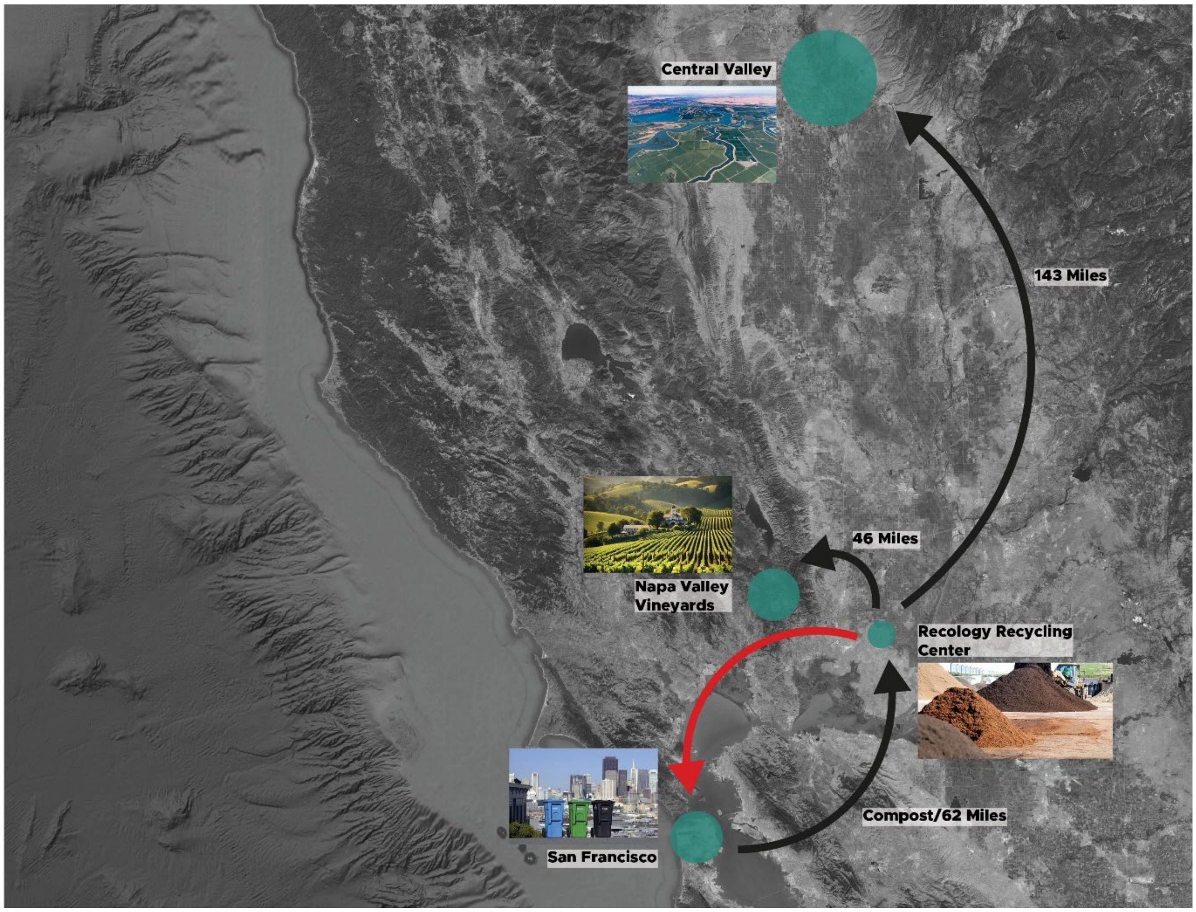


Fig 5.7: Journey of waste

- In 2009, San Francisco made recycling and composting a requirement for all businesses and residences. The city diverts about 80% of its waste from landfills, or more than 1.5 million tons every year.
- 60% of what ends up in San Francisco's trash bins could be composted or recycled.
- All the city's recyclables are brought to Recycle Center, a 200,000 square foot warehouse on Pier 96 that processes 40 to 45 tons of materials per hour.
- As for the compost, all the city's yard waste and food scraps are brought to Jepson Prairie Organics in Vacaville, about 60 miles northeast of San Francisco.
- San Francisco's waste management system costs about $300 million annually, the program is funded solely through waste collection fees.

- Another key to San Francisco's success is its exclusive partnership with waste management company Recology, working with one company eases the administrative burden and makes it possible to collaborate on long-term goals.

Existing infrastructure that is used by Garbage Trucks from San Francisco to Recology Recycling Center.

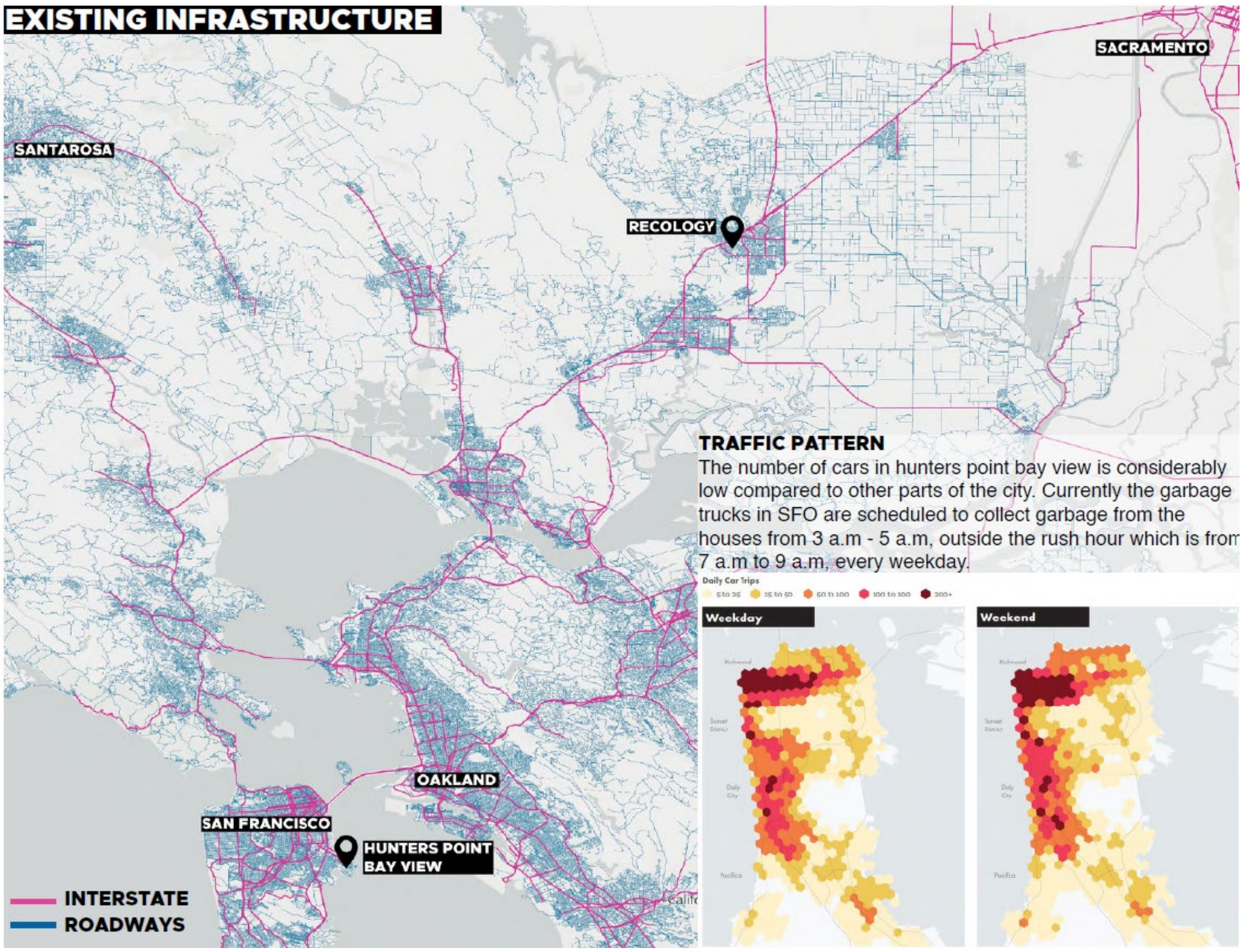


Fig 5.8: Road network in Bay area

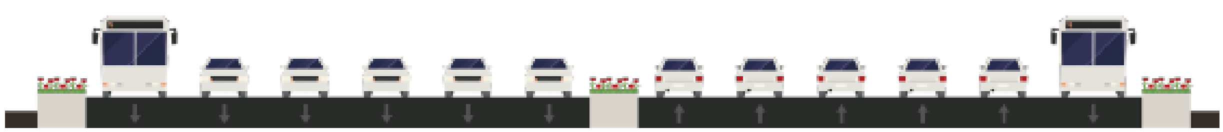


Fig 5.9: Typical cross section of I-80

The Recology garbage truck takes the interstate 80 to reach Vacaville, CA. As many as 270,000 vehicles per day use the I-80 corridor, currently one of the most congested in the San. Francisco Bay Area. The existing interstate is 165' wide, which can very well accommodate trucks.

5.7.LAW, ZONING AND REGULATIONS SURROUNDING URBAN AGRICULTURE IN SAN FRANCISCO

In 2014, California implemented **Assembly Bill 551**, recognized urban agriculture as a land use and allowed landowners in metropolitan areas to receive tax incentives for putting in agriculture use.
A state law that authorizes municipalities with populations of 250,000 or more that choose to adopt the policy to make land for urban farming available at reduced costs.
The law allows conversion of vacant land into urban farms and only for a period of 5 years unless renewed. Since the land is Urban, the Soil remediation process itself would take time. **AB551** is a promising urban agriculture policy in California because it seeks to address the issue of access to land but can include social layers such as redeveloping contaminated lands that can give way to green spaces that provide recreational, cultural, and other community facilities especially for low-income communities.

AB 551, California's Urban Agriculture Incentive Zones Act[93]

- In 2014, California implemented Assembly Bill 551, which allows landowners in metropolitan areas to receive tax incentives for putting land in agriculture use.
- "Urban Agriculture Incentive Zone" means an area within a county or a city and county that is comprised of individual properties designated as urban agriculture preserves by the county or the city and county for farming purposes.
- Authorizes cities and counties to enter contracts with landowners who agree to restrict the use of their land for a minimum of five years for small-scale agricultural production.
- The cities that have currently adopted the policy are 1. San Francisco, 2. Santa Clara and 3. Sacramento.

What Works

- The policy helps in recognizing and ensuring safety in urban food production.

What can be Added

- The current laws and regulations are made with only physical characteristics in mind, social layers can be added to ensure inclusiveness.

[93] http://www.leginfo.ca.gov/pub/13-14/bill/asm/ab_0551-0600/ab_551_bill_20130928_chaptered.html

- The current policy is limited to 5 years unless renewed.

5.8.WHERE ARE PUBLIC URBAN AGRICULTURE PROJECTS LOCATED?

Fig 5.10: Existing Urban Farms in SFO

This is a map of the existing urban farms and community gardens in San Francisco. Most of those projects are on city owned land, with the remainder distributed among private, federal and state land. The sites range in size from nearly 3 acres to a few containers, with nearly two-thirds of sites occupying less than 10,000 square feet. They mostly work on subscription models or partners with businesses that support them financially.

These urban farms and gardens are critical components of alternative food systems and bulwarks against urban food insecurity.[94]

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[94] Arnold, Joshua, and Paul Rogé. 2018. "Indicators of Land Insecurity for Urban Farms: Institutional Affiliation, Investment, and Location" Sustainability 10, no. 6: 1963. https://doi.org/10.3390/su10061963

Researchers have reacted to the growth of urban agriculture (UA) with interest, regularly advocating its benefits ecologically, socially, and economically. Policy makers and city planners have taken interest as well by reversing restrictive zoning ordinances, passing legislation incentivizing UA, publishing guides for inclusion of UA in community planning, and helping urban farmers get their harvest to markets.[95] Despite these efforts, UA is still often regarded as a transitory land-use activity, a phase in the ever-changing urban environment.[96]

5.9.CHALLENGES FACED BY URBAN FARMS IN SAN FRANCISCO

Fundamental challenges faced by urban food producers include political and economic issues affecting security of tenure and access to land.[97] It is estimated that over 79% of urban farmers do not own the property that they farm.[98] Urban agriculture often exists with only short-term, usufruct or de facto rights agreements with landowners to protect farms. Insecure tenure incentivizes rent-seeking behavior, leaving urban farms vulnerable to developments considered "highest and best use".[99] These tenuous conditions lend to a sense of temporariness, where urban food producers perceive UA sites as interim land uses, further reinforced by a legacy of intermittent support for UA during economic depressions and periods of global conflict that diminish once socioeconomic conditions stabilized.[100] Despite competitive property markets, complex legal, policy, zoning, and ad hoc agreements between landowners, institutions, and local municipalities, UA continues to exist in various forms as market, residential, kitchen, guerilla, and school gardens; soil-less farms; urban orchards; and often include the keeping of chickens, bees, goats, and other livestock.[101]

The image below shows the tenure decision status process of Urban Farms.

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[95] Horst, Megan, Nathan McClintock, and Lesli Hoey. 2017. "The Intersection of Planning, Urban Agriculture, and Food Justice: A Review of the Literature." Journal of the American Planning Association 83 (3): 277–95. doi:10.1080/01944363.2017.1322914.

[96] Drake, L.; Lawson, L.J. Validating Verdancy or Vacancy? The Relationship of Community Gardens and Vacant Lands in the U.S. Cities 2014, 40, 133–142.

[97] Blomley, N. Unsettling the City: Urban Land and the Politics of Property; Routledge: Abington-on-Thames, UK, 2004.

[98] Angotti, T. Urban Agriculture: Long-Term Strategy or Impossible Dream? Public Health 2015, 129, 336–341.

[99] Lawson, L.J. City Bountiful: A Century of Community Gardening in America; University of California Press: Oakland, CA, USA, 2005.

[100] Reynolds, K.; Cohen, N. Beyond the Kale: Urban Agriculture and Social Justice Activism in New York City; Geographies of Justice and Social Transformation Ser. (Book 28); University of Georgia Press: Athens, GA, USA, 2016.

[101] McClintock, N. Radical, Reformist, and Garden-Variety Neoliberal: Coming to Terms with Urban Agriculture's Contradictions. Local Environ. 2014, 19, 147–171.

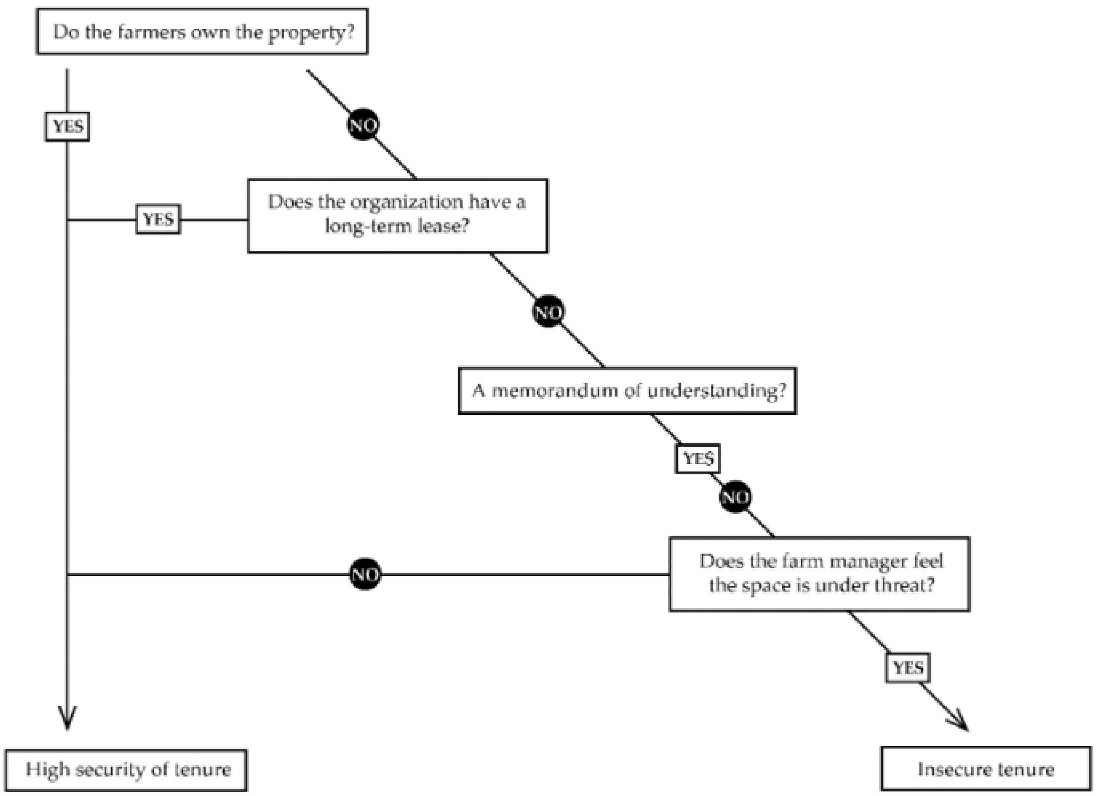


Fig 5.11: Land ownership

Image source: https://www.mdpi.com/2071-1050/10/6/1963#B11-sustainability-10-01963

Secure tenure farms: When urban farms can pay for their own irrigation, and they are affiliated with a school, they are more likely to have secure tenure status. If not school affiliated, having a full-time, paid farm manager is a strong indicator of secure tenure. Conversely, secure tenure farms that do not pay for their own water and are in areas of lower economic opportunity must be affiliated with a school to be considered tenure secure.[102]

Tenure insecure farms: When farms are unable to pay for their irrigation (less financial support) and occur in areas of higher economic opportunity, they are more likely to be insecure, while farms in underserved neighborhoods rely on school affiliation to remain secure. Farms that show indicators of financial support but lack full-time farm managers and school affiliation are also likely to be insecure.[103]

[102] Arnold, Joshua, and Paul Rogé. 2018. "Indicators of Land Insecurity for Urban Farms: Institutional Affiliation, Investment, and Location" Sustainability 10, no. 6: 1963. https://doi.org/10.3390/su10061963
[103] Arnold, Joshua, and Paul Rogé. 2018. "Indicators of Land Insecurity for Urban Farms: Institutional Affiliation, Investment, and Location" Sustainability 10, no. 6: 1963. https://doi.org/10.3390/su10061963

Category	Indicator	Measure or Levels
Economic support	Farm managers	Paid, part-time/full-time
	Irrigation	Municipal water rates
	Harvest sold to market	Percentage of harvest
Social support	School affiliated	Yes/No
	Harvest provided to community	Percentage of harvest
	Food security focus	Yes/No
Location-based	Property value	Median property value per sq. ft.
	Walk score	Index score: 1–100
	ROI–economic	Low quartiles–high quartiles
	ROI–housing	Low quartiles–high quartiles
	ROI–place-based opportunity	Low quartiles–high quartiles

Fig 5.12: Assessed characteristics of urban farms

Image source: https://www.mdpi.com/2071-1050/10/6/1963#B11-sustainability-10-01963

The tenure security of urban farms is related to specific characteristics of the above table. Traits that best predicted tenure status in UA are financial support, location, and affiliation with an educational entity.[104] Urban farms in areas of higher economic opportunity that receive more financial support appear to be more insulated from unexpected land-use changes over time.

Irrigation and labor costs are often the costliest expenditures for urban farms. One acre-foot (approximately 1233 m3) of water costs farmers around $2200 from the East Bay Municipal Water District in the S.F. Bay Area.[105]

Relationships with strong social institutions such as schools, federal institutions and direct financial support may be the best policy mechanisms to help UA persist over time in urban areas.

[104] Arnold, Joshua, and Paul Rogé. 2018. "Indicators of Land Insecurity for Urban Farms: Institutional Affiliation, Investment, and Location" Sustainability 10, no. 6: 1963. https://doi.org/10.3390/su10061963

[105] East Bay Municipal Water District. Water Rate Schedule—Effective 12 July 2017. Available online: http://www.ebmud.com/water-and-drought/water-rates/

CHAPTER 6: THE SITE-HUNTERS POINT BAY VIEW

6.1.WHAT IS THE CITY AND THE SITE BUILT ON

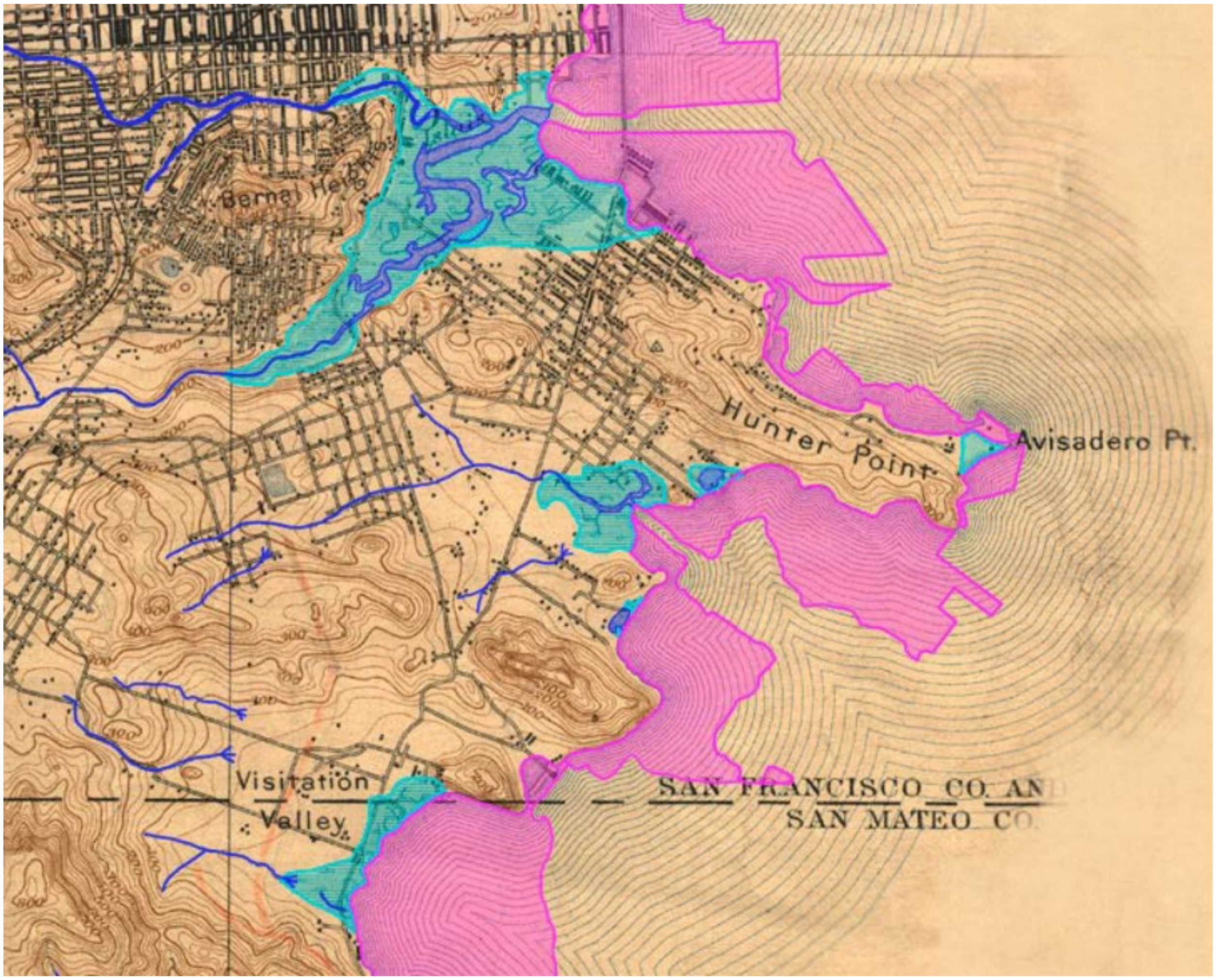


Fig 6.1: Built on Landfill

Image source: https://explore.museumca.org/creeks/SFTopoCreeks.html

This diagram represents the shoreline of San Francisco from 1895 and the pink shows areas of artificial fill, blue shows historical marshlands and creeks. San Francisco experienced a massive increase in its population during the Gold Rush of 1849.[106] Thousands flocked into the city and with them came banking, industry, and of course, waste. The peninsula was quickly running out of space and the amount of trash from all the new inhabitants was growing precipitously, so the solution seemed obvious. Large areas of the eastern and northern edges of the peninsula were filled in with a

[106] https://explore.museumca.org/creeks/SFTopoCreeks.html

combination of landfill debris, rubble, sand, and mud. Neighborhoods like the Marina, Mission Bay, Hunters Point, and large sections of the Embarcadero are built entirely on landfills.[107]

6.2.SOME FACTS

I have chosen Hunters Point Bay View as my site where:

- Median household income in Hunter's Point is $ 66,618 annually. The population count here is 35,982.
- This region is most prone to sea level rise in the future. Average number of crimes reported in this area (5Y average): 5/1000 residents.
- There are a total of 10,665 households in Hunters Point, each made up of around 3 members and are mostly families.
- The Environmental Vulnerability score is 8-10 for Hunter's Point. Most of the residences here are built on landfills and are contaminated.

It was one of the top industrial zones on the West Coast during the Second World War. The African American community that majorly lived and worked here faced extensive job losses following the closure of the Shipyard in 1974. The site is still owned by the Navy.

This neighborhood has been identified as one of the extremely poor with over 40% of the inhabitants living below the federal poverty level. According to a report from the San Francisco Department of Public Health, the neighborhood has the most residents facing food insecurity than anywhere else in the city.

6.3.WHAT IS BEING PLANNED

According to a survey conducted by the SF Planning department, the underlying need was to arrest the demographic decline of the local population, particularly African Americans, and improve its economic position.

The second concern was the reduction of health and environmental hazards caused by wastewater discharge and industrial by-products.

The development of Hunters Point is planned in two phases:

- HPS 1 is a new, mixed-income, residential community located on former United States Navy land in the Bayview Hunters Point neighborhood in southeastern San Francisco.

[107] https://www.sanfrancisco.net/history

- HPS 2 will develop vacant and underutilized land into new, master-planned, multi-use and mixed-income waterfront districts.

Fig 6.2: Proposal Phase 1

6.4.WHAT CAN BE ADDED?

The current plan does not include spaces for food production. The CP-HPS Phase 2 project includes a total of 337.7 acres of existing shoreline parkland and open space in the Candlestick Point State Recreation Area. Along with what is proposed, spaces for food production can be integrated.

6.5.OBJECTIVES FOR THE SITE

- To create accessible food production spaces that are inclusive, by first prepping the site following EPA recommendations.
- To create a sustainable long-term plan for the site which is predominantly unused for growing, selling and recycling agriculture products.
- Creating decentralized production and distribution systems as a step towards resilient and sustainable city.

- Integrate food production and its related activity in federally owned land, the Naval shipyard here, to ensure sustainability.
- To increase pervious surfaces and reduce urban heat effect in vulnerable neighbourhoods.

6.6.CURRENT LAND USE

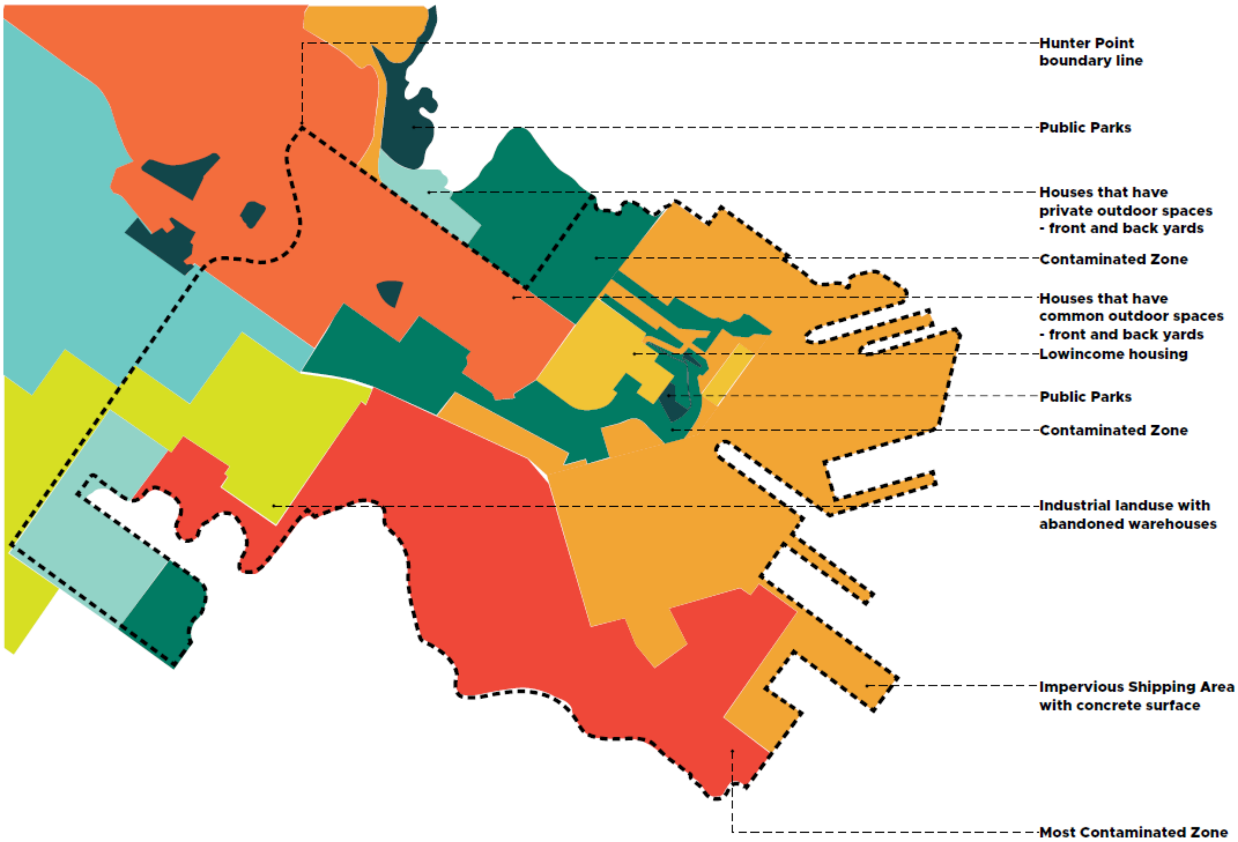


Fig 6.3: Current landuse

The 866-acre Hunters Point Naval Shipyard site is in San Francisco, California. The site was home to a shipyard from 1945 to 1974 and the Naval Radiological Defence Laboratory (NRDL) from 1948 to 1960.[108]

NRDL activities contaminated soil, dust, sediments, surface water and groundwater with petroleum fuels, pesticides, heavy metals, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs) and radionuclides. Soil at the site contains naturally occurring asbestos and metals.[109]

[108] https://www.sanfrancisco.net/history
[109] EPA- United States Environmental Protection Agency https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second. Cleanup&id=0902722

Photos of the site

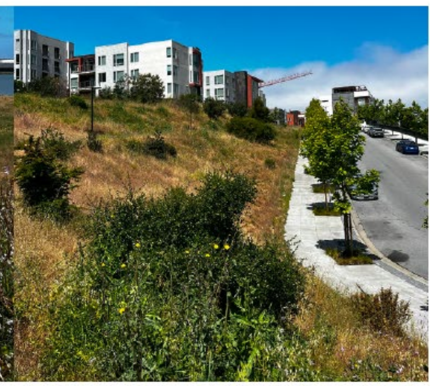
Residential areas with shared/common outdoor spaces.

Residential areas with very wide concrete pavements upto 25'.

Industrial area with a lot of abandoned warehouses.

Abandoned buildings within the limits of Naval shipping yard.

Open space that is restricted for access within the Naval shipping yard.



New low income housing project under construction at Hunters point.

Fig 6.4: Existing site conditions

Fig 6.5: Existing site conditions

An overlay of the zoning seen at the site over an aerial imagery of the site, visual evidence of how different each zone looks from the other in terms of composition, layout and the surface materials.

6.7.CONTAMINATION AT THE SITE

EPA has identified the chemical substances (i.e., hazardous substances, pollutants or contaminants) as contaminants of concern (COCs) for the site. COCs are the chemical substances found at the site that EPA has determined pose an unacceptable risk to human health or the environment. These are the substances evaluated by EPA to be addressed by cleanup actions at the site.[110]

To identify COCs, EPA:

- Identifies people and ecological resources that could be exposed to contamination found at the site.
- Determines the amount and type of contaminants present; and

[110] EPA- United States Environmental Protection Agency https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.contams&id=0902722

Fig 6.6: Existing site conditions

A common sight at the boundaries of the area that belongs to the Navy.

- Determines the human health or ecological effects that could result from contact with the contaminants.[111]

The list of COCs provided come from EPA's remedy decisions for this site. Few of the contaminants are listed below, for an exhaustive list please visit:

https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.contams&id=0902722

CONTAMINANT NAME	CONTAMINATED MEDIUM
1,3-dichloro-1-propene	Groundwater
1,1,1-trichloroethane	Soil, Groundwater
1,1-dichloroethane	Groundwater, Soil
1,2,3-trichloropropane	Groundwater, Soil
1,2-dichlorobenzene	Soil, Groundwater
1,2-dichloroethane	Soil, Groundwater
1,2-dichloropropane	Groundwater, Soil
1,3,5-trimethylbenzene	Groundwater, Soil
1,3-dichlorobenzene	Groundwater, Soil
cadmium	Soil, Groundwater
benzene	Groundwater, Soil
arsenic	Groundwater, Soil
beryllium	Soil, Groundwater
chloroform	Groundwater, Soil
cobalt-60	Groundwater, Soil, Buildings and Structure
copper	Sediment Soil, Groundwater
iron	Groundwater, Soil
lead	Sediment, Groundwater, Soil
manganese	Groundwater, Soil
mercury	Sediment, Groundwater, Soil
methane	Landfill Gas
radium-226	Buildings/Structures, Sediment, Groundwater, Soil
strontium-90	Buildings/Structures, Sediment, Groundwater, Soil
uranium-235	Buildings/Structures, Sediment, Groundwater, Soil
zinc	Sediment, Buildings/Structures, Sediment, Groundwater, Soil
nickel	Groundwater, Sediment, Groundwater, Soil

6.8.SUPERFUND SITES OPERABLE UNITS

During cleanup, complex sites may be divided into several distinct areas to make the response more efficient. These areas, called operable units (OUs), may address geographic areas, specific problems, or medium (e.g., groundwater, soil) where a specific action is required.[112]

EPA has provided a list of the remedial actions selected pertaining to each operable unit.

[111] https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.contams&id=0902722

[112] https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.ous&id=0902722

OU ID	**Name**	**Decision Document**	**Cleanup Technologies Selected in the Decision Document**
00	SITEWIDE	Not applicable	
01	PARCEL A	Record of Decision November 28, 1995	No Action
02	PARCEL B	Record of Decision October 09, 1997	Solidification/Stabilization (insitu) Institutional Controls Disposal (offsite) Monitoring Drainage/Erosion Control (other, not otherwise specified) Containment (other, not otherwise specified, onsite) Excavation
02	PARCEL B	Explanation of Significant Differences October 20, 1998	ESD - Nonfundamental Change (other)
02	PARCEL B	Explanation of Significant Differences May 05, 2000	ESD - Nonfundamental Change (other)
02	PARCEL B	Record of Decision Amendment January 28, 2009	Shoreline Stabilization Soil Vapor Extraction (insitu) Cover (soil) Institutional Controls Demolition Excavation Monitoring (ambient air) Decontamination Cap (engineered cap) Wetlands Replacement Bioremediation (anaerobic, insitu) Disposal (offsite) Monitoring (groundwater)

Table 6.1: Clean up activities

OU ID	Name	Decision Document	Cleanup Technologies Selected in the Decision Document
03	PARCEL C	Record of Decision September 20, 2010	Disposal (offsite) Decontamination Bioremediation (anaerobic, insitu) Cap (engineered cap) Monitoring (groundwater) Soil Vapor Extraction (insitu) Chemical Reduction (insitu) Monitored Natural Attenuation Excavation Institutional Controls Demolition
03	PARCEL C	Explanation of Significant Differences October 22, 2014	ESD/Amd - Significant Volume Change ESD/Amd - Cleanup/Performance Standard Change ESD/Amd - Remedy Component Removal ESD/Amd - Significant Cost Change ESD/Amd - Treatment Area Change
04	PARCEL D-1	Record of Decision September 11, 2009	Cover (soil) Bioremediation (anaerobic, insitu) Decontamination Institutional Controls Sampling Monitoring (groundwater) Disposal (offsite) Excavation
05	PARCEL E	Record of Decision December 31, 2013	Disposal (offsite) Monitored Natural Attenuation Bottom Liner Shoreline Stabilization Cap (engineered cap) Decontamination Solidification/Stabilization (insitu) Free Product Recovery (active or passive, excluding MPE and bioslurping) Soil Vapor Extraction (insitu) Vertical Engineered Barrier (other) Cover (soil) Demolition Thermal Treatment (insitu) Physical Separation (exsitu, onsite) Excavation Bioremediation (other, not otherwise specified, insitu) Monitoring (groundwater) Institutional Controls
06	PARCEL F	No decision document	

Table 6.1 cont.: Cleanup activities

OU ID	Name	Decision Document	Cleanup Technologies Selected in the Decision Document
07	PARCEL E-2 (LANDFILL)	Record of Decision November 20, 2012	COC Only Wetlands Replacement Vertical Engineered Barrier (other) Drainage/Erosion Control (other, not otherwise specified) Carbon Adsorption (vapor phase) Extraction (recovery trench/subsurface collection drain) Disposal (offsite) Cap (engineered cap) Shoreline Stabilization Hydraulic Control (containment) Institutional Controls Flame Flare (enclosed, open, other, not otherwise specified) Discharge (POTW) Recycling (onsite) Wetlands Restoration Monitoring (sediment) Consolidate (onsite) Excavation Monitoring (soil) Monitoring (groundwater) Physical Separation (exsitu, onsite) Monitoring (landfill gas)
08	PARCEL D-2 (BLDGS 813+819)	Record of Decision June 22, 2010	No Further Action
09	PARCEL G	Record of Decision February 18, 2009	Bioremediation (other, not otherwise specified, insitu) Sampling Decontamination Disposal (offsite) Demolition Cap (engineered cap) Chemical Reduction (insitu) Institutional Controls Excavation Monitoring (soil gas)
10	UTILITY CORRIDORS	Record of Decision December 17, 2009	Institutional Controls Disposal (offsite) Monitoring Monitored Natural Attenuation Excavation Cover (soil) Decontamination

Table 6.1 cont.: Cleanup activities

OU ID	Name	Decision Document	Cleanup Technologies Selected in the Decision Document
10	UTILITY CORRIDORS	Record of Decision January 24, 2014	Decontamination Bioremediation (other, not otherwise specified, insitu) Disposal (offsite) Monitored Natural Attenuation Cap (engineered cap) Excavation Institutional Controls Monitoring (soil gas)
11	PFAS	No decision document	

Table 6.1 cont.: Cleanup activities

6.9.ZONING OF PARCELS ON LAND THAT BELONGS TO THE NAVY

This led to further zoning of parcels within the area that belonged to the Navy. The Navy had divided the site onto several sub sites to organise and prioritize clean up activities. And this gets updated every 5 years based on the efforts that is put into each sub site.[113]

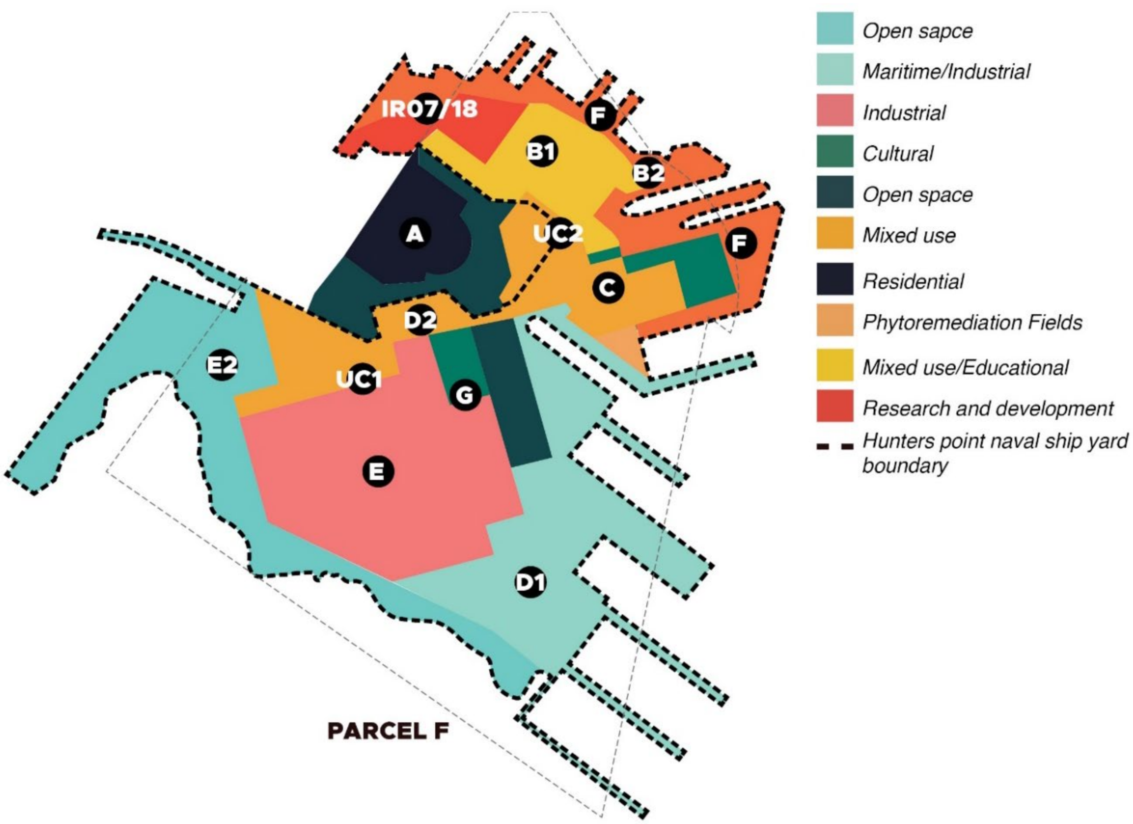


Fig 6.7: Sub zones by Navy

[113] EPA- United States Environmental Protection Agency https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0902722

The Navy has divided the site into several subsites to organize and prioritize cleanup activities. List of the remedial actions selected pertaining to each operable unit.[114]

A- No further action

B- Excavation and disposal of contaminated soil finished in 2010.

C- Soil excavation and disposal, groundwater treatment, soil vapor extraction and radiological removal activities are ongoing.

D1- Groundwater treatment done in 2008, Excavation and disposal of contaminated soil finished in 2010.

D2- No further action

G- Groundwater treatment done in 2008, Soil excavation and disposal, groundwater treatment, soil vapor extraction and radiological removal activities are ongoing.

UC1, UC2, UC3, E, F- Remedial investigation activities, operation and maintenance activities, and monitoring are ongoing for these subsites.

Bioremediation and **Decontamination** were two mostly recommended activities at majority of the sub sites.

[114] EPA- United States Environmental Protection Agency-https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.ous&id=0902722

CHAPTER 7: PROPOSAL FOR THE SITE

7.1.PHYTOREMEDIATION

Phytoremediation is the direct use of living plants for in situ remediation of contaminated soil, sludges, sediments, and ground water through contaminant removal, degradation, or containment. Growing and, in some cases, harvesting plants on a contaminated site as a remediation method is an aesthetically pleasing, solar energy driven, passive technique that can be used to clean up sites with shallow, low to moderate levels of contamination. This technique can be used along with or, in some cases, in place of mechanical cleanup methods. Phytoremediation can be used to clean up metals, pesticides, solvents, explosives, crude oil, polycyclic aromatic hydrocarbons, and landfill leachates.[115]

The use of specific plant species for phytoremediation can be tailored to the type of heavy metal pollution, as different plant species have varying abilities to accumulate specific heavy metals.[116] Bioremediation can also involve using microorganisms to break down or transform contaminants into less toxic forms. Microorganisms can degrade organic pollutants or transform heavy metals into less harmful substances. For example, some bacteria can convert poisonous forms of mercury into less toxic elemental mercury, which can then be released into the atmosphere. Other microorganisms can break down organic pollutants, such as petroleum hydrocarbons, into harmless byproducts.[117]

7.2.EXAMPLE OF SUCCESSFUL PHYTOREMEDIATION

Assessments of the Efficacy of a Long-Term Application of a Phytoremediation System Using Hybrid Poplar Trees at Former Oil Tank Farm Sites.[118]

A poplar tree-phytoremediation system was installed at former refinery and tank farm sites in Cabin Creek, West Virginia, to clean-up petroleum-contaminated-soils and groundwater. Groundwater and soils in both sites were sampled and analyzed on a regular basis to monitor changes in contaminant

[115] https://www.epa.gov/sites/default/files/2015-04/documents/phytoresgude.pdf
[116]Eid E.M., Galal T.M., Sewelam N.A., Talha N.I., Abdallah S.M. Phytoremediation of Heavy Metals by Four Aquatic Macrophytes and Their Potential Use as Contamination Indicators: A Comparative Assessment. Environ. Sci. Pollut.
[117] Priya, A K et al. “Clean-Up of Heavy Metals from Contaminated Soil by Phytoremediation: A Multidisciplinary and Eco-Friendly Approach.” Toxics vol. 11,5 422. 2 May. 2023, doi:10.3390/toxics11050422
[118]El-Gendy, Ahmed S., et al. “Assessments of the Efficacy of a Long-Term Application of a Phytoremediation System Using Hybrid Poplar Trees at Former Oil Tank Farm Sites.” Water Environment Research, vol. 81, no. 5, 2009, pp. 486–98. JSTOR, http://www. jstor.org/stable/40575334. Accessed 27 Sept. 2024.

concentration since 1999. The concentration of benzene, toluene, ethylbenzene, xylene, and gasoline range organics (GRO) decreased an average of 81%, 90%, 67%, 78%, and 82%, respectively, in the lower soil horizons and 34%, 84%, 12%, 19%, and 59%, respectively, in groundwater. In addition, concentrations of oxygen, methane, and carbon dioxide in soil gas demonstrated that tree roots dewatered soils and allowed penetration of oxygen deep into the soil profile, creating necessary conditions for rhizosphere bioremediation. Although required clean-up time can limit phytoremediation, it has proven to be a cost-effective strategy for site improvement if imminent pathways for human exposure and risk are not an issue.

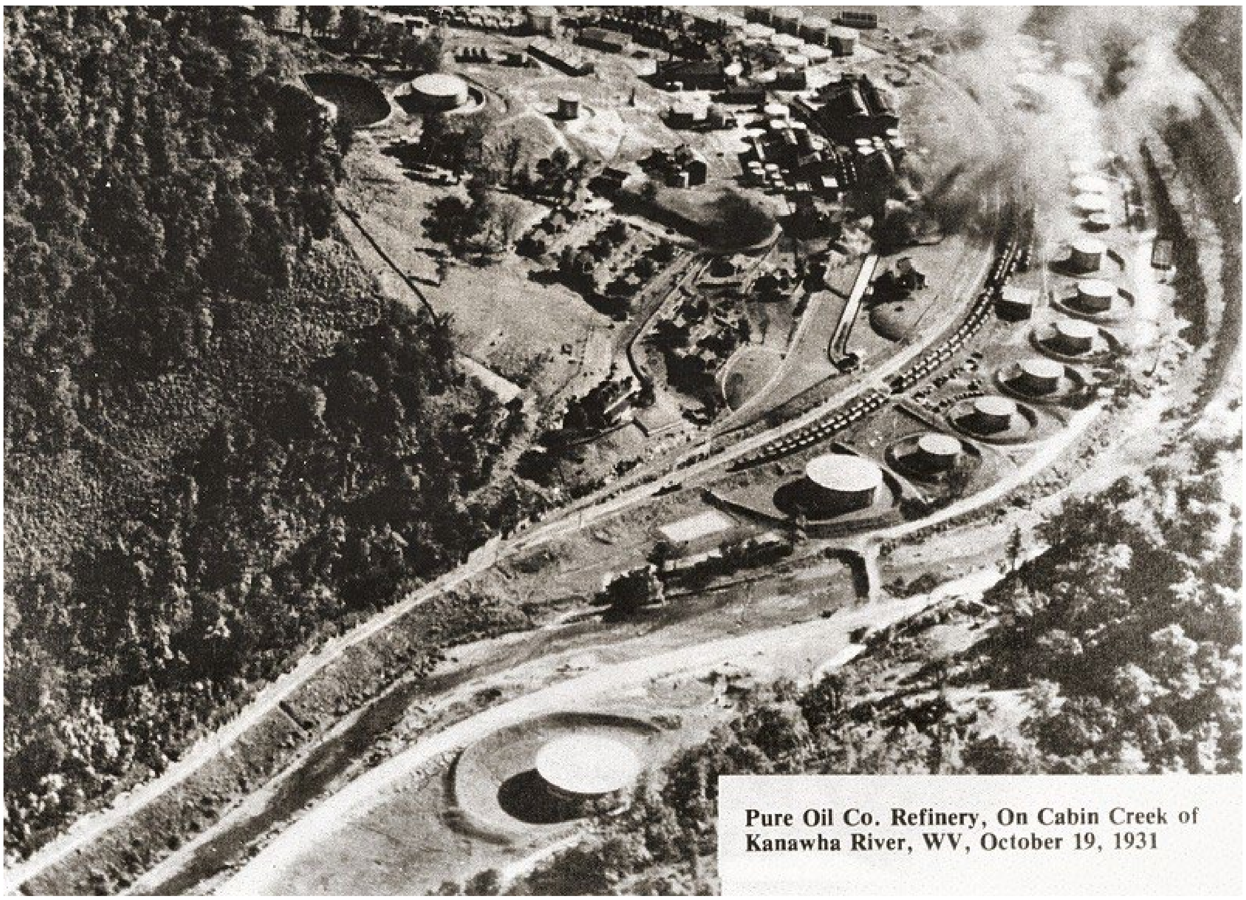


Fig 7.1: Cabin Creek

Image source: PURE OIL REFINERY AT CABIN CREEK -https://www.mywvhome.com/thirties/cabincreek.html

Characterization of contaminated sites during the 1990s revealed that petroleum products contaminated most active sites. Petroleum hydrocarbons comprise a diverse group of chemicals with variable physical and chemical characteristics.[119]

[119] Pichtel, J.; (2007) Fundamentals of Site Remediation: for Metals and Hydrocarbon-Contaminated Soils, 2nd ed.;. Government Institutes; The Scarecrow Press: Lanham, Maryland.

Variable characteristics of petroleum hydrocarbons and the variety of site conditions have made it challenging to devise a single cleanup method. Many remediation methods have been developed, mostly through trial and error.[120] Effort has been directed towards designing remediation programs based on sound scientific principles and data. Ex-situ remediation methods that remove and destroy affected soils primarily have been replaced with in-situ treatment that remediates the soil in place.[121] Phytoremediation is the use of plants for in-situ treatment of contaminated soils, sediments, and groundwater. It may be applicable at sites contaminated with organics, nutrients, or heavy metals. These pollutants can be sequestered, degraded, immobilized, or metabolized in situ when accessed by plant roots.122 Cost effectiveness, aesthetic advantages, long-term applicability, and high sustainability have made phytoremediation a popular and attractive alternative.[123]

There are three primary applications for phytoremediation:

- Hazardous waste sites where other methods are too expensive or impractical.
- Low-level contaminated sites where only polishing treatment is required over long periods of time.
- Sites where phytoremediation can be used in conjunction with other technologies as a final cap and closure.

The site

The contaminated areas at Cabin Creek, West Virginia, included two sites—an eastern site and a western site. The eastern site [66 100 m2 (16.33 acres)] is the former location several aboveground storage tanks (ASTs) at the former Pure Oil Refinery, which discontinued operation in 1954. The western site [34 900 m2 (8.32 acres)] was used to house one 8.6 × 106 L (54 000 bbl.) and three 4.6 × 106 L (29 000 bbl.) ASTs that stored petroleum products. In 1996 and 1997, environmental assessments at both sites revealed that soil and groundwater were affected by petroleum hydrocarbons. Key characteristics of both sites included an unsaturated zone ranging from about 2.4 to 3.6 m thick across the site and limited areas of free product occurrence.

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[120] El-Gendy, Ahmed S., et al. "Assessments of the Efficacy of a Long-Term Application of a Phytoremediation System Using Hybrid Poplar Trees at Former Oil Tank Farm Sites." Water Environment Research, vol. 81, no. 5, 2009, pp. 486–98. JSTOR, http://www. jstor.org/stable/40575334. Accessed 27 Sept. 2024.

[121] La Rue, V. S.; Bioremediation of Petroleum Hydrocarbons in Soil: Activated Sludge Treatability Study. M.Sc. Thesis, The University of Manitoba, Winnipeg, Manitoba, Canada, 1993.

[122] Dietz, A. C.; Schnoor, J. L.; (2001) Phytotoxicity of Chlorinated Aliphatics to Hybrid Poplar (Populus Deltoides × Nigra DN34). Environ. Toxicol. Chem., 20, 389–393.

[123] urken, J. G.; Schnoor, J. L.; (1996) Phytoremediation: Plant Uptake of Atrazine and Role of Root Exudates. J. Environ. Eng., 122, 958–963.

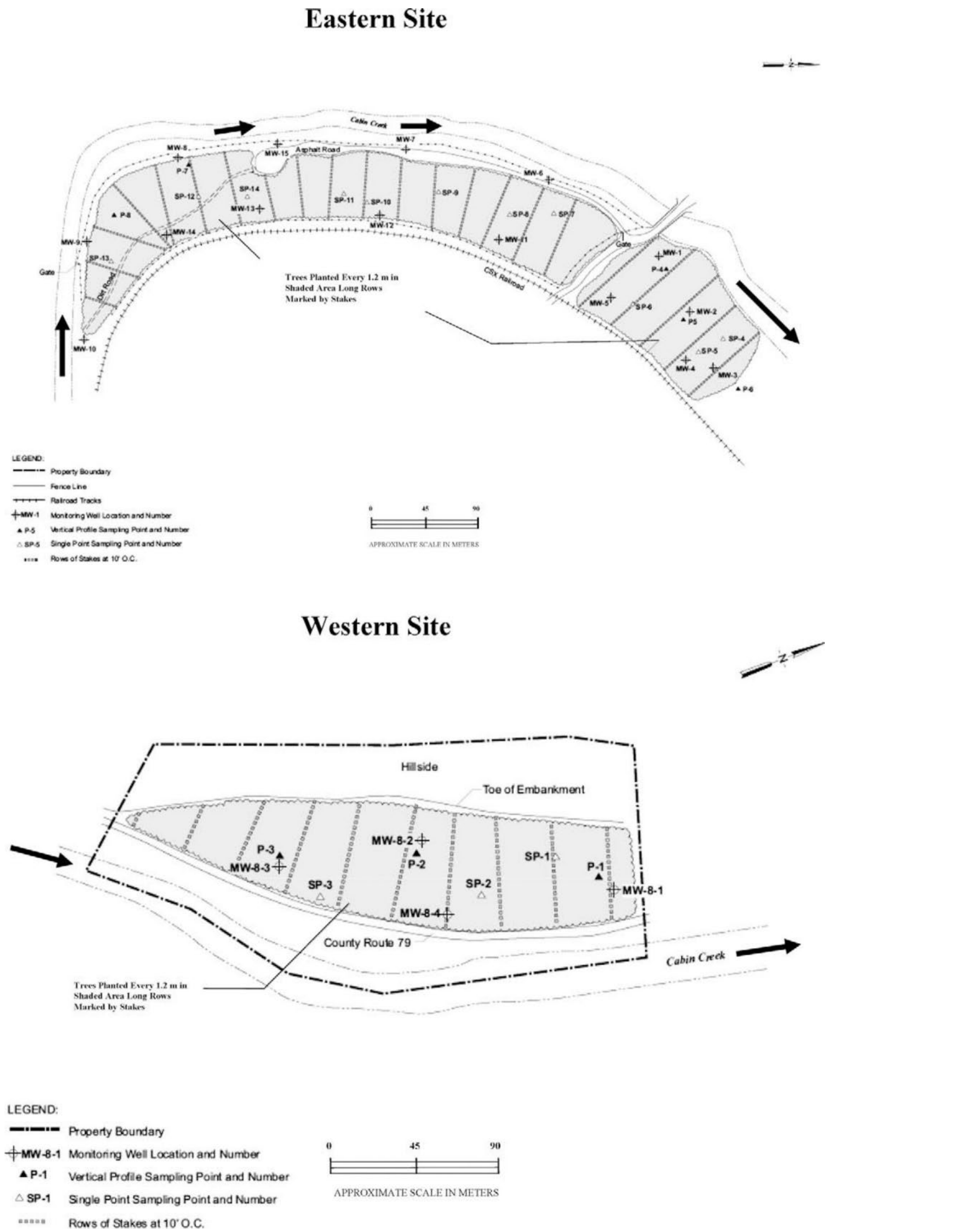

Fig 7.2: Cabin Creek plan of buildings

Image source: https://onlinelibrary.wiley.com/doi/full/10.2175/106143008X357011?saml_referrer#waer-81-5-Pichtel1

Layout of the eastern and western sites include areas planted with trees (shaded) and locations of monitoring wells (MW), vertical soil profile sampling points (P), and single soil sampling points (SP).

Phytoremediation using hybrid poplar trees was the most promising option for full-scale application at the contaminated sites in Cabin Creek because of its high potential for site cleanup.[124]

Materials and methods

The former tanks and facilities at both sites had been removed several years before phytoremediation. Before tree planting began in 1999, both sites were cleared of brush and miscellaneous debris. In addition, fertilizer [10:10:10 nitrogen/phosphorus/potassium (NPK)] initially was applied at a rate of 1120 kg/ha (1000 lb./acre). In April 1999, Harmor Nursery Manistee, Michigan) delivered hybrid poplar cuttings (poles), which were stored at near-freezing temperatures until planting. Tree planting at both sites began by the end of April 1999 and completed by the end of May 1999. Approximately 2840 hybrid poplar trees were planted per hectare. A total of 15500 trees were planted in both sites. Approximately 14 200 m2 (3.5 acres) and 40 500 m2 (10 acres) were planted in the western site and the eastern site, respectively. The remaining unplanted areas consisted of steep slopes, roadways, and drainage ways.

Contamination found from soil and groundwater sampling.

Between April 1996 and March 1999, soil and groundwater samples were collected from both sites at Cabin Creek to assess conditions and to provide information that would be useful in selection and design of the remediation system. The soil and the groundwater sampling at both sites revealed several findings as outlined below.

[124] Dietz, A. C.; Schnoor, J. L.; (2001) Phytotoxicity of Chlorinated Aliphatics to Hybrid Poplar (Populus Deltoides × Nigra DN34). Environ. Toxicol. Chem., 20, 389–393.

Media	Location	DRO	GRO	Benzene	Toluene	Ethylbenzene	Xylene
Soil (mg/kg)	Western Site	3.3 to 320	0.1 to 12,000	0.001 to 0.340	0.001 to 770	0.001 to 440	0.001 to 2,400
	Eastern Site	up to 7,100	up to 18,000	up to 32	up to 7.4	up to 110	up to 330
	Soil Limits by WVDEP[1]	100	100	0.05			
Groundwater (mg/L)	Western Site	0.1 to 19	0.1 to 50	0.001 to 0.3	0.001 to 11	0.001 to 2.0	0.001 to 7.3
	Eastern Site	up to 910	up to 380	up to 5.0	up to 2.3	up to 6.0	up to 23.0
	GW Limits by WVDEP	1	1	0.005	1	0.7	10

[1] The West Virginia Department of Environmental Protection (WVDEP) stated that the concentrations of petroleum hydrocarbon in soil should not exceed 10 mg/kg (ppm) for total benzene, toluene, ethylbenze, and xylene (BTEX) (DRO = diesel range organics; GRO = gasoline range organics).

Fig 7.3: Ranges of soil and groundwater concentrations for different petroleum hydrocarbons at both sites of Cabon Creek prior to phytoremediation

Image source: https://onlinelibrary.wiley.com/doi/full/10.2175/106143008X357011?saml_referrer#waer-81-5-Pichtel1

Polar Trees *(Populus deltoids X nigra, DN34)*

Poplar trees (Populus spp.) are phreatophytic trees known for deep root systems that can reach up to 12 m, growing up to 10 mm per day in suitable site conditions.[125] poplar trees were planted in columns (diameter of 0.10 m) filled with soil contaminated with petroleum hydrocarbons and topped with clean soil.[126] The vertical root growth rate averaged 3.9 mm per day for different conditions (with or without induced air to the root zone). This value was used to estimate root growth of poplar trees at Cabin Creek. The average value was used because in actual field conditions, roots typically explore the entire volume of soil around the contaminated area and are not confined to a limited space as in the laboratory setup.[127] Based on this information, it is estimated that the tree roots at the eastern site would have reached 0.3 m below groundwater surface approximately 33 months from planting. It is also estimated that roots would have reached 0.3 m below groundwater at the western site in approximately 31 months. After the poplar roots reach groundwater, remediation of the contaminants in groundwater was promoted.[128]

[125] Negri, M. C.; Gatliff, E. G.; Quinn, J. J.; Hinchman, R. R.; (2003) Root Development and Rooting at Depths. In Phytoremediation: Transformation and Control of Contaminants, S. C. McCutcheon, J. L. Schnoor, Eds.; John Wiley & Sons: Hoboken, New Jersey, pp. 233–262.
[126] Espina, A. A.; Oxygen Addition to Stimulate Hybrid Poplar Root Growth in Petroleum Contaminated Soils. M.Sc. Thesis, University of Iowa, Iowa City, Iowa, 2004.
[127] Hutchinson, S. L.; Schwab, A. P.; Banks, M. K.; (2003) Biodegradation of Petroleum Hydrocarbons in the Rhizonsphere. In Phytoremediation: Transformation and Control of Contaminants, S. C. McCutcheon, J. L. Schnoor, Eds.; John Wiley & Sons: Hoboken, New Jersey, pp. 355–386.
[128] El-Gendy, Ahmed S., et al. "Assessments of the Efficacy of a Long-Term Application of a Phytoremediation System Using Hybrid Poplar Trees at Former Oil Tank Farm Sites." Water Environment Research, vol. 81, no. 5, 2009, pp. 486–98. JSTOR, http://www. jstor.org/stable/40575334. Accessed 27 Sept. 2024.
La Rue, V. S.; Bioremediation of Petroleum Hydrocarbons in Soil: Activated Sludge Treatability Study. M.Sc. Thesis, The University of Manitoba, Winnipeg, Manitoba, Canada, 1993.

Fig 7.4: Polar tree root system

Soil Remediation: Change over time.

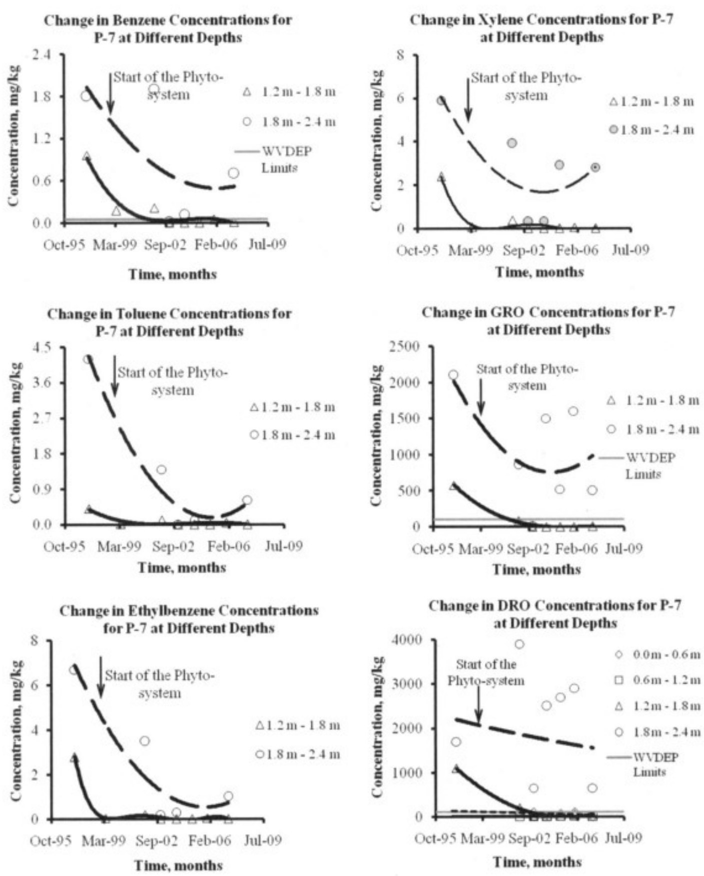

Fig 7.5: Change in concentration over time and depth of petroleum hydrocarbons in soil at easter site

Image source: https://onlinelibrary.wiley.com/doi/full/10.2175/106143008X357011?saml_referrer#waer-81-5-Pichtel1

Limitations

Phytoremediation using poplar trees can be used for the treatment of soils and groundwater contaminated with petroleum hydrocarbons. It can be applied at sites with contaminants at relatively shallow depths (for both soil and groundwater). It is well suited for low levels of petroleum hydrocarbons and large land areas where application of other remediation methods would be prohibitively expensive. Compared with other technologies, however, longer times are required for the cleanup of contaminated sites to below action levels. Phytoremediation using poplar trees may not be suited or efficient in cleaning up soils or groundwater highly contaminated with petroleum hydrocarbons. In such cases, it may be used in conjunction with other remediation technologies—such as soil vapor extraction (SVE), air sparging, or pump and treat—as a polishing step.[129] Phytoremediation systems require maintenance; however, the maintenance is less than for any mechanical system. Some of the significant problems in the field have been killing frosts or drought, insect or disease infestation, and herbivore browsing. The trees may require irrigation for the first couple of years to ensure survival. Application of fertilizer and other soil amendments (lime, limestone, phosphate rock, sulfur, peat, compost, organic materials) typically is required during initial stages. It is recommended that agronomic soil testing be used to determine suitable amendments, but there is no substitute for pot studies conducted in a greenhouse or plot studies performed at the site before final installation.

Summary

The experience gained at Cabin Creek shows that phytoremediation using poplar trees for the removal of petrochemical hydrocarbons such as BTEX and GRO can be applied at full scale with acceptable performance on relatively large, petroleum-affected sites. It is a slow process but with high sustainability and many positive environmental effects. Because these sites are not likely to be developed in the immediate future and there is no current groundwater use or other identified risk, the timing, cost, and physical effectiveness of the phytoremediation approach makes it an excellent choice for such sites.

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[129] El-Gendy, Ahmed S., et al. “Assessments of the Efficacy of a Long-Term Application of a Phytoremediation System Using Hybrid Poplar Trees at Former Oil Tank Farm Sites.” Water Environment Research, vol. 81, no. 5, 2009, pp. 486–98. JSTOR, http://www. jstor.org/stable/40575334. Accessed 27 Sept. 2024.
La Rue, V. S.; Bioremediation of Petroleum Hydrocarbons in Soil: Activated Sludge Treatability Study. M.Sc. Thesis, The University of Manitoba, Winnipeg, Manitoba, Canada, 1993

A similar cost-effective approach is needed at the recommended, contaminated parts of Hunters Point which was one used by the Navy before the land can be used for food production.

7.3.PLANTS SUITABLE FOR PHYTOREMEDIATION AT HUNTERS POINT

Few examples of plants that are suitable for phytoremediation that and are also suitable to be grown in San Francisco. [130, 131,132, 133, 134]

Fig 7.6: Plants for phytoremediation

[130] Ruttens A., Boulet J., Weyens N., Smeets K., Adriaensen K., Meers E., Van Slycken S., Tack F., Meiresonne L., Thewys T. Short Rotation Coppice Culture of Willows and Poplars as Energy Crops on Metal Contaminated Agricultural Soils. Int. J. Phytoremediation.
[131] Fulekar M.H. Phytoremediation of Heavy Metals by Helianthus Annuus in Aquatic and Soil Environment. Int. J. Curr. Microbiol.
App.
[132] Zhuang P., Ye Z.H., Lan C.Y., Xie Z.W., Shu W.S. Chemically Assisted Phytoextraction of Heavy Metal Contaminated Soils Using Three Plant Species.
[133] Yang S.X., Deng H., Li M.S. Manganese Uptake and Accumulation in a Woody Hyperaccumulator, Schima Superba.
[134] Priya, A K et al. "Clean-Up of Heavy Metals from Contaminated Soil by Phytoremediation: A Multidisciplinary and Eco-Friendly Approach." Toxics vol. 11,5 422. 2 May. 2023

7.4.POSSIBLE LOCATION OF PRODUCTION CENTERS

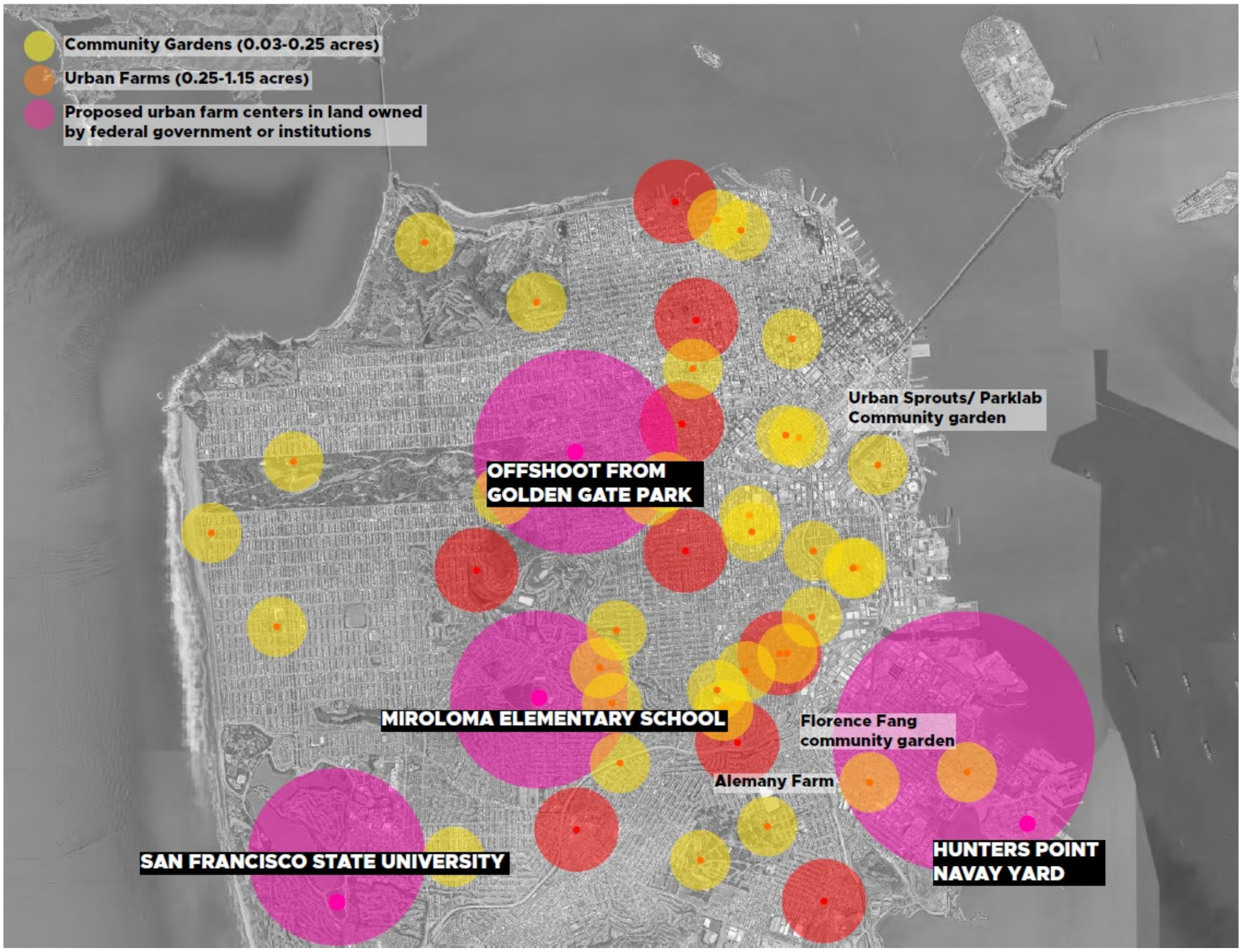


Fig 7.7: Proposed Urban farms in SFO

As discussed in the previous chapters, introducing a network of facilities in a loop system needs immense support from the government. Hence, to ensure their sustainability, initially these prototypes can be proposed in land that belongs to an institution or the government.

For this thesis the site for testing the loop system is Hunters Point.

7.5.STREETS OF SAN FRANCISCO

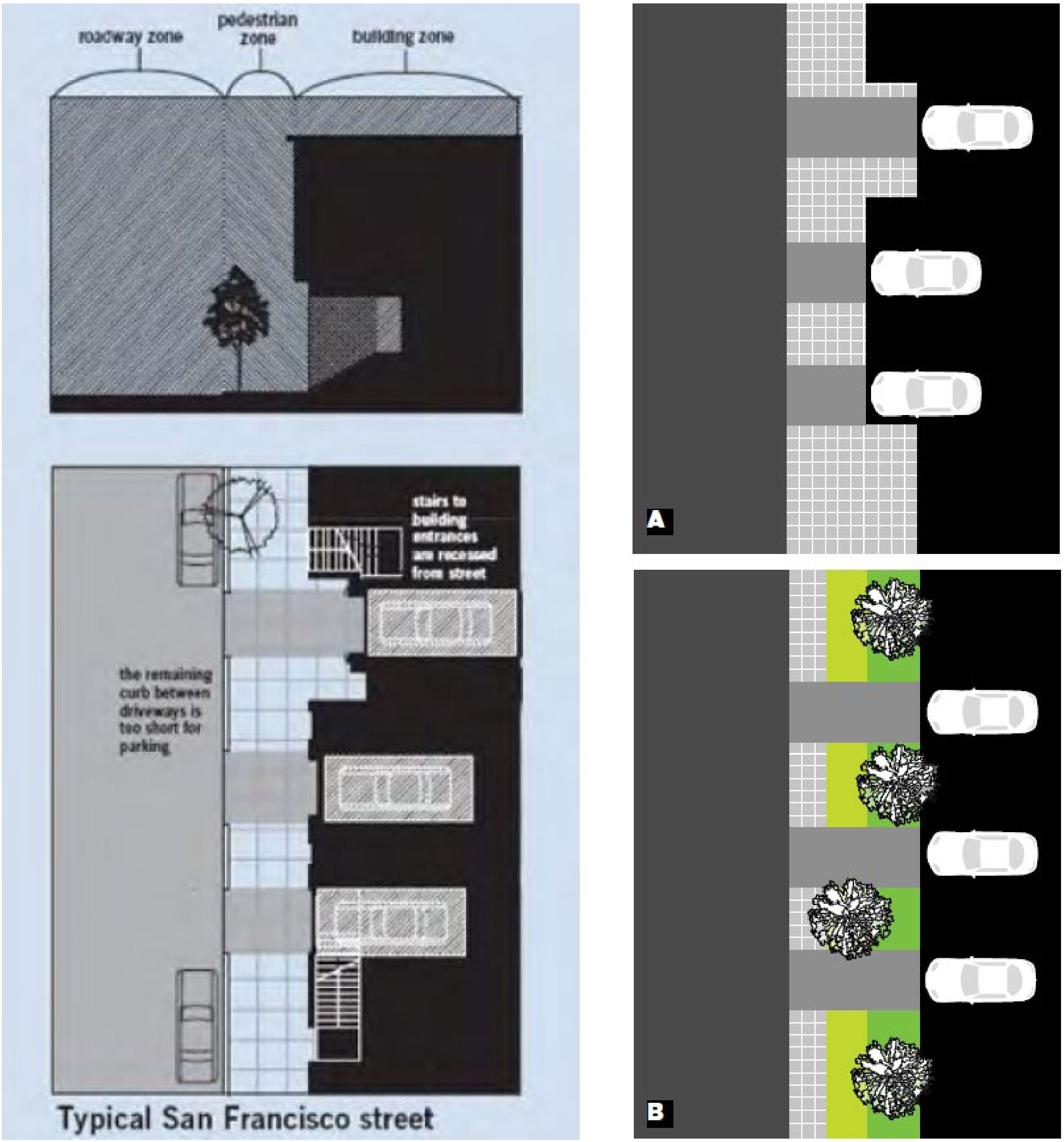


Fig 7.8: Existing and proposed streets of SFO

A. In a typical San Francisco street, transitions are absent or compressed. Curb cuts often preclude trees, curbs, and parking, exposing pedestrians to traffic and preventing the definition of a distinct pedestrian space. Buildings often lack a setback, reducing the privacy of residents and the comfort of pedestrians. Stoops and entry stairs are usually articulated inward, creating deep, cave-like spaces with poor security and no social use.[135]

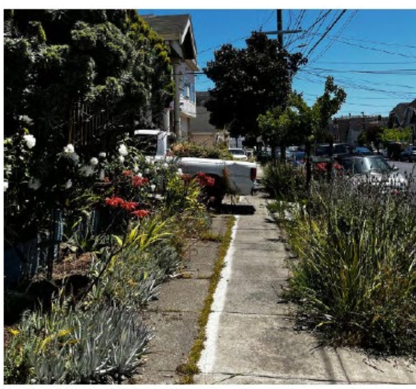
B. A proposal of how these uneven spaces can be used to make the space better socially and economically by introducing urban farming in front of houses in curbs.

7.6.EXAMPLES OF FRONT YARD GARDENS IN THE STREET OF HUNTERS POINT


Houses with gardens in front, in the pavements which are 25' wide.


Houses with gardens in front, in the pavements which are 25' wide.


Houses with gardens in front, in the pavements which are 25' wide.


Houses with gardens in front, in the pavements which are 25' wide.


Houses with potential for gardens in front, in the pavements which are 25' wide.

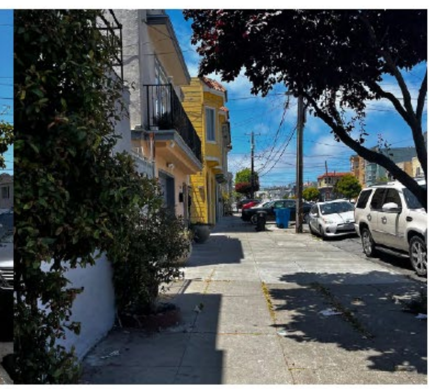

Houses with potential for gardens in front, in the pavements which are 25' wide.

Fig 7.9: Existing conditions at site

[135] https://www.spur.org/publications/ urbanist-article/2008-06-01/eye-street

7.7.PROPOSED NETWORK OF FACILITIES BASED ON CURRENT LAND USE AND ZONING BY NAVY

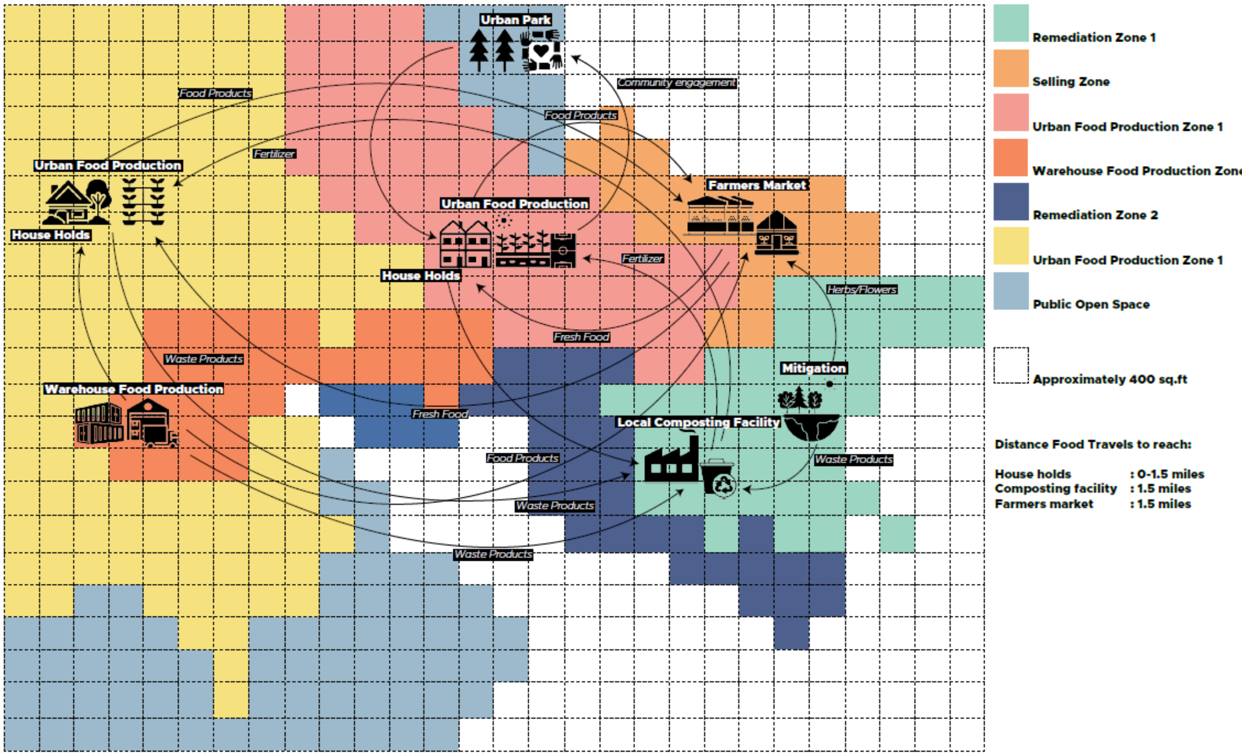


Fig 7.10: Proposed flow of resources

In the ideal circular future of organic residual streams in San Francisco, organic flows such as food and water of the highest quality are delivered to consumers. Organic residues are recovered in a high-value manner and reused in innovative applications. Core to this circular vision is int grated food production, food processing and biological processes, where nutrients and water flows are efficiently directed, and residual flows are valorised. This leads to a more varied chain for organic residual streams that requires less energy, nutrients, water and resources and achieves significant economic, environmental and social benefits.

7.8.NEIGHBORHOOD LEVEL LOOPS

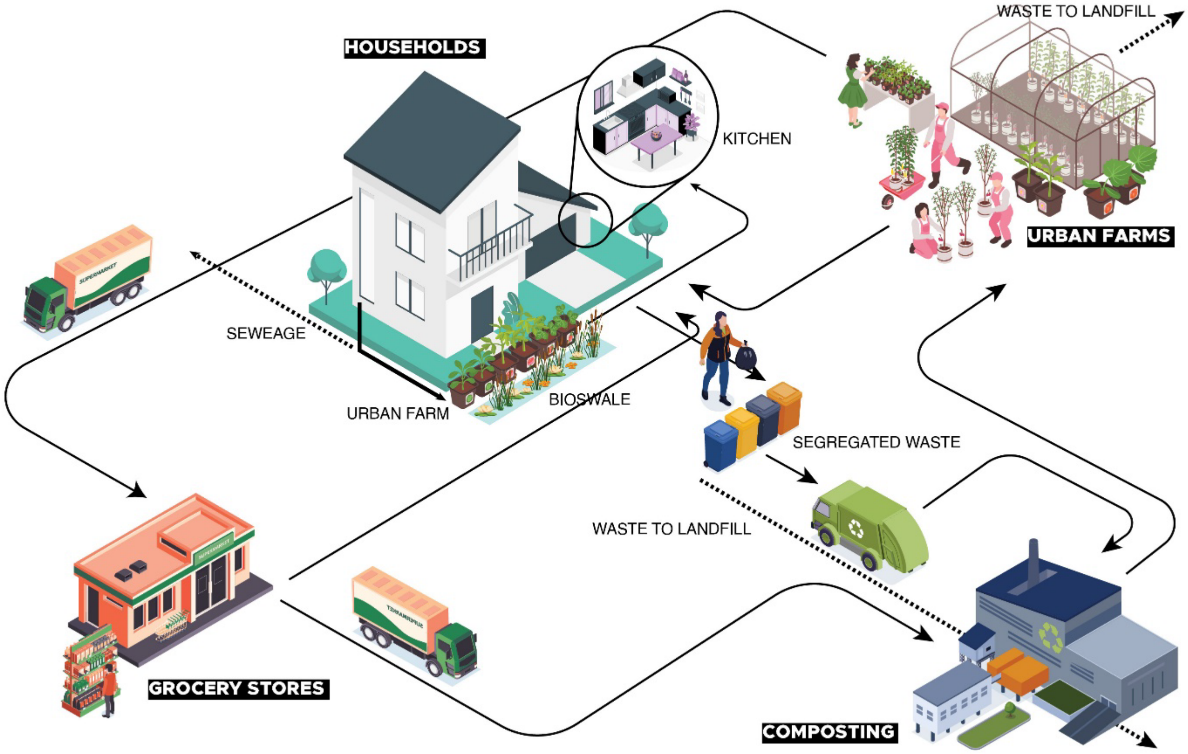


Fig 7.11: Neighborhood Loop Day 1

Waste from Kitchen

- The **waste** from the kitchen is disposed into color coded bags and segregated based on nature which is then taken to the composting facility. The compost from the facility travels to farm centers and markets from where it can be purchased for a subsidized price.

Water from Households

- The houses can be retrofitted with **a water** recycling system that can be used in front yard farms, and bioswales can be added when there is space in front of the house. Pavements can be made using permeable pavers, allowing water to flow into the production area.

Food Production

- **Food** from urban farm centers can be sent to farmers' markets and supermarkets in the neighborhood.

7.9.PROPOSED ACTIVITIES ON SITE

Master Plan

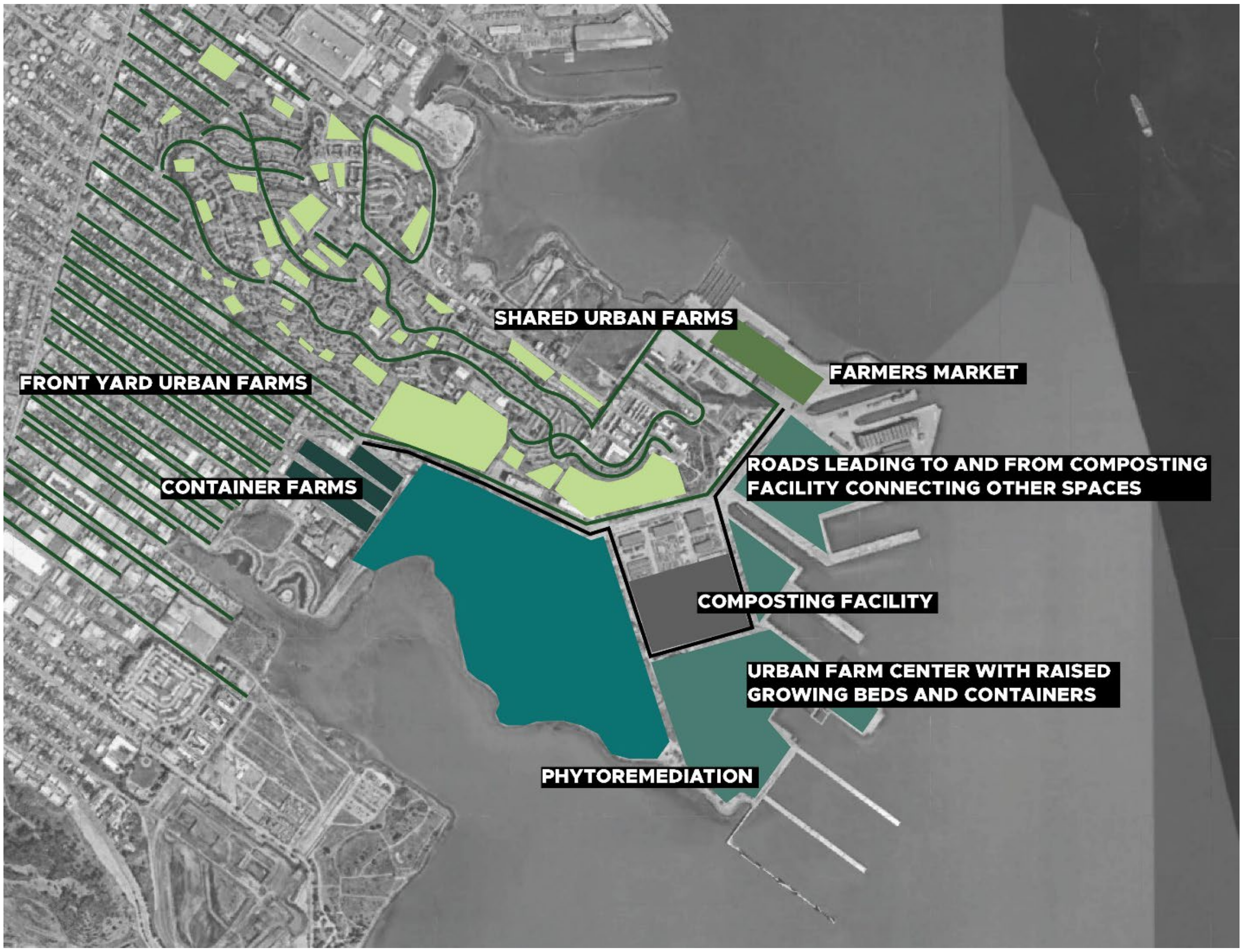


Fig 7.12: Proposed mater plan

Based on current land use and other recommendations, The master plan is proposed to host production of food in three ways:

- **Front yard farms where food can be produced in pavements that tare 25’ or wider.**
- **Shared urban farms at neighbourhoods that have common shared open spaces e.g. apartment communities.**
- **Food production in containers in abandoned warehouses.**

A farmers’ market to sell and buy produce is proposed in existing built structures present in the site. The buildings have also been found to have contamination to a certain level, hence cannot be used for growing food.

At this site, there is an existing road infrastructure that can be used to link the composting facility with the farms and the market.

A typical section of how spaces for food production can be designed on pavements.

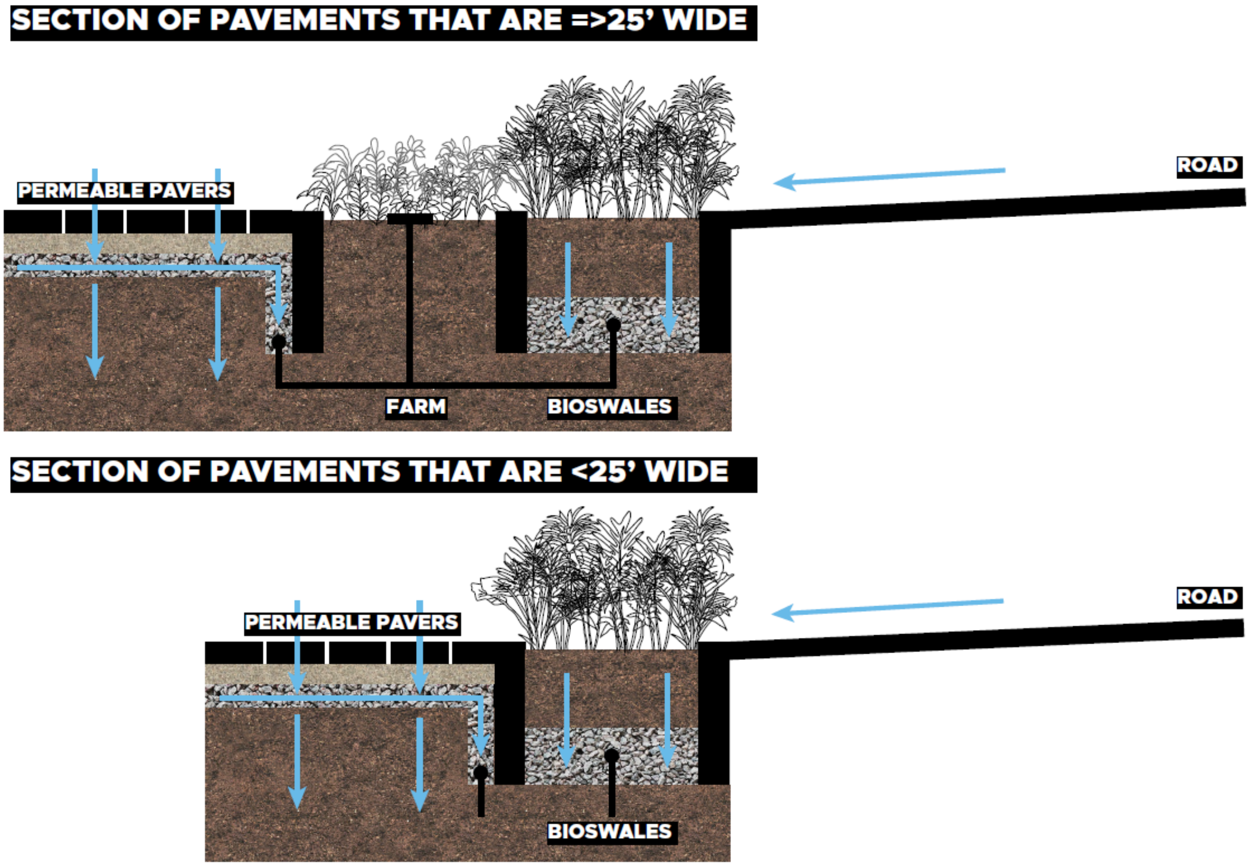


Fig 7.13: Sections of pavements based on width

Ideally, all impervious paving will be replaced with permeable pavers that allow water to infiltrate, which can then be collected and utilized by nearby farms. Road runoff will be captured by bioswales, providing an additional water source for the farms.

By incorporating bioswales along pavements where the width is less than 25 feet and combining bioswales with farms where the width exceeds 25 feet, a natural buffer is created between vehicles and pedestrians. This design enhances safety for street users while promoting sustainable water management for urban farms.

Fig 7.14: A perspective of how pavements with introduction of bioswales and urban farms can look.

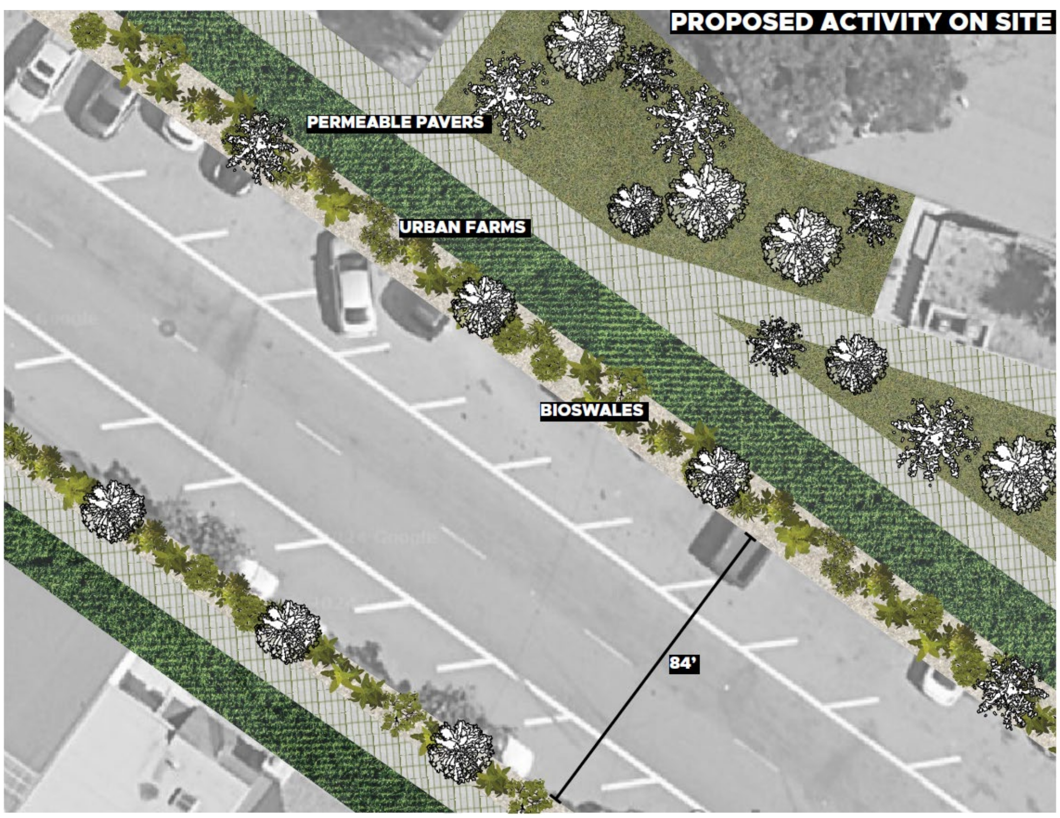


Fig 7.15: A plan of how neighborhoods with introduction of bioswales and urban farms can look.

Fig 7.16: A perspective of how farmers market can look.

7.10. PLANNING IN PHASES FOR THE SITE

There are parts of the site where food production can begin today but there are also other parts that need to be prepared to ensure safe growing medium. A timeline for 25 years and how the use of the land can change slowly with some zones starting with phytoremediation and slowing incorporation crop production.

An outline of how the site can change over the years. The timeline shows the progress that can be seen on the site in 25 years, starting with phytoremediation in the contaminated land that belongs to the shipping yard and urban agriculture in the front yards of residences moving on to introducing food production in land after remediation years later.

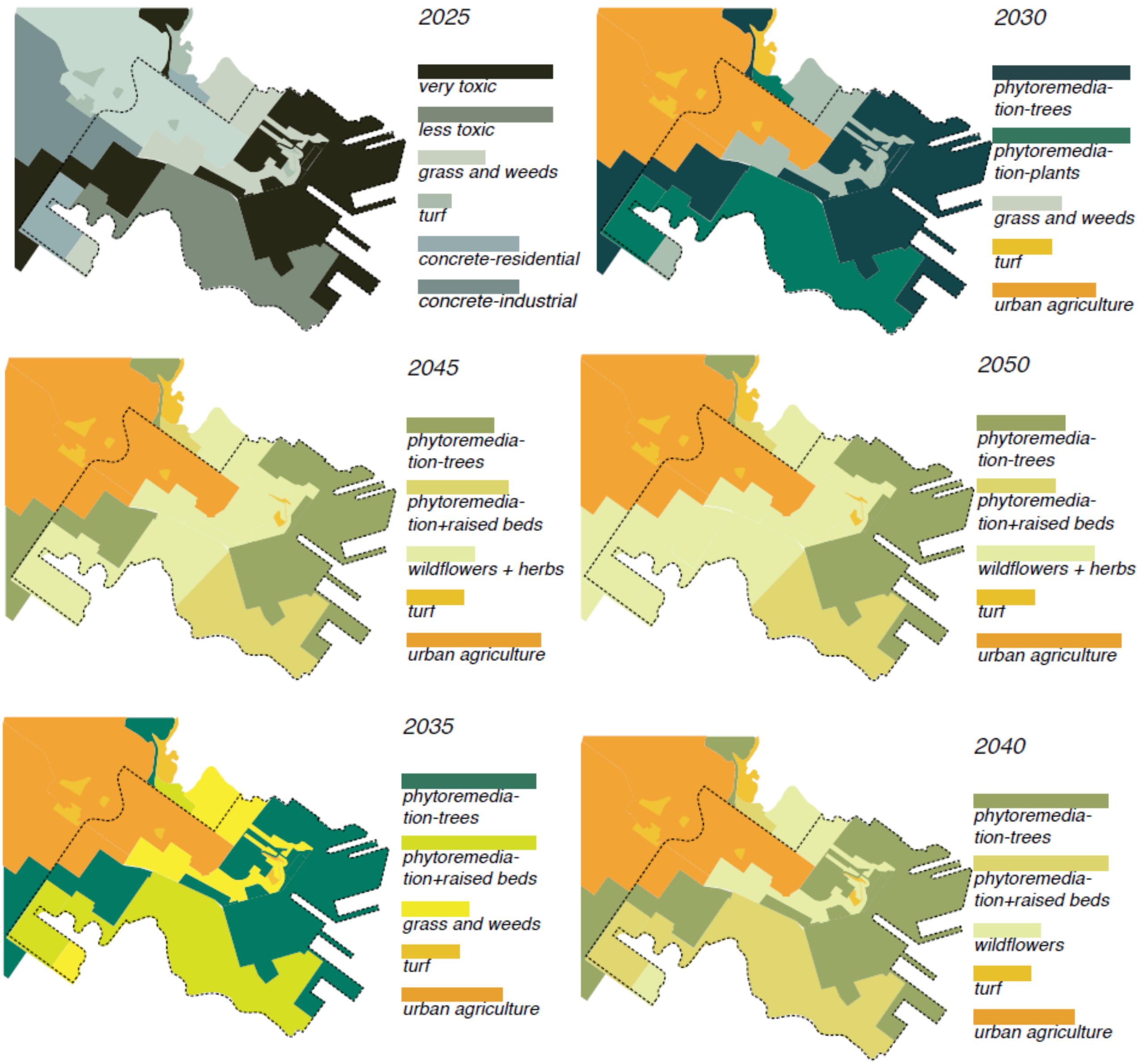


Fig 7.17: Phases of planning from 2025-2050

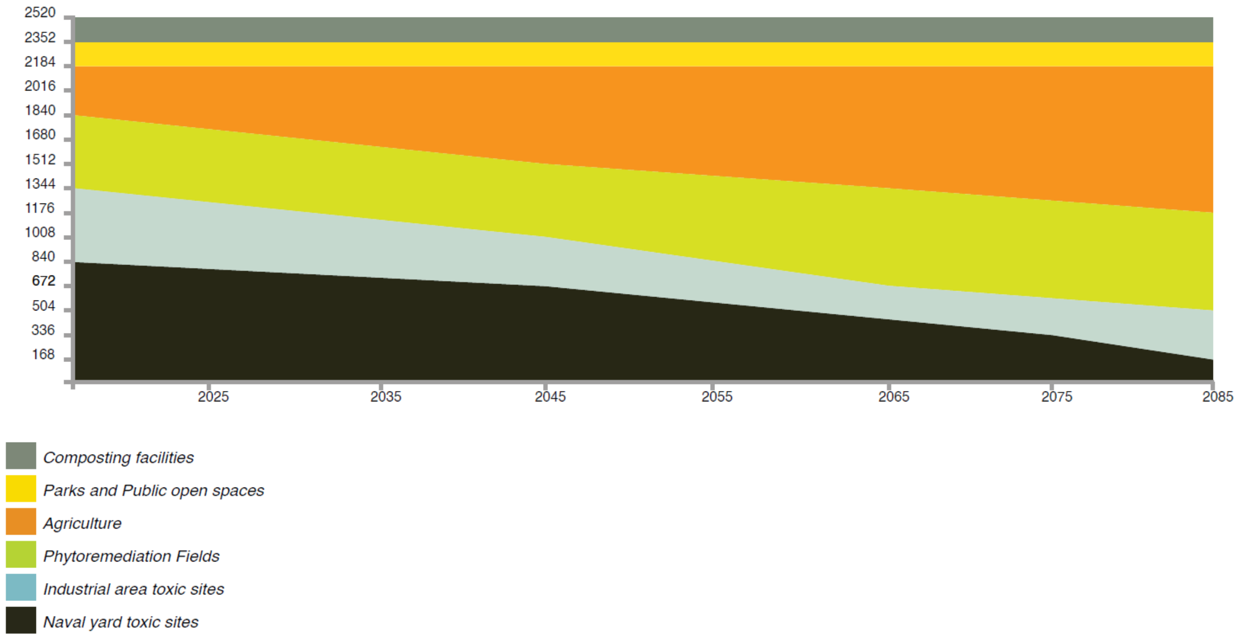


Fig 7.18: Phases of planning from 2025-2050

This graph shows changes in how the site will be used over time and the use of acreage over the years for a particular use.

CHAPTER 8: CONCLUSION

City models that are compact, which greatly reduce travelling distances are currently favored and are most likely to support sustainable development. Concepts like Continuous Productive Landscapes, Living machine compliment this idea by including the major contribution food production can make towards sustainability.

The ideas presented in this thesis focus on developing a loop system for a circular future, specifically emphasizing urban farming. However, urban farming represents just one of many components essential for creating a sustainable circular system to enhance urban resilience. This proposal is a starting point and Stakeholders, both within the government and in the market, will need to be engaged to act on the proposed directions.

The limitations of this proposal are

- Till date, producing food in urban areas like pavements is not a recognised land use.
- Some municipalities regulate where and how agricultural products can be sold. For example, some municipalities may only allow vegetable sales at farmers' markets or on-site.
- Urban farms face legal risks related to land use, water access, noise and odour, and food safety. Failure to comply with regulations can lead to fines, criminal penalties, or abatement orders.
- Taxation can be difficult for urban agriculture.
- There is no assurance for the maintenance of urban farms and may become eye sores if not well maintained.
- There are no guidelines on the ownership over these lands and can cause disputes between homeowners and tenants.

This thesis initiates a dialogue on implementing loop systems to benefit the city, its environment, and its residents. By integrating further research into additional components that could enhance the resilience of urban systems, alongside existing proposals and literature on similar approaches, it is possible to develop a network of facilities. Such a network could decentralize production in U.S. cities, fostering sustainability and adaptability.

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