URBAN EARTHSHIP 2026

Resource Generative Architectural Design

Master Thesis in Architecture

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Year of graduation/publication: 2026

Examiner:
Paula Femenias

Supervisor:
Walter Unterrainer

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Master Thesis in Architecture report

CHALMERS
UNIVERSITY OF TECHNOLOGY

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Master's Program: Architecture and Planning Beyond Sustainability

Profile: Building Design and Transformation for Sustainability

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Abstract

Most of the global population live in urban areas with limited control over production and the quality of their food. The scarcity of biologically productive space together with the degrading agricultural soils caused by conventional farming and the process of climate change have led to severe negative consequences for the environment and for food security.

There have been recent advancements in methods of decentralized and compact resource production. Controlled Environment Agriculture (CEA) techniques such as hydroponic vegetable cultivation and Recirculating Aquaculture Systems (RAS) have spatial qualities to be implemented in dense contexts like in cities.

This thesis explores how compact methods of onsite resource production can be architecturally merged in the design of a new multi-family urban residential building.

The project is complemented with the development of a bespoke inhabitation concept for the design. The design is influenced by references of in situ resource generation projects, the field of autonomous architecture and analysis of the specific site chosen for project.

The design process included concept development to formulate the project program and the synthesizing of the material into an architectural development procedure utilizing physical and CAD-models.
The result is a building design proposal on a site in Stockholm, in the northern parts of Hagaparken on a plot currently used as parking site.
A collective inhabitation concept for 200 residents who not only live but also work part time in the building together.

The building is open to the public by its restaurant that serves both the inhabitants and visitors food from what is grown and produced in the project.
The thesis draws conclusions from the design regarding architectural consequences, inhabitation aspects and diet.

The experimental architectural outcome of this project indicates that it is plausible to facilitate self-sufficient food production in an urban residential building and fulfill most of its inhabitants' daily demand of food nutrition like proteins. This is achieved by the design of a collective inhabitation concept, architectural synthesis of spatial functions and technology together with the composition of a healthy and tasty diet cooked from what is grown in the house.

Table of contents

Front cover	I
Front page	II
Abstract	III
Table of contents	IV
Student background	V
Introduction	1 - 12
Introduction	1
Purpose / exploration	3
Background & Discourse	6
Aim and research questions	11
Methods & Tools	12
Delimitations	13
Context & Analysis	14 - 30
Site selection	15
Site Annelund	25
Site Analysis	26
Agriculture	27
Concept development	29
System design	30
Concept & Design	31 - 56
The Urban Earthship	32
A day in the Urban Earthship	33
Inhabitation concept	36
Diet	37
Program	39
Design	40
Sitemap	41
Sections	42
Spatial composition	45
Floor plans	46
Summary agriculture yield	59
Discussion	61
References	64

Student background

Education:
Master Program: Architecture and Planning Beyond Sustainability
Studios at Chalmers:
Design and Planning for Social Inclusion
Beyond Sustainability: Crash Course
Sustainable Architectural Design
Building Climatology for Sustainable Design
Material and Detail*

Bachelor of Fine Arts in Architecture, Umeå University

General Arts and Craft, Nyckelvikskolan

Internships:
Arcus architecture, Stockholm
Axeloth architecture, Stockholm

Previous occupations:
Chef at preschool and at various restaurants. Military veteran with four abroad deployments.

Introduction

Welcome to the report of my MSc thesis in architecture at the architecture and planning beyond sustainability program at Chalmers university of technology in Gothenburg, Sweden.

This is the report of a design investigation project with the ambition to elaborate on and to connect emerging resource production strategies with residential architecture. With the intention to advance urban resilience and self-reliance of food where most people live.

Initially this report establishes the thesis area of exploration, the purpose of the study and the thesis' main questions and objectives are specified. As well as the thesis methods and delimitations.
A site study and the explorations of technologies regarding in situ resource generation and management relevant for the project are researched followed by the studies of reference projects and theoretical concepts and buildings dealing with autonomy, decentralization and self-sufficiency in architecture.

The material is processed together with a concept development and system design phase resulting in a proposal of an inhabitation strategy with an corresponding program.
A process of further architectural synthesis and design generates an architectural concept and building design proposal. An outcome that is described and extrapolated from its model the potential resource generation quantities specifically in terms of food estimated.
The project is finally concluded and reflected upon.

/ Enjoy Magnus Olsson

“Global food production threatens climate stability and ecosystem resilience and constitutes the single largest driver of environmental degradation and transgression of planetary boundaries”

EAT-Lancet Commission. 2019

Purpose / exploration

In 2004 the World Wide Fund for Nature (WWF) estimated that the footprint on space with an average of global biological productivity was on average 2,2 hectares per person in world. Unfortunately, there is only 1,8 of these hectares available per person on this planet. Meaning that we are using about 1.2 planets or it will take 1.2 years for the planet to regenerate what we use in one year.

The limited farmland and its vital soil are also declining. Modern agrarian practices such as monoculture farming degrade the soil by compaction, erosion, and rising salt levels. In 2000 it was estimated that agricultural productivity globally decreased by 15 % in fifty years because of soil degradation (Walker & Salt, 2006, page 2).

Global food production is the environmental degradation single largest driver. A system that still leaves 820 million people without enough food and many more that live on adverse diets. The summary report of the EAT-Lancet commissions asserts that:
- “Unhealthy diets now pose a greater risk to morbidity and mortality than unsafe sex, alcohol, drug and tobacco use combined” (EAT, 2019. page 5).

The process of climate change with temperatures assumed to rise at least 1,5° Celsius over pre-industrial levels put the agricultural sector and global food security at risk. Even with the swiftest mediating reduction of greenhouse gas emissions, the changing of climate patterns and the increased frequency of extreme weather events are to be expected.

The agricultural sector is very exposed to this and if it fails it will bring down not only the local farmers but also economic networks on all scales and the global trade that people all over the world depend on (Adams et al, 2021, page 14).

As water has become an increasingly precious resource the centralized aging pipe networks in the cities come with a significant cost to maintain and operate. The inefficiencies in these systems designs are also wasting resources like energy, water, and nutrients (Leigh & Lee, 2019). Decentralization is proposed as a main strategy to
improve the resilience of the Urban Water infrastructure (UWI). An approach that promotes the introduction of small scale or community managed water system or facilities in the city (Asghari et al, 2023, page 11).

In 2017 54% of the global population were living in the urban areas. Cities are responsible for the consumption of 75% of natural resources. They produced 60 -80% greenhouse gas emissions and 50% of the world’s waste (Ellen MacArthur Foundation, 2017, page 4).

The rural farmland needs to be relieved from its unsustainable production demands to feed the cities with food that in many cases ends up being unhealthy for its consumers.

What if agriculture and resource production could be relocated to the places where most people live, and rural farming were given the opportunity to transform its methods into more sustainable practices?

What if people in the cities had the opportunity to grow a substantial proportion of their own food by themself?

What if the urban population were in direct control of the production of renewable energy and water and were given the opportunity to take responsibility and advantage of their own waste?

What if it was possible for people and communities in the cities to achieve increased autonomous self-sufficiency over these fundamental resources?

This thesis aim is to address all these questions. With the design of an urban building the thesis will exemplify how the lessons from the field of autonomous architecture can be synthesized together with novel technological systems to create generative and resilient buildings in the urban landscape.

This thesis project is an architectural design of a resource generative building in an urban context. As a previous professional chef I have great interest in the aspect of food as well as in food production.

The expected outcome of the thesis is an architectural design proposal for a building that produces food by farming, harvesting energy and water on site and having strategies for waste treatment on how the different functions in the building can support each other in system.

The project will be inhabited and operated by its residents and the scale of the building is to be relevant for an urban context. The project will be located at a specific site and the relationship with the context will influence the design.

The architectural process will produce a model to be measured and evaluated in terms of its potential to produce food, water, energy. The architecture will be presented with visualizations, 2D drawings such as plans, sections, elevations and CAD as well as a psychical model.

Background & Discourse

In comparison to conventional urban residentials buildings there are very few examples of bringing substantial food production into the cities and its inhabitants by architectural design and the implementation of controlled environmental agriculture. However, the field Resource Generative Architecture has all the potential to expand as necessity, and the rewards of this approach will hopefully be further acknowledged.

Contemporary Autonomous Architecture projects have upgraded the aspects of self-sufficiency and on the site resource production and utilization. These projects are often rural and benefit from the possibilities with larger areas, but architectural ideas developed in these buildings can be source of influence for all building designs with the ambition to have a conscientious relationship with resources and the elements.

Figure 1. Center for Urban Agriculture. (Mithun 2007). Design and image by Mithun

Resource Generative Architecture

The Center for Urban Agriculture
In 2007 Mithun Architects, planners and designers won the “Best in Show” at the Cascadia Green Building Council 2007 Living Future Competition for this proposal in Seattle. It is a hybrid building that combines dense multifamily urban residentials of 318 apartments together with food production, energy harvest with storage and water collection. The 21-story building is designed for a specific triangular site in Seattle. The south facing side of the building has 3150 m^2 of photovoltaic panels with energy generation of approximately 550 000 kWh per year. The vertical growing spaces give every resident 17 m^2 of farmland in the building.
The project also includes a chicken farm and collective spaces such as a restaurant and café and an educational library (Gorgolewski et al, 2011, page 144–148). The project’s hybrid program as residential and resource producing function in an urban context have influenced the thesis concept and architectural development.

Greenhouse 5.0
An example of the vision to combine urban living and substantial self-sufficient farming is the Greenhouse 5.0 house by Joost Bakker in Melbourne, Australia. A project that showcases the potential of a zero waste and generative way of living in the city. It is an exhibition of how an urban residential space can be
integrated with various methods of farming for food.

The 87 m^2 building is inhabited by the two chefs Jo Barrett and Matt Stone who operate the house and production and cook food from what is produced on site to small groups (Johnston, 2020). The project has an emphasis on food and food production which is supported by several systems of farming (including CEA) and recycling. The focus on in-house urban food production with a corresponding diet are beneficial aspects for system and program design during the development of thesis project.

Autonomous Architecture

Autonom Byggnad
At Chalmers University of Technology, the architecture professor Hans Nordenström and the research group EKO-BYGG explored the subject in 1970s. The group inquired how the built environment could be developed for greater resilience to face the expected challenges like energy crises and other disturbances of the functions in society.
The group established that they should be guided by an ecologist, interdisciplinary and democratic perspective to invest in combined technological building systems with a high rate of self-sufficiency based on recycling and upcycling.

Nordenström elaborated extensively on the system design of the Autonomous Building (artificial ecosystem) concept. The idiosyncratic diagram of the project from 1973 connects features like resources, materials, technologies and processes regarding the building in systems that conceptually stem from notion of four elements, such air, earth water and fire (Nordenstrom, 1974, page 14).
The method of developing schematic diagrams in the buildings system design will be used in the thesis as well as processes and features in the Autonomous Building (artificial ecosystem) concept.

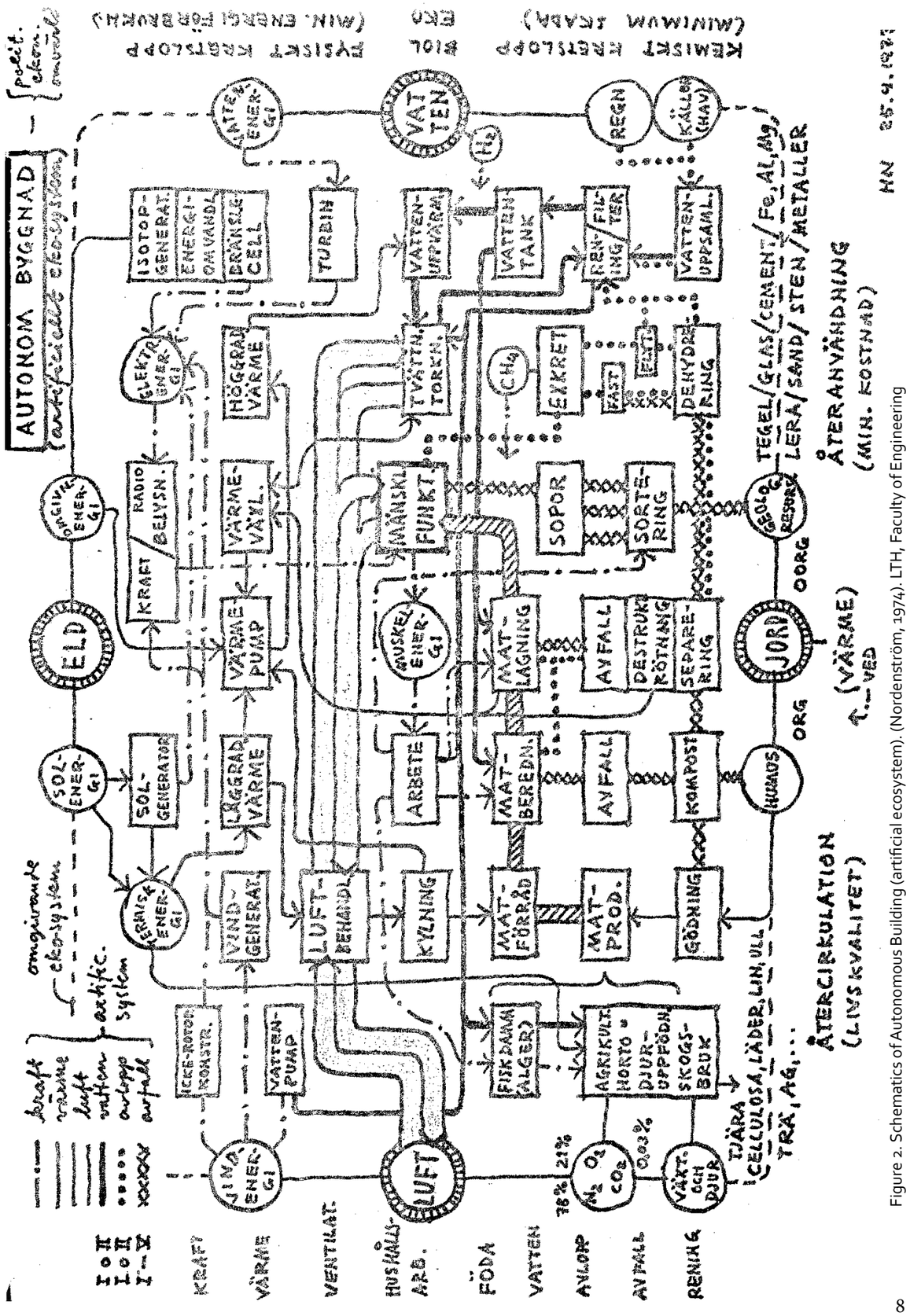


Figure 2. Schematics of Autonomous Building (artificial ecosystem). (Nordenström, 1974). LTH, Faculty of Engineering

Earthships
In the American desert independent off the grid buildings has been unconventionally pioneered by the architect Michel Reynolds. The development of the Earthships shelters has set a precedent on how a building can actively contribute to its own operation and sustenance for itself and its inhabitants often in a remote and rural context. These are homes with integrated methods for autonomous living such as system for potable water production, energy harvest, and food production on site (Booth et al, 2021).

The fundamental source of energy to life on earth is the sun (Fuller, 1969, page 59), and the influence of the sun's influence cannot be underestimated in the designs of these buildings. With floor plans aligned towards the south and the sun the houses are planned with the intention that the interior climate is to be energized and mediated by the sun. Passive solar energy strategies that make use of thermal mass and solar heat gains are architecturally implemented in these buildings.

Consideration of the environmental conditions in the context with be done in the thesis project development both in the selection of the projects site and in the architectural composition and use of materials. Passive strategies to harvest and manage resources like energy and water will apply in the thesis building design.

Figure 3. Amzi Smith. (2011)
Inside greenhouse of Global model Earthship (cropped). Wikipedia. CC BY-SA 3.0

Figure 4. Biodiesel33. (2011) G2 Global model Earthship Taos N.M. (cropped). Wikipedia. CC BY-SA 3.0

Controlled Environment Agriculture

The technological development of space and water efficient controlled environment agriculture (CEA), the increased efficiency of photovoltaic solar cells and the method of treating and recycling wastewater with bioreactors have reached great potential for the possibilities for decentralized resource production.

Vegetables, plants and mushrooms can now grow space efficiently indoors. Farming methods that can be combined with indoor fish farming such as recirculating aquaculture systems (RAS) that utilize organic bioreactors that significantly reduce the water demand compared to conventional systems.

Fungiculture

Aquaculture

Hydroponic horticulture with artificial lighting

Aim and research questions

To direct my thesis investigation, I have formulated an aim and research question that is followed by a couple additional sub-questions.

Aim:
To explore, conceptualize and to exemplify alternative ways of living in relationship with resources that advance resilience and promote food sovereignty in the city where most people live.

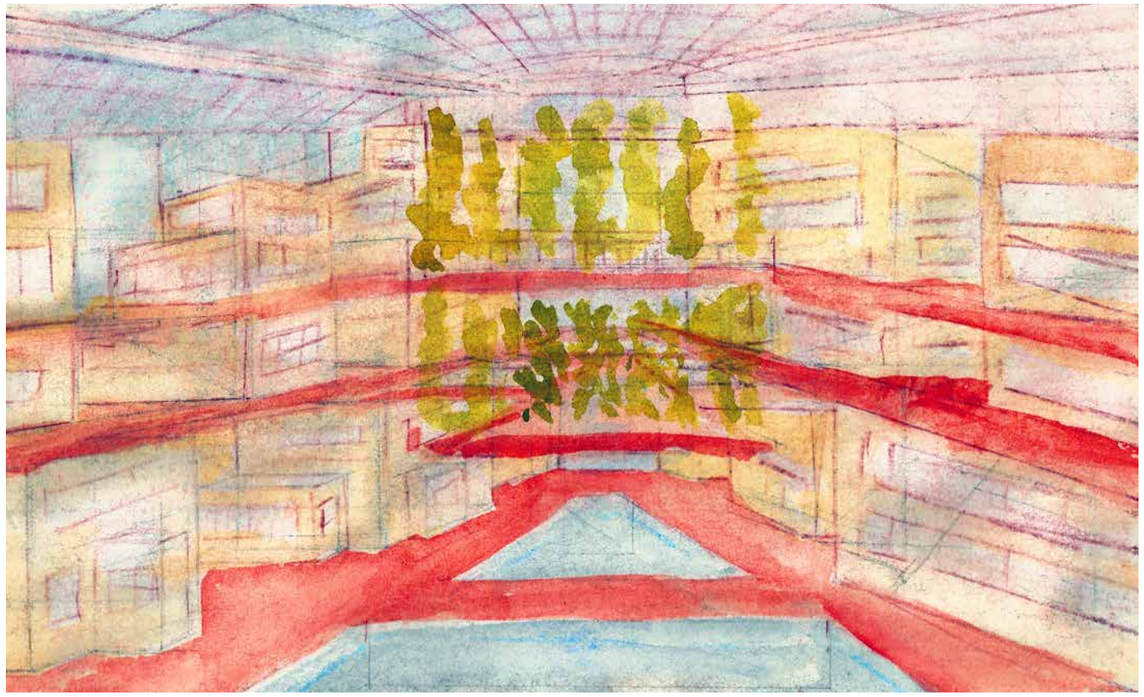
To develop an experimental design prototype of an urban inhabitation concept with an architectural proposal on a site that synthesizes the dwelling with onsite resource generation such as the production of most of the food consumed by its residents.

Research questions:
How can resource generative technologies such as Controlled Environment Agriculture be architecturally integrated with urban dwellings?

Sub-questions:
How could the lifestyle and the homes look like when merged with substantial resource generation?

What would be the architectural and dietary consequences by an architectural design that synthesize Controlled Environment Agriculture with urban dwellings?

What characteristics could appear when urban lifestyle and home are synthesized with substantial resource generation?



Watercolor sketch

Methods & Tools

Methods:

Literature studies
To acquire relevant knowledge regarding purpose, architectural concepts and technical properties I have studied written sources both online and in print. This also includes site specific environmental data and individual resource information like the nutrient information of certain agricultural crops

Precedent studies
By examining architectural projects and proposals that have introduced agriculture and resource generating functions in residential buildings I have obtained material and approaches suitable to consider for implementation in the project.
This includes case studies and properties relating to conventional and controlled environment agriculture methods.

Observations
By visiting and studying the site and the context I gathered impressions and insights regarding the local circumstances. This information was integrated in following site analysis that supported the conceptual and architectural design development.

Site analysis
The collected site information was analyzed with the SWOT technique to identify strengths, weaknesses, opportunities and threats to be regarded in design process. The material was visualized in a diagrammatic site map.

System design
Whilst developing the concept and the program I coordinated the functions into a system where the various features and processes in the building were connected and arranged to support each other as they were operated and/or transformed.

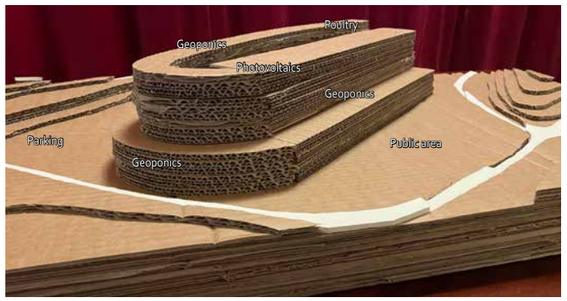
Architectural design
Architectural design has been the main method to synthesize the concepts, program contextual features into a building protype proposal.

Tools:

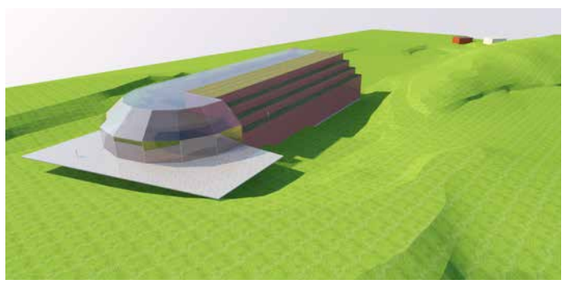
Sketches
Hand drawn sketches were used especially during the design process to visualize architectural concepts and potential solutions.

Psychical models
Rudimentary physical sketch models in scale 1:200 was used to spatially compose the volumes of the project in relationship of the site.

BIM-CAD
The building design was developed with Graphisofts BIM-software ArchiCAD 29 as the primary digital modelling software.
Visualizations are rendered with Twin motion / Unreal engine software.



Physical sketch model 1:200



CAD sketch

Pencil sketch

CAD iterations

Delimitations

Some of the architectural aspects and agricultural systems may be unconventional and can challenge current rules and regulations.
The thesis design process will allow itself with a speculative relationship with
legislation if necessary to advance the design.

The architectural design aims to be economically reasonable but novel technologies may be expensive. The thesis will not elaborate on the design's up-front economic conditions.

Site selection

With the intention to finally be a to present a straightforward example of a design prototype and readable architecture, the project was positioned at a specific site.
Even thou the conceptual development and system design would be possible to expand on with a predominantly hypothetical and schematic focus. Such approach would risk only generating a generic outcome without any relationship to any context and thus miss the opportunity to anchor and bring the ideas into existence with the support of place in the real world.

To find a suitable location for the project several features of the potential site were to be of key consideration in the search. I was primary located in Stockholm at the time of this thesis development. A city with a relevant inhabitation density for the project could be found.

Stockholm also has climate with cold winters and warm summers that gives architectural challenge circumstances that in end would generate a more flexible and adaptative design. The access for in-situ observations and the other basic factors to be regarded as appropriate, Stockholm was set to be urban context where the additional criteria for site selection were formulated.

Photograph from visit at the Annelund site.

Criterions for site selection:

Urban relevance
The locations distance from the city center and the areas building and population density. The closer to the city center (Gustaf Adolfs Torg) and higher density the more relevant for the project.

Ground water availability
The prospects to autonomously harvest recourses like water and energy on site to compliment the municipal grid. The government agency Geological Survey of Sweden provided data online (https://apps.sgu.se/kartvisare/kartvisare-grundvattentillgang.html) regarding the ground water availability in Sweden and Stockholm.
This information was used to extract a selection of locations with promising ground water availability aspects in Stockholm.

Sun conditions
The potential to harvest solar energy with photovoltaics and vegetable cultivation can be supported by natural sunlight on the site. Preferably unobstructed views towards the south with a low presence of shadows from things like adjacent buildings and trees.

Connectivity
The locations proximity to roads, public transport and potential for utility connections.
This information was collected from primary maps studies, and the utility connection potential was estimated by the presence of neighboring connected buildings in the vicinity of the site.

Topography
How is the landscape shaped and create challenges and/or opportunities for architectural design.

Current site use
What is the on the site now and to what degree would it be constrictive or disadvantageous to replace or transform the present situation.

Contribution to the context
What effect would the project have on area and what activates or stakeholders would be affected by the change caused by the additional development?
Are there any current processes that go on at the site or are there any groups in the area that can be empowered by the project and what is the potential for the project supporting the local environment and cultural life in the context?

Potential sites 1-3 (6)

Frösundavik

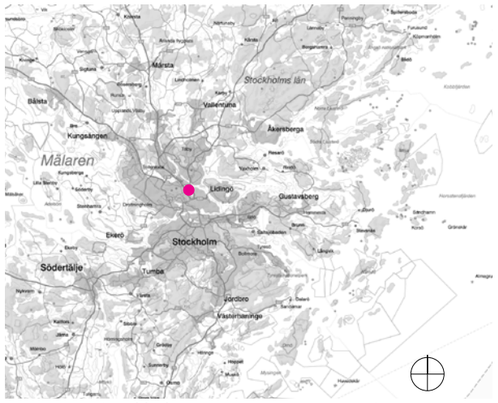
Strengths
A very central location north of the recreational park of Haga Parken with it is nature and historical royal recreational architecture and current royal presence. The area presents up to three potential plots that can be suitable for the project.

One of them, site B, is a circular car park. A shape that is suitable for a sun-linked/facing architectural building. The three sites also give the opportunity for a dispersed project and an elaborate development of a community management of the project.

Weaknesses
According to the municipality zoning, it is only allowed to build on plot A.
Disregard of zoning can accentuate the speculative character of the project. A dispersed design can also inflate the scope of the project.

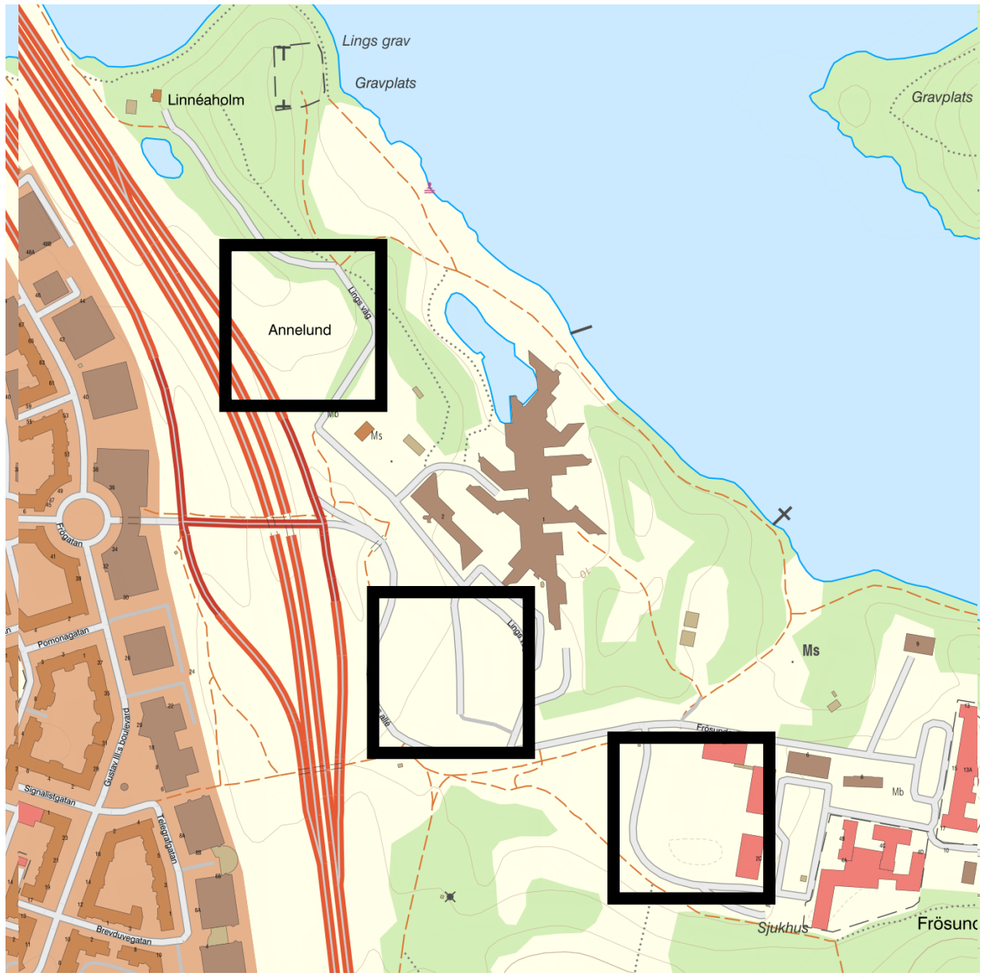
Opportunities
The area is varied with parks, forests and pastures. Historical and modern buildings with expressive design. But some plots seem to be overlooked. The area can handle additional idiosyncratic buildings, especially if it manages to connect to the nature in the park.

Threats
The area is of interest to several actors who can be critical of the project. Stakeholders like estate investors (which own parts of the land) to associations of recreational users which previously had their own ideas on how to develop the land.



Location in Stockholm @Lantmäteriet

@Lantmäteriet



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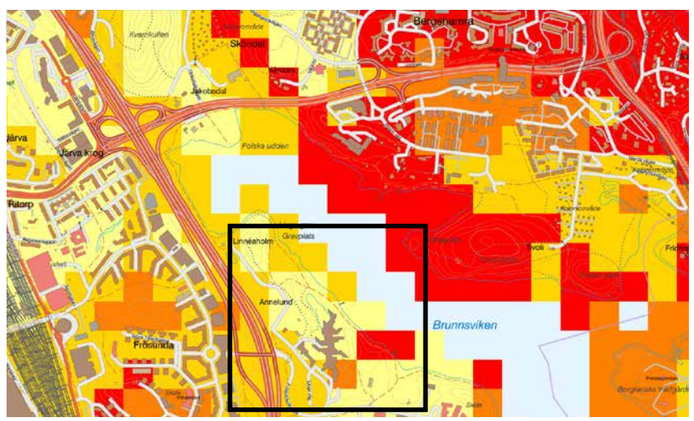
Groundwater availability (l/day/ha)
sgu.se

- < 250
- 251 - 500
- 501 - 1 000
- 1 001 - 1 500
- 1 501 - 2 000
- 2 001 - 3 000
- 3 001 - 4 000
- > 4 000
- Ingen data



@SGU CCo

Potential site 4 (6)

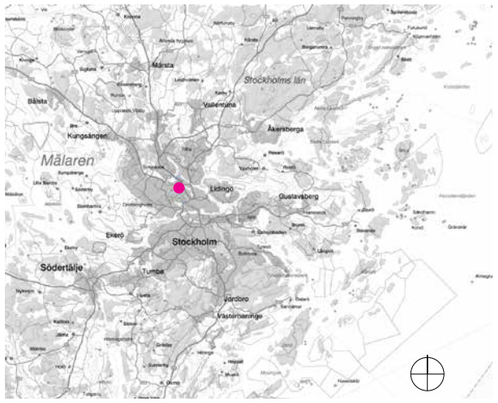
Solna

Strengths
A project here can both reclaim the area of the neighboring nature reserve and create an interface with it that is both beneficial for the nature reserve and the architecture.
The site size suggests an architectural intervention with a limited footprint and vertical composition.

Weaknesses
Current activities on the site such as parking may be problematic or even illegal.
Noise from the trains may be issue for residentials.
The site is partially shadowed from the buildings in the east.

Opportunities
For its central location and the neighborhood recent prominent development such as the National Arena, the plot seems now neglected from any qualitive development.

Threats
If the connection between the nature reserve and project fails and/or is communicated poorly the project may be perceived as harmful for the nature reserve. Actors which are using the site improperly can be exposed and act defensive.



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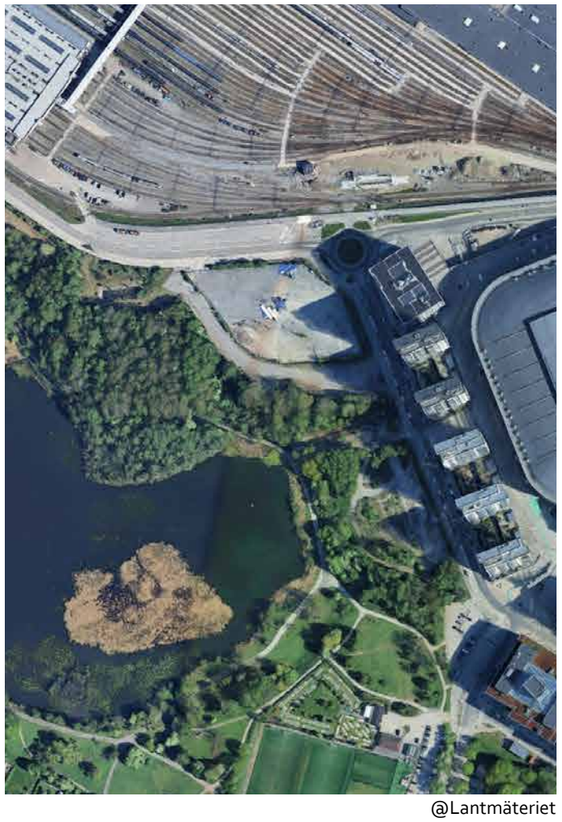
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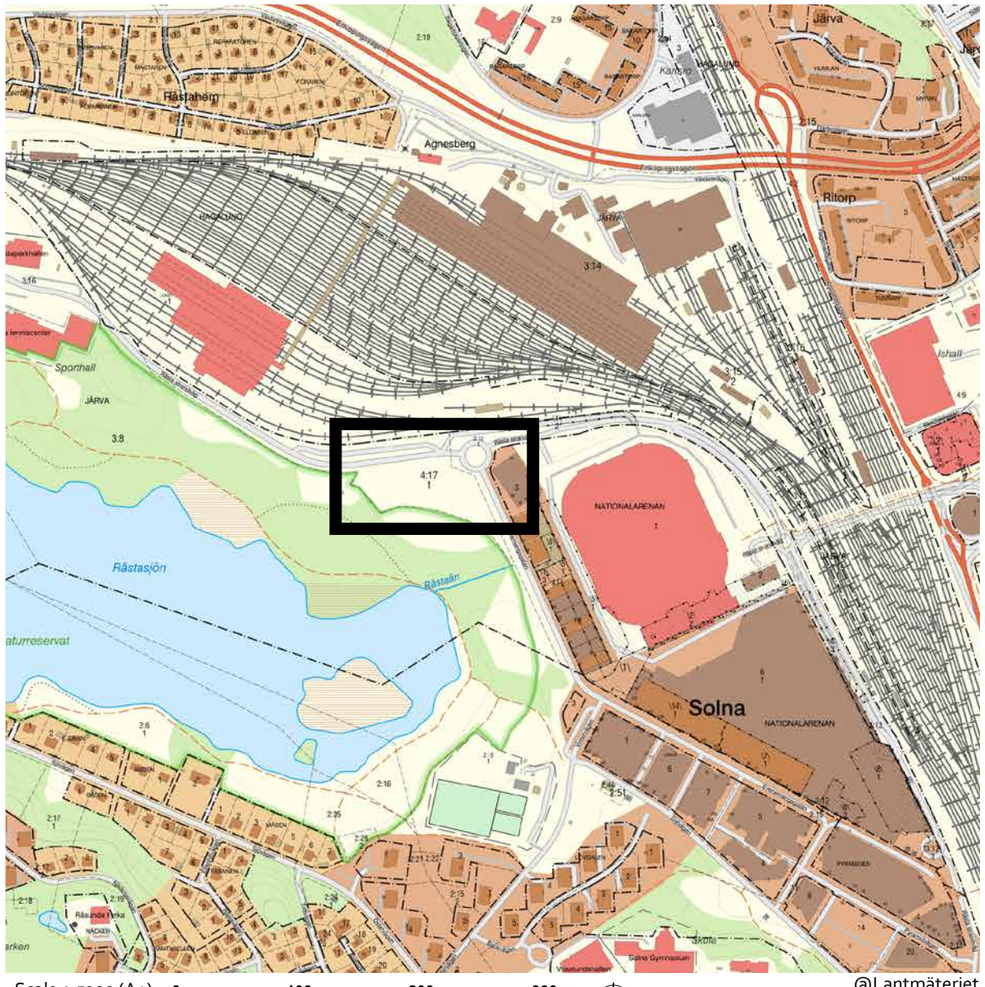

Råstahöjden
Agnesberg
Järva
Ritorp
Sporthall
JÄRVA
NATIONALARENAN
Rålambshovsparken
Rålambshovsleden
Rålambshovsbadet
Rålambshovsbron
Rålambshovsvägen
Rålambshovsparkens tennisarena
Rålambshovsparkens hundrastgård
Rålambshovsparkens lekplats
Rålambshovsparkens parkeringshus
Rålambshovsparkens restaurang
Rålambshovsparkens utegym
Rålambshovsparkens vattenspel
Rålambshovsparkens vattenspel och fontän
Rålambshovsparkens vattenspel och fontän
Rålambshovsparkens vattenspel och fontän

Potential site 5 (6)

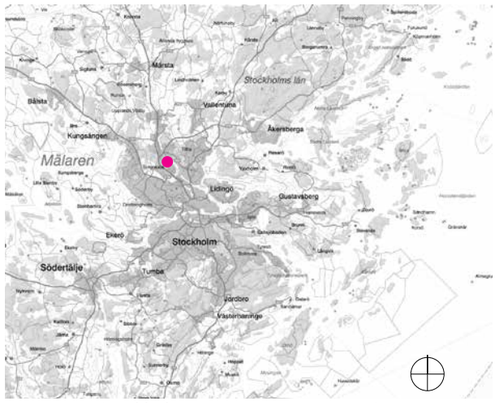
Sollentuna

Strengths
A municipality owned area that can be complemented with the project's additional functions and serve as a transition of residential to sports and recreational areas.

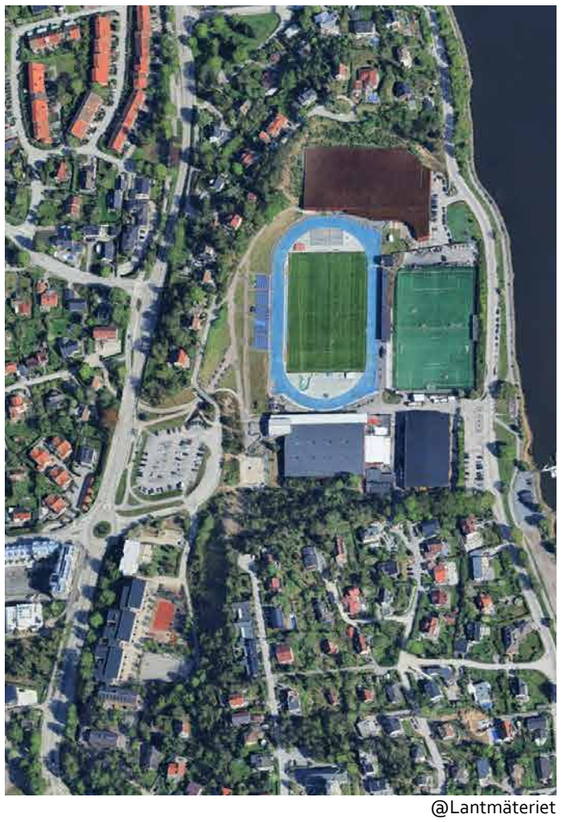
Weaknesses
The site has a challenging topography with slopes to the north and to the west.

Opportunities
A project that can collaborate with local actors like restaurants to strengthen and to promote local identity in the suburban district.

Threats
A project on the location may disturb local activities if implemented carelessly.
The project can be too expensive and speculative because of the cost of building on such a steep site.



Location in Stockholm @Lantmäteriet



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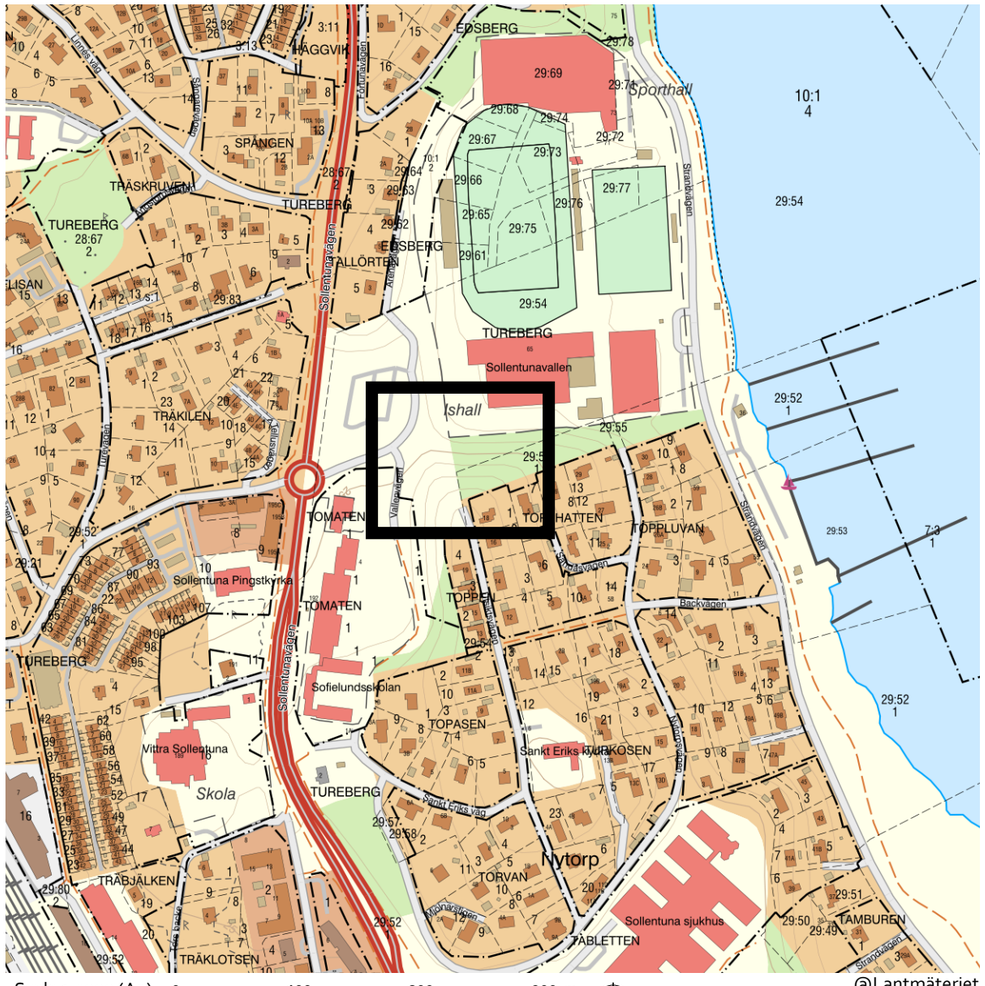

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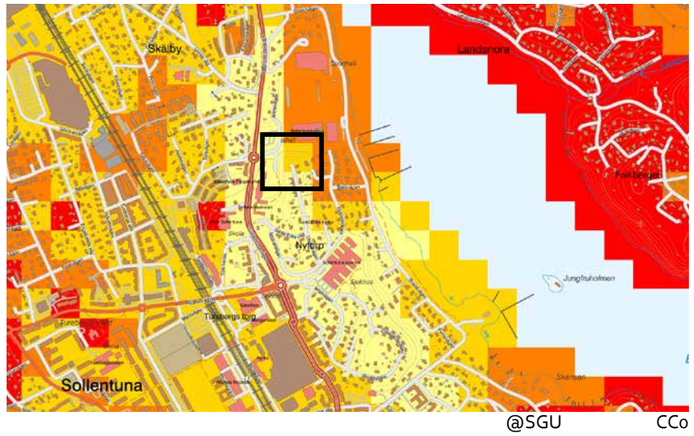


@SGU CCo

Potential site 6 (6)

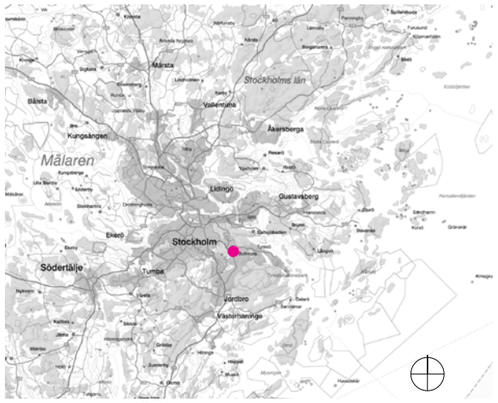
Lindalen

Strengths
A municipally owned site facing south with forgiving topography.
Located in area of predominantly single-family houses, the project can be scaled to size relevant for the local context.

Weaknesses
The site is currently used as pétanque court, and the community will lose its recreational boule terrain if implemented.

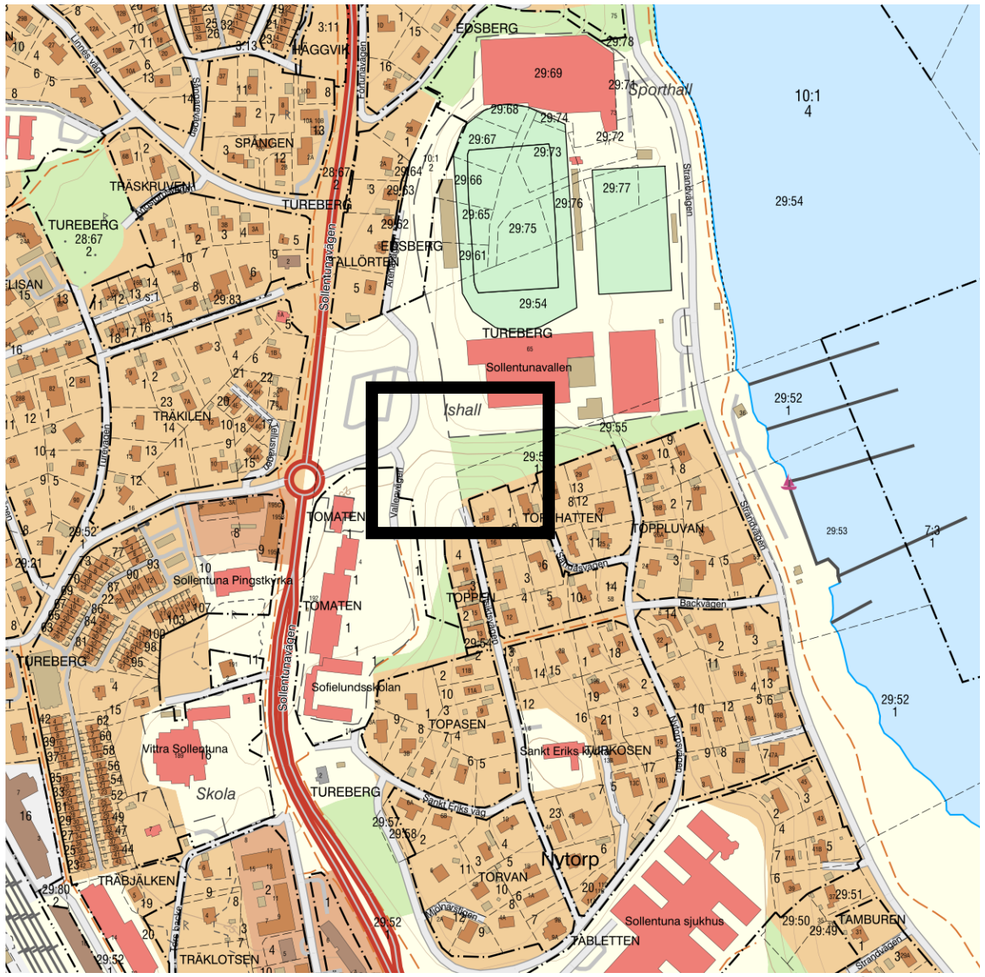
Opportunities
The location insinuates the design of a prototype on Urban Earthships concept in the scale of single-family housing. Perhaps a more manageable and accessible scale with potential to be implemented in similar contexts by versions of the Suburban Earthship.

Threats
The distance from city center and the locations population density may not be relevant for the original purpose of the project.



Location in Stockholm @Lantmäteriet

@Lantmäteriet



@Lantmäteriet

Groundwater availability (l/day/ha)
sgu.se

- < 250
- 251 - 500
- 501 - 1 000
- 1 001 - 1 500
- 1 501 - 2 000
- 2 001 - 3 000
- 3 001 - 4 000
- > 4 000
- Ingen data

@SGU CCo

Site Annelund

With 5,6 km north of the city center the decision fell on site 1 A, Annelund in Frösundavik to be the site for the intervention. The site is located at the northern end of the park Hagaparken and is a part of the recreational and cultural area of Nationalstadsparken where certain environmental and cultural heritage considerations need to be taken regarding any development. The project will stay within the borders and transform an existing parking lot on a site that has seen professional development plans previously.

Site from NW

Site from S

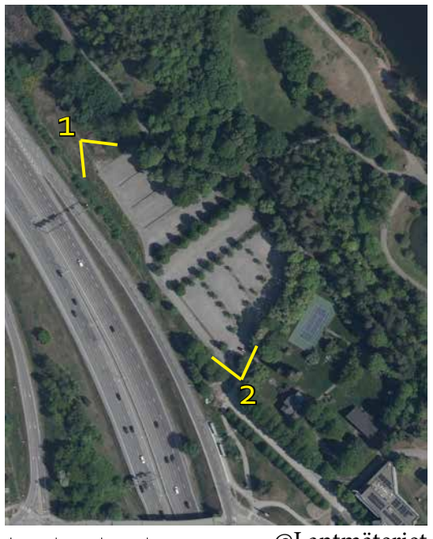
Stockholm

@Lantmäteriet

Solna / Haga

@Lantmäteriet

Annelund



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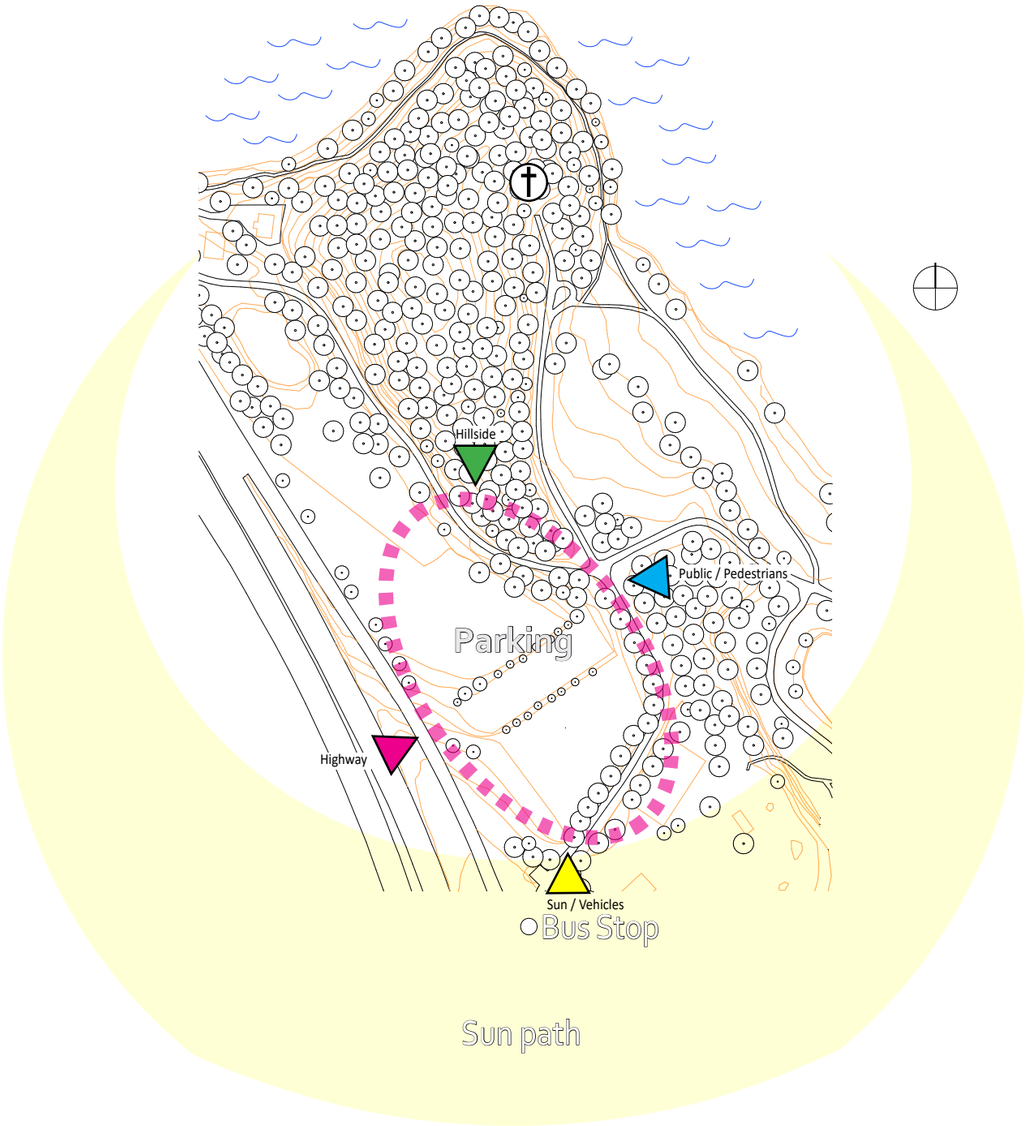
Site Analysis

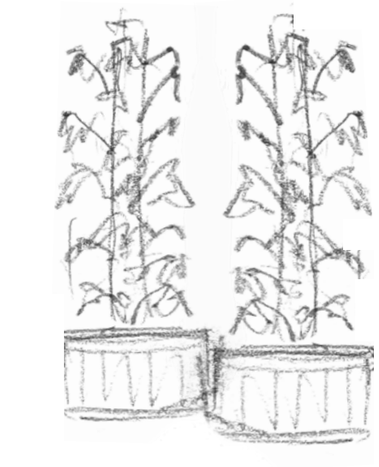
The site is on the far north end of the park with only the forested hill including the gymnastics pioneer Ling private graveyard to the north. The area is surrounded by water to the north and west. Only a few park visitors utilize this part of the recreational park compared to its southern areas. The northern side lacks public facilities and venues.

Recreational pedestrians and bicyclists arrive generally from the east of the site. Vehicle access is from the south where there also is a bus stop not far from the site. The sun conditions are good will only a couple of trees cast shadows at the site. To the east is the major challenge of the site where E4 highway boarders the context and disturbs the site with sound and air pollution.



Agriculture

Information regarding various farming methods and a selection of their potential kinds of produce and its properties like nutrient content. The selection of the type of produce demonstrated is intended to being able to compose a varied diet and be representative of the vast array of potential produce that can be farmed with the different methods.



Geoponics
Conventional vegetable cultivation method which use soil as source of nutrients and growth medium.

Plant	Plants / m2	Kg / plant(edible part)	Energy (kcal) / kg	Protein (g)/ kg
Beetroot	37	0,088	510	12
Potato	6	1	810	18
Cauliflower	9	0,625	240	19
Broccoli	9	0,3	400	43
Corn	2,5 (cobs)	0,46	1 250	39
Black Currant	0,5	5,75	680	14
Buckwheat	0.085 kg		3 530	96

Aeroponics
A CEA hydroponic vegetable cultivation method without soil and uses 95% less water than soil-based agriculture. The plants are suspended whilst their roots are sprayed with nutrient-rich water solution. The plants can be stacked vertically.
In this example the 2,5-meter high aeroponic towers with 44 plants from Agrotonomy are utilized (Agrotonomy, 2026, page 5).

Plant	Kg / plant(edible part)	Energy (kcal) / kg	Protein (g)/ kg
Eggplant	1,5	190	11
Butternut squash	9	400	9
Tomato	5.6	180	8
Strawberries	0.45	410	5
Chickpeas	0.18	1 330	70
Green Peas	0.27	690	52

Fungiculture
Indoor mushroom farming in a controlled environment. A medium sized mushroom farm of 200 – 400 m^2 can produce 5-10 tons of mushrooms per month (Satrise, 2026).

Strain	Energy (kcal) / kg	Protein (g)/ kg
Oyster mushrooms	260	20

Aquaculture
Aquaculture is the process of farming animals such as fish, shrimps and crabs. It can be done out in open water, on land or indoor. The indoor methods are related to the Controlled Environment Agriculture where the fish and the water environment is supervised.

Recirculating Aquaculture Systems are aquaculture systems with integrated water treatment and water recycling. This method consumes 90 -99% less water compared to conventional aquaculture systems (Timmons & Vinci, 2022, page 4).

A case study of Irish RAS perch farm (Cooney, Tahar, Kennedy & Clifford. 2021) with an annual average production 3000 – 3500 kg (fillet 1200 – 1400 kg) / yr describes the water tank and ponds composition. Hatchery 12 x 670 l tanks, nursery 14 x 2-4m3 and grow out ponds 3 x = 1151 m3..

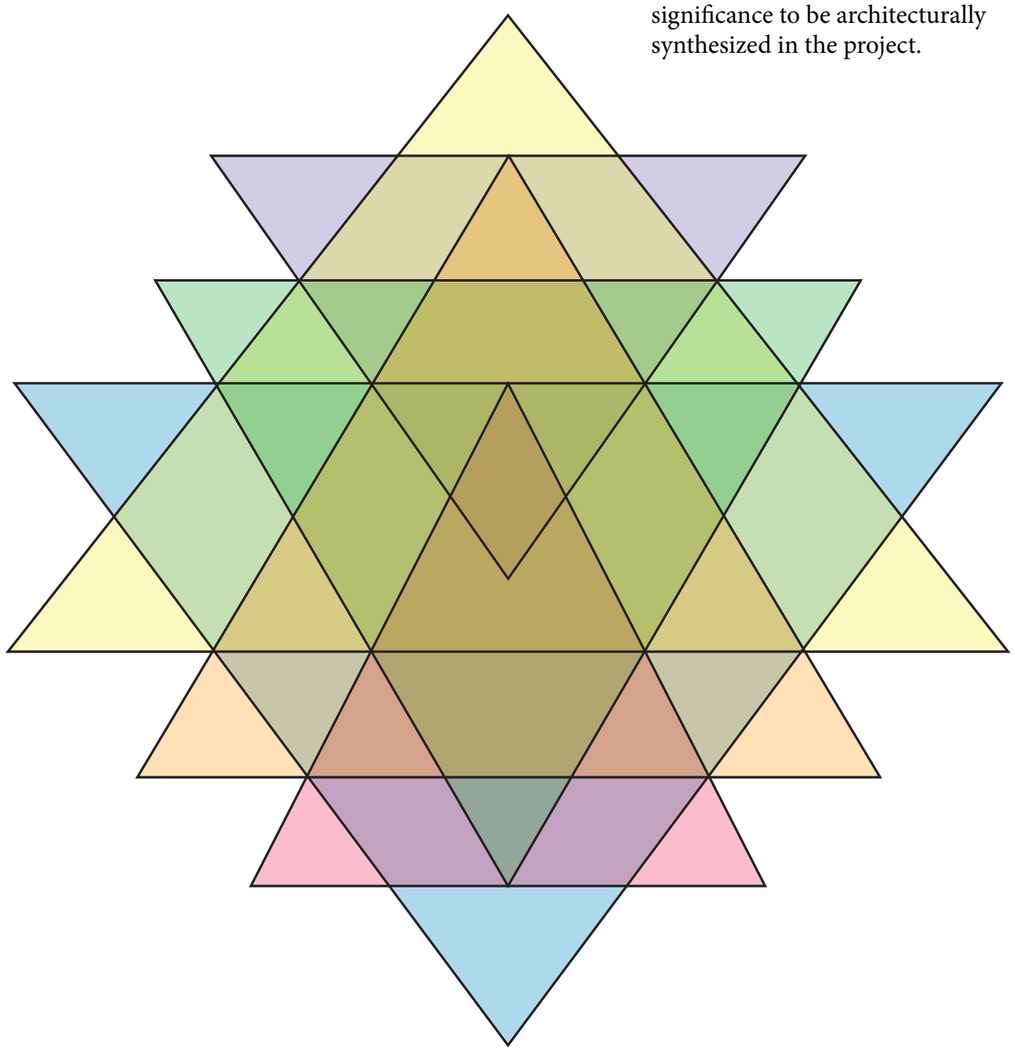
Fish	Energy (kcal) / kg	Protein (g)/ kg
Perch	860	198

Poultry
In ecological chicken production every chicken requires 4m2 of outdoor space per chicken and the minimum indoor space is 20kg per m2 (Odelros, 2022, page 5). Standard breeds lay 250-300 eggs per year (Nutrena. 2026).

	Energy (kcal) / kg	Protein (g)/ kg
Egg	1410	124

Concept development

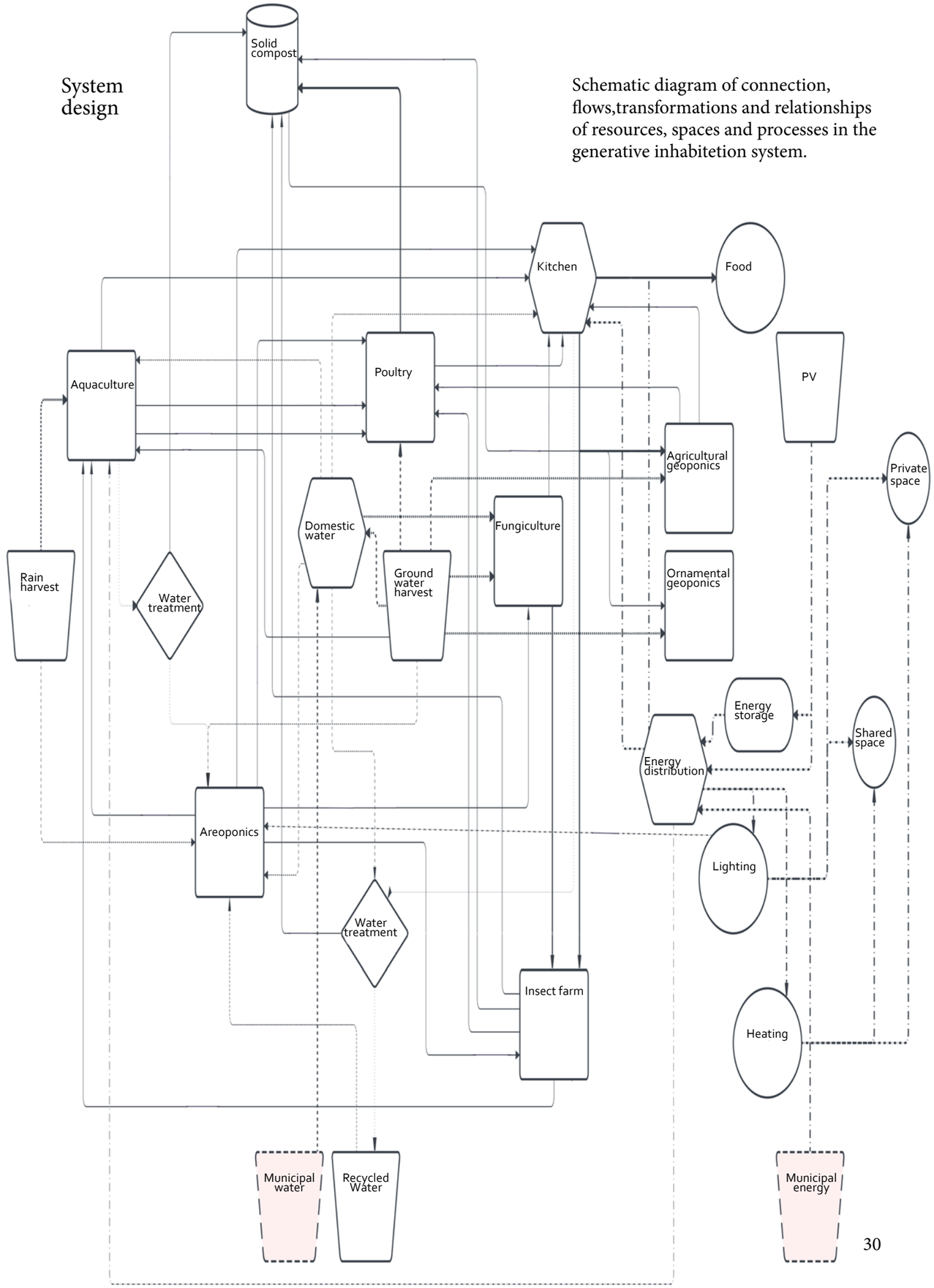
Yantra diagram of actions, resources and spatial features of conceptual significance to be architecturally synthesized in the project.



Collective space
Water
Generative space
Private space
Energy
Stewardship

System design

Schematic diagram of connection, flows,transformations and relationships of resources, spaces and processes in the generative inhabitetion system.



Concept & Design

The Urban Earthship

The Urban Earthship is a concept prototype of a building that expands the notion of self-sufficiency of fundamental resources for people living in the city.

The project is designed for a site in the northern area of the city park of Hagaparken in Stockholm.
The building is situated on a plot that is currently used as a parking lot and the new addition to the context vivifies the area with the presence of new inhabitants and their agricultural activities.

The project gives this overlooked area of the park a destination for park visitors in terms of the project's cafeteria and greenhouse spaces that are open to the public.

It is a hybrid multi-family residential building with considerable collective features synthesized with a substantial amount of in situ resource and food production runed by the building's 200 inhabitants, with a lifestyle that is characterized by a high level of community and co-habitation where both work, space and food are shared
with the neighbors.

The residents' dwell in 86 downsized private apartments of different sizes which are complemented with common spaces and functions shared amongst the inhabitants.

Besides the residential spaces, the project has agricultural areas that utilities water and space efficient farming methods like aeroponic vegetable cultivation, recirculating aquaculture systems, and indoor fungiculture.

The substantial food in production has the potential to feed the population in building with 38% of their essential kcal demands and fulfil 125% of their protein demand.

The agriculture methods utilized are suitable to generate a selection of produce with a special diversity. This kind of produce is the foundation for the diet and dishes that are served to the residents and to public visitors in the wintergarden cafeteria.

Drone view from Southwest

A day in the Urban Earthship

As a resident of the Urban Earthship the day usually starts when you are waking up in your bed in your apartment. A space that is similar of a conventional apartment, but it is perhaps a little bit downsized with a mini kitchen. The dwelling is of elementary size but more than sufficient for your lifestyle. In this space you can sleep and retreat from the dynamic activities in the building.
A private space for yourself or your family or close friends and partners.
The size of the apartments in the building reflects the size of the family that occupies it with distribution of approximately 24 square meters of private space per inhabitant.
In this eight-story building the individual apartment units for the 200 inhabitants are located along the eastern sides on floors 0 to 6. The apartments interface with the outside to the east with windows individual balconies. To west side of the apartment is the entrance from large central winter garden of the building.

You get dressed and after that you go to the sink in the room and fill up a watering can and go outside on your balcony for a brief check and watering of your flowers and herbs which are growing there in containers filled with nutritious dense soil.

You leave your private space and go down to the collective quarters at the ground floor level. You reach the main collective cafeteria for the whole building. It is located where the main east entry is. The food from the cafeteria is free for the inhabitants in the building. The meal cooked there is all produced by ingredients grown and produced on the site, in and around the building. This morning the cafeteria served tomato and egg-based dish shakshuka for breakfast.

In the dining area in the kitchen, you meet and chat a bit with some of your closet neighbors from the same floor while they like you enjoy your fresh meal.

A few of your neighbors are about to go to work in the city and some of them, as well as you, are about to work in the Earthship today.

You get ready for your day of work at the fish farming aquaculture production facilities in the building. You work part time on the collective projects in the building. This means for your schedule that you will work for two days at the Urban Earthship and after that you are free from work in the building for four days. At this time, you can attend some other kind of profession or use it for recreation or other activities.

Interior view from the cafeteria

The collective effort in the building makes the almost self-sufficient regarding food. The house can grow, produce and serve its population three meals per day with an average nutrient content of 66 grams of protein per individual per day.

The Aquaculture operation is located centrally in the building on the ground floor. Its production is the majority contributor of protein and calories for the diet in the building.

You take the stairs down again to the aquaculture meet up with two colleges and neighbors from the building which you are going to work with at the fish farm today.

After a brief chat you get to work by initially checking the status of the aquaculture system. You look at the condition of the fish who swim in three large ponds as well as in the hatchery and nursery tanks. You check the water quality, the climate control and the recirculating water treatment system which recycles 90% of the water in the system.

The water in the is recycled in the systems by treatment of filters and bioreactors. A process that makes the used unclean water to be suitable to be returned to the fish tanks or be directed to the hydroponic vegetation farming in the building.

After the aquaculture system inspection, it's time to harvest some fish for tonight's dinner at the com-munity cafeteria. The kitchen group have requested 20 kilograms of perch fillet the fish tacos they are about to prepare.

You and your colleagues gather therefore 50 kilograms of a suitable perch from the fish tanks. You har-vest and process the fish and deliver the meat to the kitchen.
After delivery it is time for some lunch. You and most of the other residents who are at home or work in the building today gather at the community cafeteria on the ground floor.
Today the collective kitchen serves the bean and herb stew Lobio with cornbread for lunch. Once again, the kitchen has only cooked with products produced and farmed in the building.

Interior view from the North stairs, Atrium

After lunch you and your colleges return to the duties at the aquaculture facilities. The scarps from the previous fish harvest and processing will be used as fodder for the other animals like chickens and insects that are farmed in the building. You take the elevator and deliver some of the scraps to the poultry farm on the building's rooftop and then you go down and give the rest for it to the insect farm located in basement.

From the insect farming facilities with its production of black soldier larvae, you return to aquacul-ture with buckets of larvae to be served to the fishes. You feed the fish with the larvae and after that you begin your last task on aquaculture production for today, which is some daily cleaning and maintenance of the system.

The system is a recirculating aquaculture system where the water in the rearing tanks can be reused after treatment by filters and bioreactors. The treated water is recycled back to the fish farm or is be used in the hydroponic agriculture farming in the com-plex. The production of vegetables is extensive in and around the building.

You clean the coarse water filters manually and dis-pose of the sludge waste at the solid compost outside on the ground floor. You do a final check of the bio-reactors and the water circulation and after that you are now ready to check out your work-related duties at the Urban Earthship for today.

You can now set out to enjoy the building's benefits and recreational services. After work you return to your apartment floor and take a shower. The grey water from the shower is also treated and recy-cled in the building.

In the building there are several shared functions like a library, a gym and lounges that complement the reduced apartments. There are a couple of hours left before the dinner that is to be served in the cafeteria again and you decide to hang out in the library until it is time to eat again.

For dinner the kitchen serves fish and chips with green peas. The fish is the same as you harvested ear-lier today. After dinner there is a screening of a mov-ie at the community area which you attend. When the movie is finished you return to your apartment. Tomorrow, you will work on your other commercial job in the city center.

Rooftop poultry farm

Inhabitation concept

The inhabitation concept connected to the architec-ture is an active and social way of life in city where interactions between neighbors is frequent and of the kind more to be expected in a rural village. As a resident of the Urban Earthship you will probably know the names of almost all the people that live in the building.

The lifestyle in a home with substantial resource gen-eration is a lifestyle where the resource production will require space, time and work that is not needed in a conventional setting. This can be achieved by adding additional space and outsourcing the labor but that would be both uneconomical and the social and empowering benefits would probably be lost.

Example of work schedule with a labor pool of 120 people. Operators work for two days which are followed by a four-day break from work in the building.

Daily Tasks	Operators / day
Restaurant	10
Water Harvest and recycling	2
Aeroponic farm	3
Geoponic farm	3
Poultry	2
Entomo and apiculture	2
Energy harvest and distrubution	2
Solid compost	2
Aquaculture	3
Cleaning	6
Maintinence	3
Administration	2
Total	40

In the collective inhabitation concept of 200 residents. The dwellers not only live but also work part time in the building together with the neighbours. Living in the Urban Earthship is an is an active and social way of life in city where interactions between neighbours are frequent and of the kind more to be expected in a rural village.

As a resident of the Urban Earthship you will probably know the names of almost all the people that live in the building. A couple of days a week your neighbors are also your coworkers, and you share several recreational spaces and functions like a library, gym and lounges with them in the house. On other days you may spend some time somewhere else, perhaps on another part-time job in another area of the city.

Diet

Free food is served to the inhabitants three times per day in the restaurant on the entrance floor. The restaurant is open to public and park visitors.

The dishes served are based on in-house production. It is a diet based on vegetables, mushrooms, pseudocereals, fish, eggs and occasionally chicken meat. Notably is the absence of dairy products, red meat and glutinous grains.

Week Menu Urban Earthship Annelund

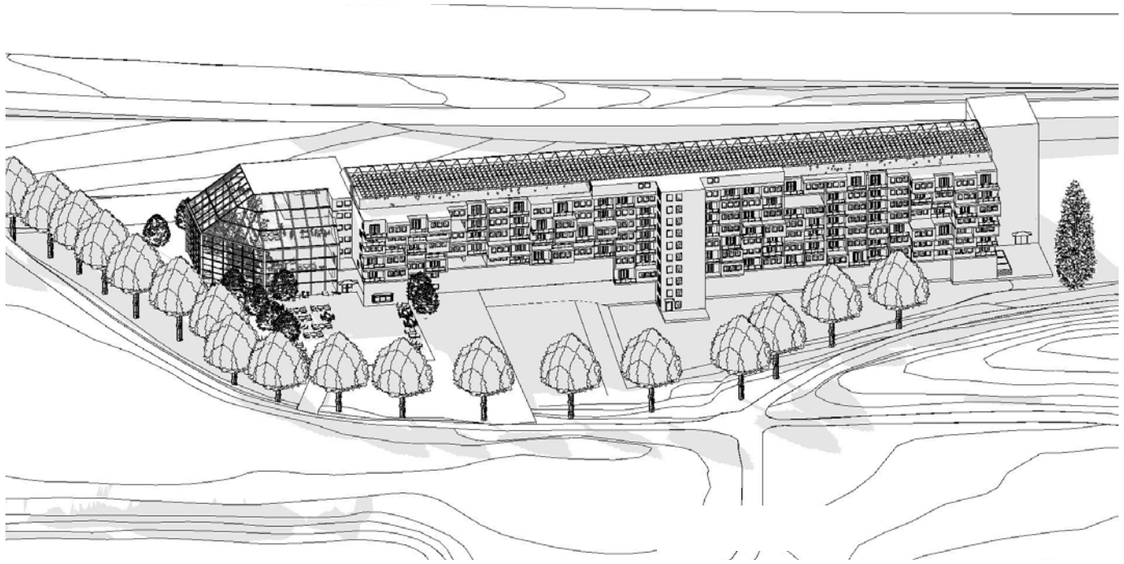
	Breakfast	Lunch	Dinner
Monday	*Blinis with strawberry jam*	*Green pea soup with poached egg*	*Smoked trout with roasted butternut and cauliflower purée*
Thuesday	*Ful medames*	*Chicken stew*	*Oyster muschrooms with cole slaw and baked potatoes*
Wednesday	*Shakshuka*	*Lobio*	*Fish and chips with green peas*
Thursday	*Pumpkin pie*	*Yellow pea soup*	*Tempeh with ratatouille*
Friday	*Mushroom and potato omelette*	*Borscht*	*Fish tacos*
Saturday	*Hashbrowns with jam*	*Egg sallad*	*Herb baked artic char with mashed root vegetables*
Sunday	*Egg muffins*	*Carrot and ginger soup*	*Falafel*

Program

Dwellings Restaurant Aquaculture Greenhouses Fungiculture Entomoculture Poultry
Food Preservation Storage Cold Storage Community areas Technical Space Aeroponics
Energy Harvest Water Treatment Vertical and horizontal circulation Vehicle access
Parking Public Ourdoor area Geoponics Gym Libray Lounge Wintergarden

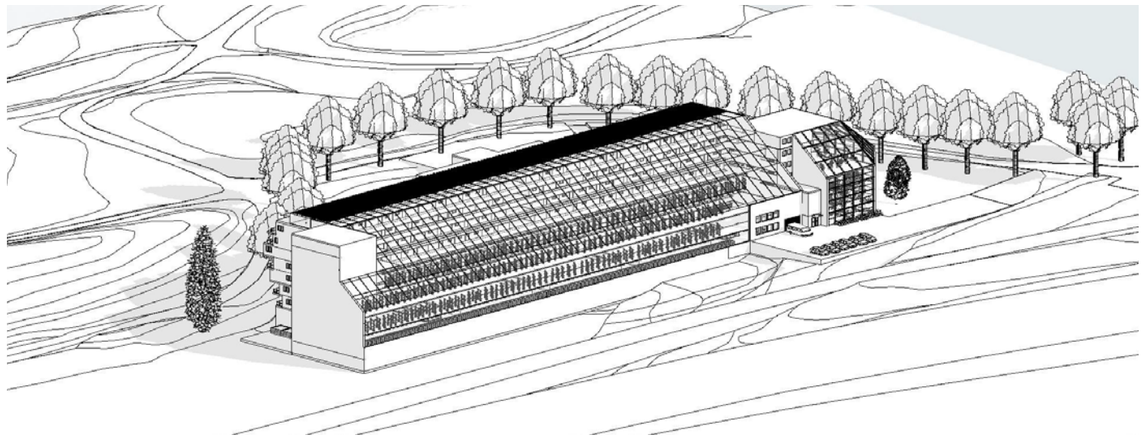
Aeroponic farming towers on the west walkways.

Design



AXO View from E

View from SE

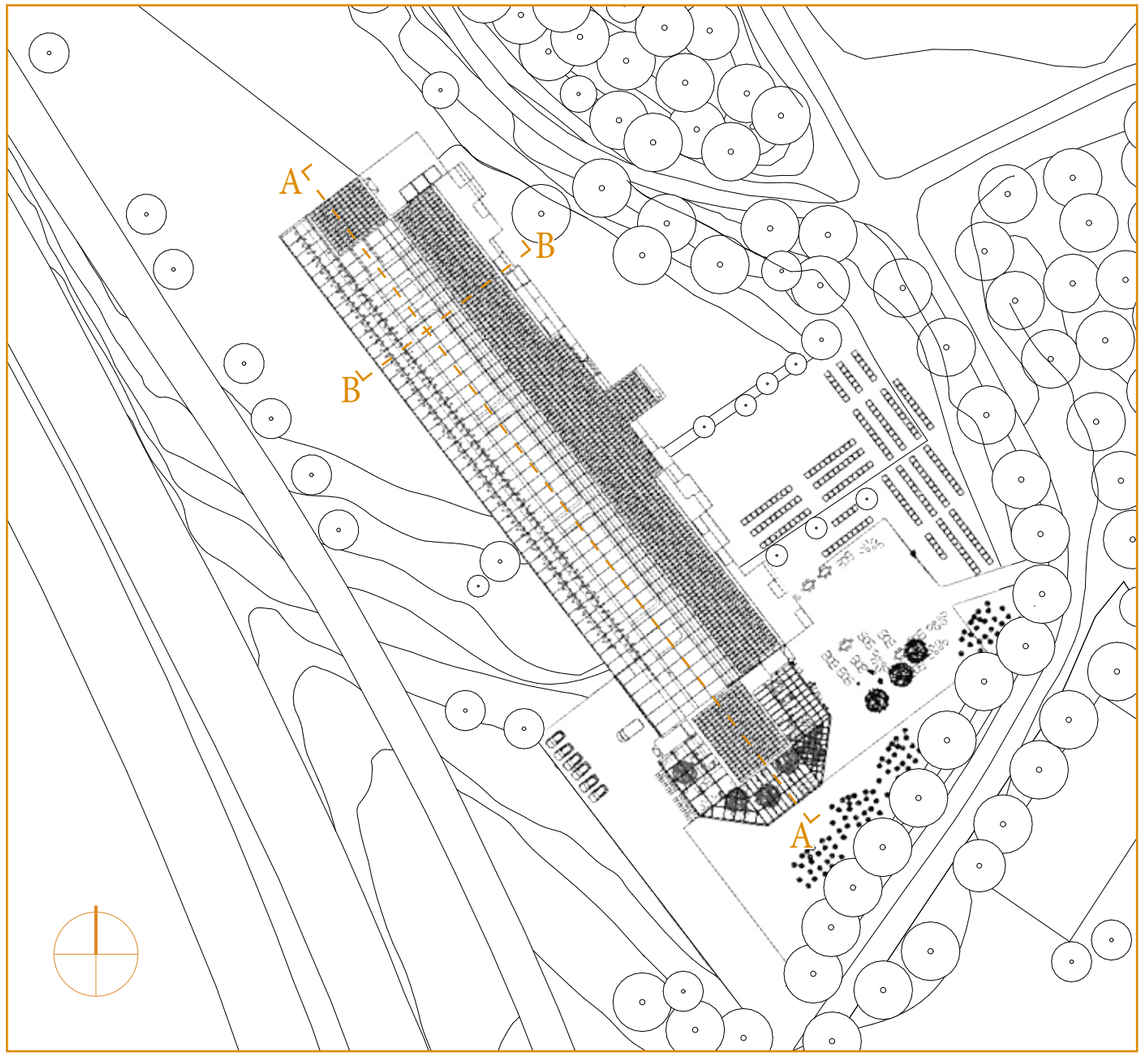


AXO View from NW

Experimental hybrid urban multifamily residential with substantial in situ food production prototype.

Location: Stockholm, Haga / Annelund
Inhabitants: 200
Footprint: 3 301 m2
Width: 33 (27) m
Length: 125 m
Height: 27 m (10 levels)

The building has a synthesized program of shared spaces, 86 private downsized apartments, conventional and controlled environment agriculture, a common kitchen that cooks primarily from the in-house produce and serve free food to the inhabitants three times per day. The cafeteria is open to the public and provides service to the context.

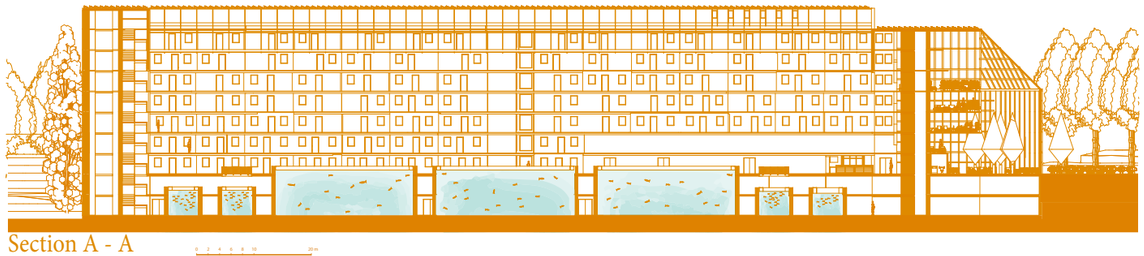


Sitemap

0 25 50 100 m

1:1000

View from West



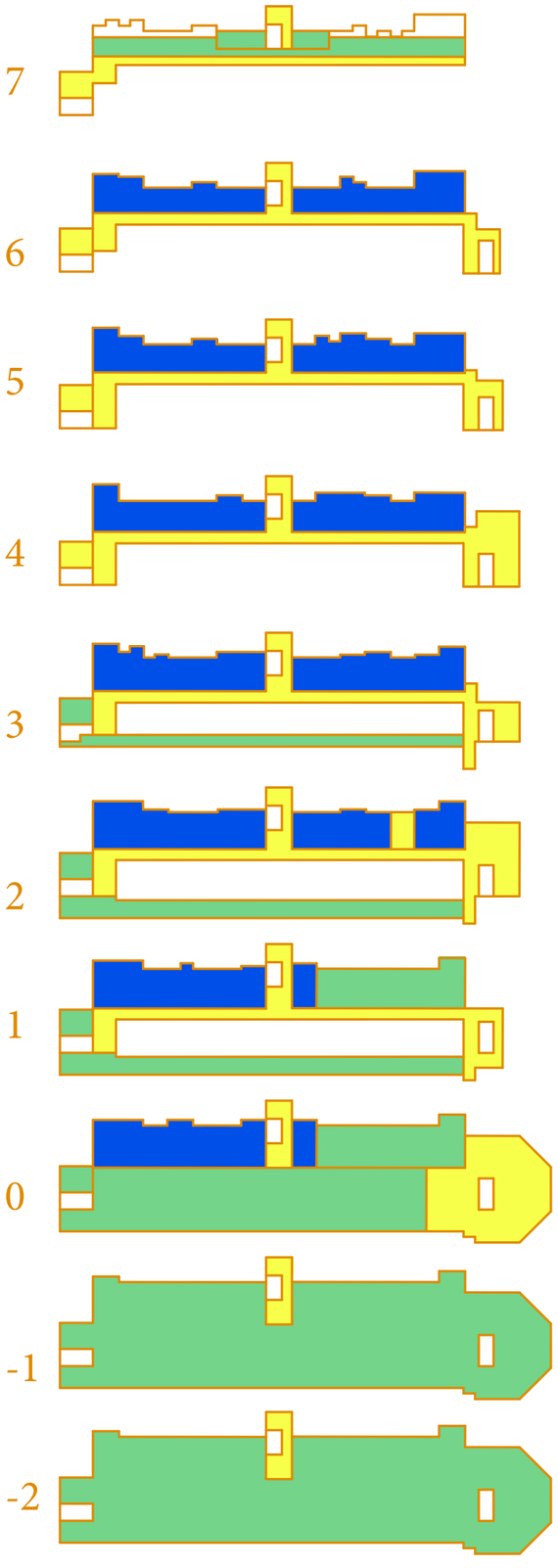
Section A - A

Section B - B

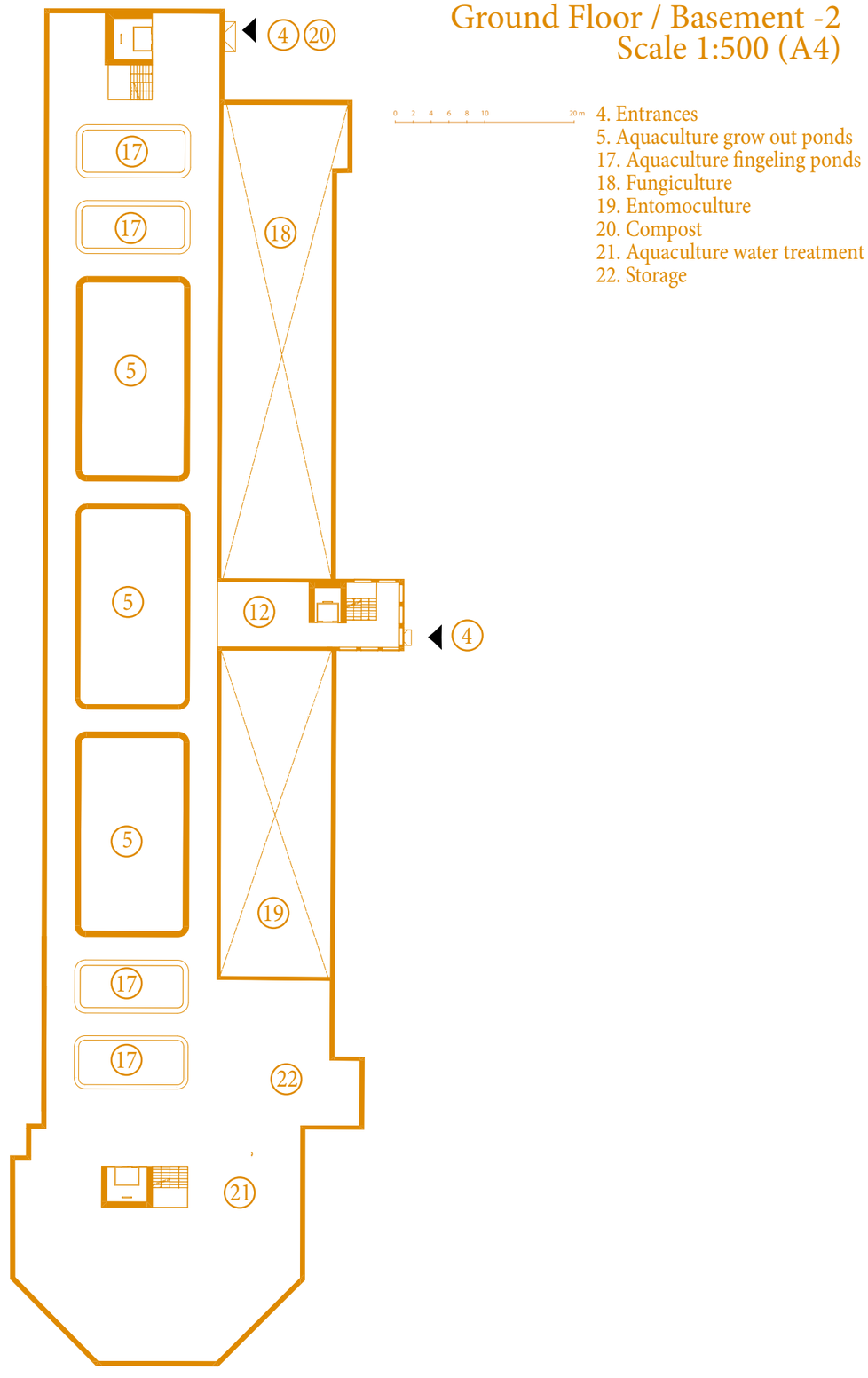
View from Southeast

Spatial composition per floor

- Agriculture / Service space
- Common space
- Private space

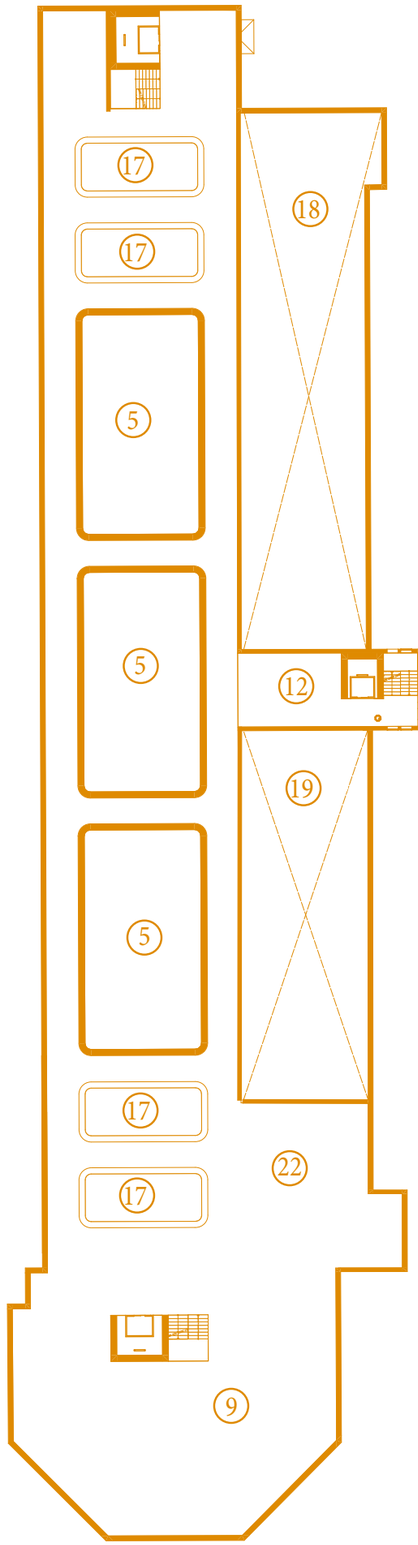


Ground Floor / Basement -2
Scale 1:500 (A4)



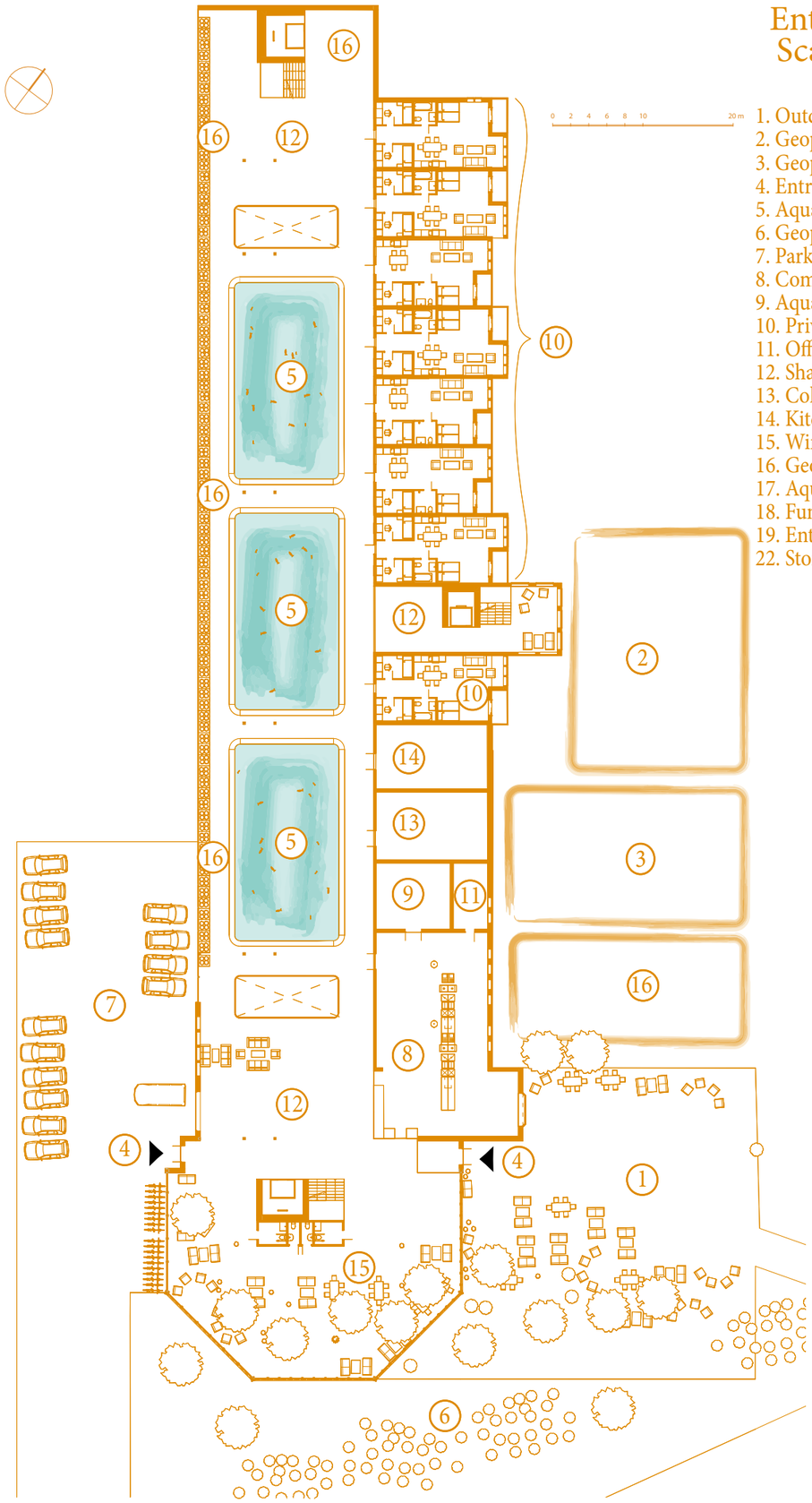
4. Entrances
5. Aquaculture grow out ponds
17. Aquaculture fingeling ponds
18. Fungiculture
19. Entomoculture
20. Compost
21. Aquaculture water treatment
22. Storage

Floor -1
Scale 1:500 (A4)



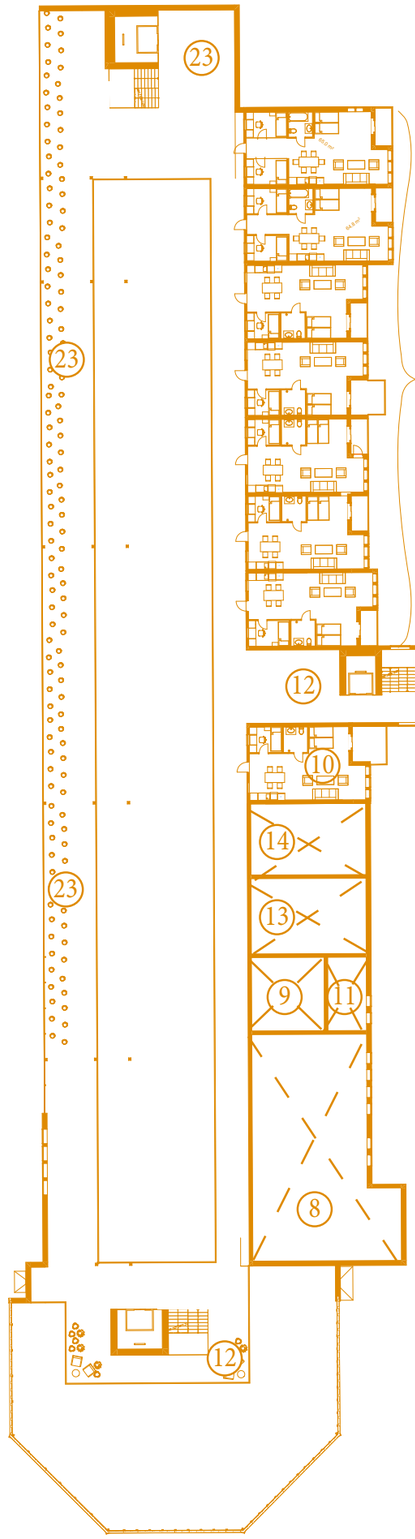
5. Aquaculture grow out ponds
6. Geoponics black currant
9. Aquaculture processing
12. Shared space
17. Aquaculture fingeling ponds
18. Fungiculture
19. Entomoculture
22. Storage

Entrance Floor 0
Scale 1:500 (A4)



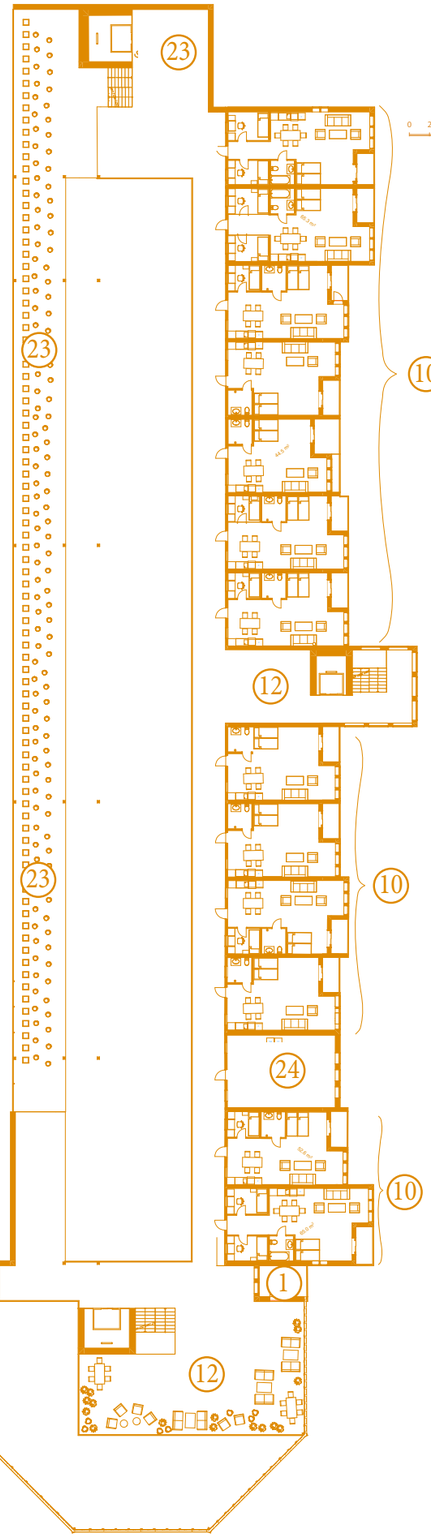
1. Outdoor seating
2. Geoponics buckwheat
3. Geoponics corn
4. Entrances
5. Aquaculture grow out ponds
6. Geoponics black currant
7. Parking
8. Common kitchen
9. Aquaculture processing
10. Private apartments
11. Office
12. Shared space
13. Cold storage
14. Kitchen storage
15. Wintergarden
16. Geoponics
17. Aquaculture fingeling ponds
18. Fungiculture
19. Entomoculture
22. Storage

Floor 1
Scale 1:500 (A4)



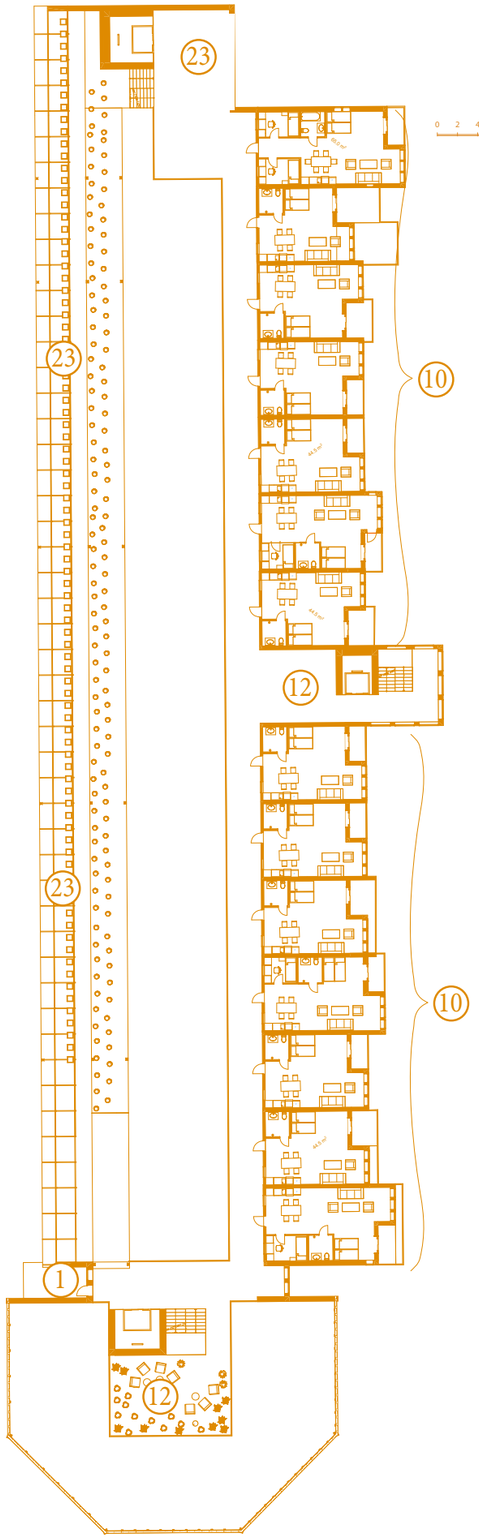
8. Common kitchen
9. Aquaculture processing
10. Private apartments
11. Office
12. Shared space
13. Cold storage
14. Kitchen storage
23. Aeroponics

Floor 2
Scale 1:500 (A4)



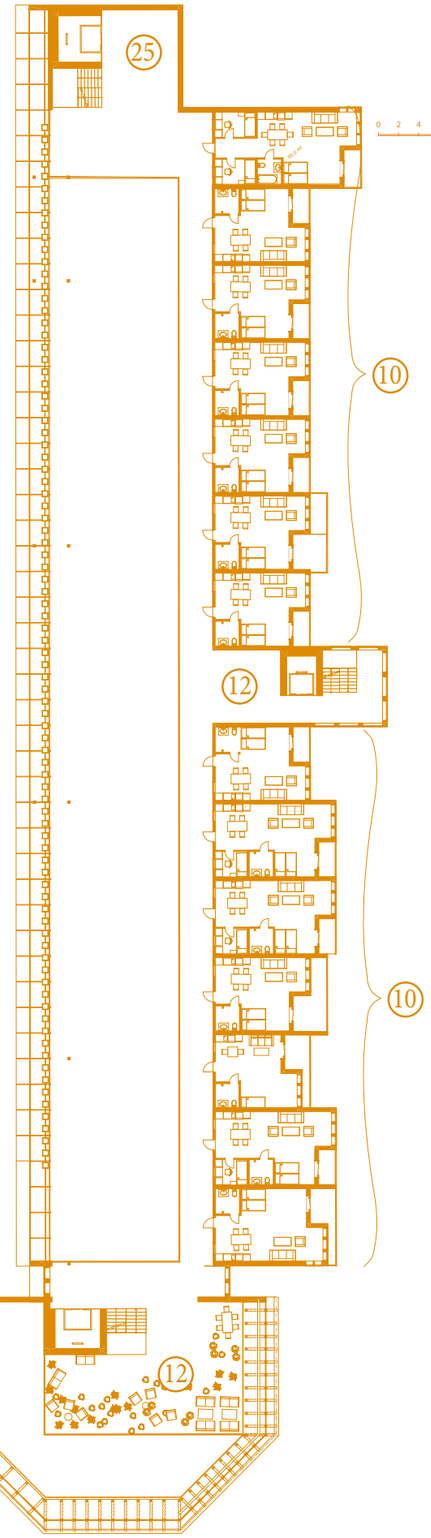
1. Outdoor seating
8. Common kitchen
9. Aquaculture processing
10. Private apartments
11. Office
12. Shared space
23. Aeroponics
24. Laundry

Floor 3
Scale 1:500 (A4)



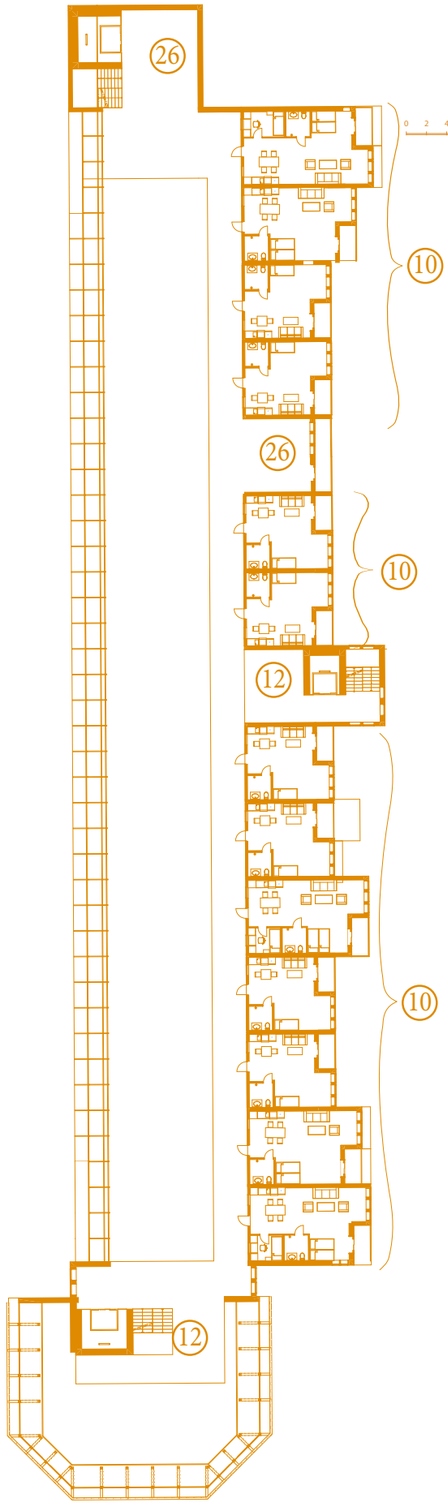
1. Outdoor seating
10. Private apartments
12. Shared space
23. Aeroponics

Floor 4
Scale 1:500 (A4)



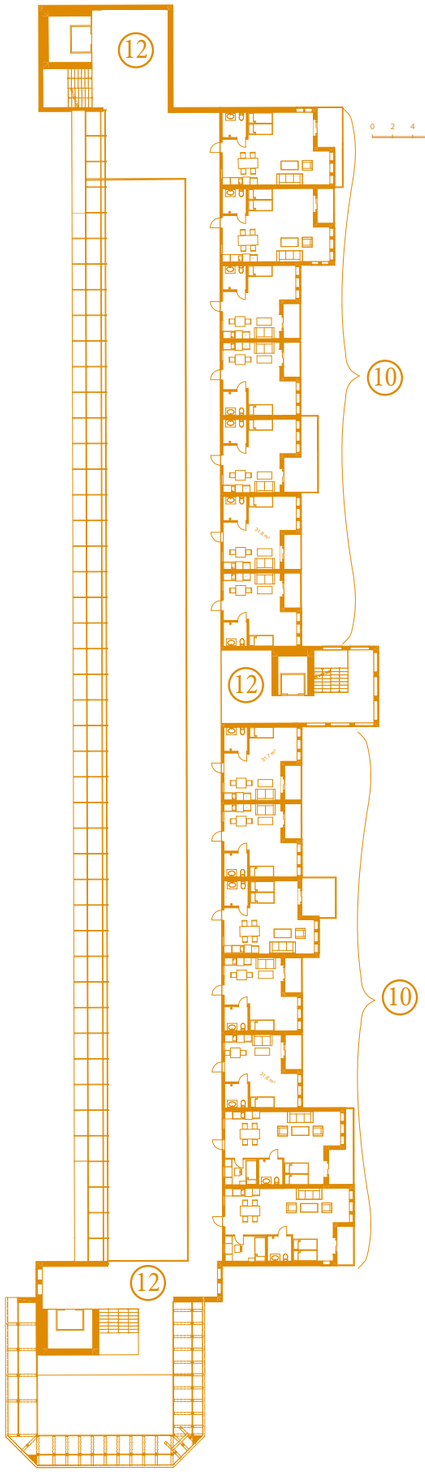
10. Private apartments
12. Shared space
25. Gym

Floor 5
Scale 1:500 (A4)



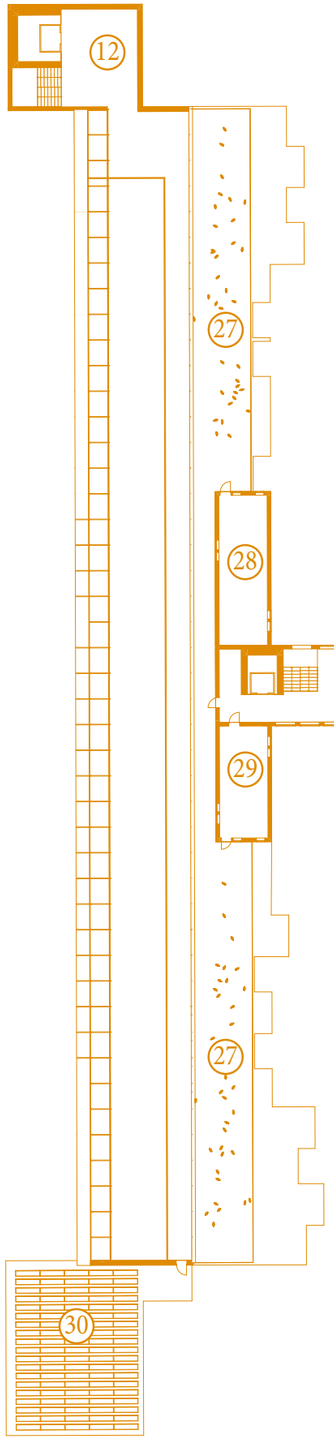
10. Private apartments
12. Shared space
26. Library

Floor 6
Scale 1:500 (A4)



10. Private apartments
12. Shared space

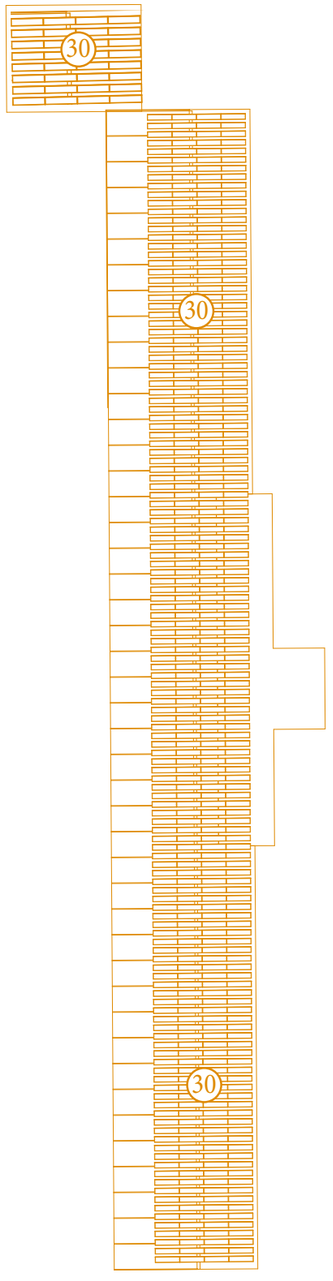
Floor 7
Scale 1:500 (A4)



0 2 4 6 8 10 20 m

12. Shared space
27. Poultry range
28. Chicken coop
29: Poultry processing
30. Photovoltaics

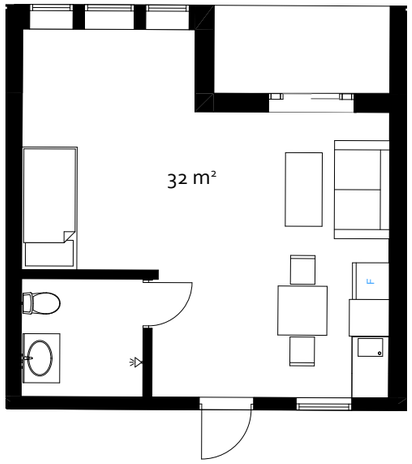
PV roof
Scale 1:500 (A4)



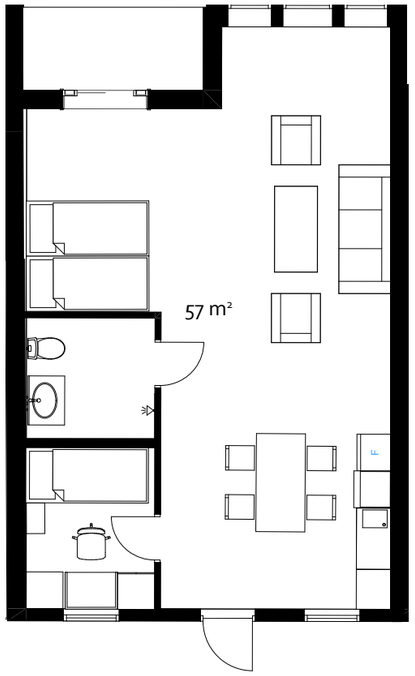
0 2 4 6 8 10 20 m

30. Photovoltaics

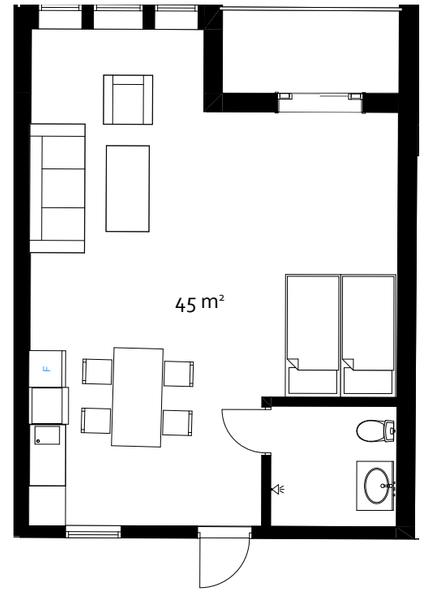
1 bed apartment



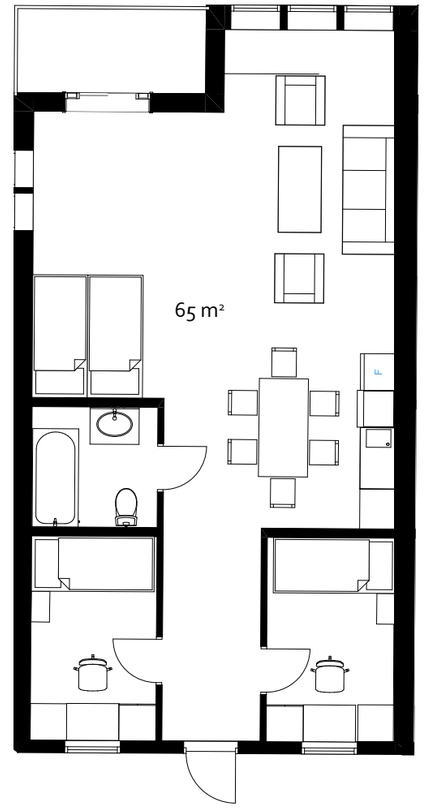
3 bed apartment



2 bed apartment



4 bed apartment



Summary agriculture harvest

Geoponics	Indoor beds m^2 (2 yeilds / yr)	Outdoor beds m^2	Outdoor field m^2
Potato		130	
Beetrot		70	
Cauliflower	43		
Broccoli	43		
Buckwheat			500
Corn			300
Black Currant			200

Aeroponics	Towers (44 plants)	Plants / yr (2 yeilds / yr)
Eggplant	62	5 456
Butternut squash	48	4 224
Strawberries	33	2 904
Tomato	76	6 688
Chickpeas	74	6 512
Green peas	89	7 832

Poultry	Outdoor area m^2	Hens	Eggs / yr
	378	94	24 017

Fungiculture	Farm area m^2 (dubble height)
	452

Aquaculture	Grow out ponds m^3
	3 499

Geoponics	Plants / m^2	Yeild kg / yr	kcal / yr	Protein (g) / yr
Potato	6	780	631 800	14 040
Beetrot	37	228	116 280	2 736
Cauliflower	9	484	116 160	9 196
Broccoli	9	232	92 800	9 976
Buckwheat		42.5	150 025	4 080
Corn	2.5 (cobs)	138	172 500	5 382
Black Currant	0.5	575	391 000	8 050
Geoponics Total:		2 480	1 670 565	53 460

Aeroponics	Yeild kg / yr	kcal / yr	Protein (g) / yr
Eggplant	8 184	1 554 960	90 024
Butternut squash	38 016	15 206 400	342 144
Strawberries	1 307	535 870	6 535
Tomato	37 453	6 741 540	299 624
Chickpeas	1 172	1 558 760	82 040
Green peas	2 115	1 459 350	109 980
Aeroponics Total:	88 247	27 056 880	930 347

Poultry	Yeild kg / yr	kcal / yr	Protein (g) / yr
	11 393	16 064 130	1 412 732

Fungiculture	Yeild kg / yr	kcal / yr	Protein (g) / yr
Oyster mushrooms	84 000	21 840 000	1 680 000

Aquaculture	Yeild kg / yr	kcal / yr	Protein (g) / yr
Perch fillet	3 840	3 302 400	760 320

	Yeild kg / yr	kcal / yr	Protein (g) / yr
Urban Earthship Total	189 960	69 933 975	4 836 859
Resident share / day	2.6 kg	958 kcal	66 g

Discussion

This thesis had the ambition to explore and to constitute an architectural design with strategies that advance potential sustainable resource production practices and to promote food sovereignty for city dwellers.

By researching relevant architectural references and concepts and emerging resource generative technologies and introducing a specific suitable context together with conceptual and architectural development the thesis delivered a design prototype with the potential to considerably manage resources in terms of food in an urban environment.

The site was observed and analyzed to guide the following inhabitation concept development, building system design and architectural design process.

With drawings, psychical models and CAD modelling I designed a building to home 200 residents together with the ability to grow and produce a substantial amount of food in situ.
A production that is estimated to be able satisfy the average daily demand of protein and almost half of the daily demand of kcal of all the 200 inhabitants.
The system provides a based on vegetables, mushrooms, pseudocereals, fish, eggs and occasionally chicken meat.
Notably is the absence of dairy products, red meat and glutinous grains.

Throughout the building is an atmosphere of cultivation, life and the influence of the elements. The sun has a fundamental influence on architectural design.

The building is oriented in relation to the path of the sun over the sky and the sunlight is sought to flood into the building in support of the interior vegetation. Interior spaces are filled with an abundance of vegetation. Plants, crops, herbs and flowers fill the air with fragrance. Scents that mediate the notes from the central water ponds and shoaling fish.

The design shows the potential of architectural aspects in terms of program, spatial composition, light, greenery, water and other qualities that can be achieved with this synthesize of housing, urban farm and public space.

The building design can serve as a conceptual example of how substantial food production can be implemented in the urban landscape and serve as protype for further resource generative architectural design iterations and explorations.

Controlled Environment Agriculture can be integrated with urban dwellings by extending the residential functions with agricultural spaces. CEA methods like aeroponic vegetation cultivation, indoor fungiculture mushroom production and fish farming with recirculating aquaculture system have the potential to be integrated into urban habitats.

The aeroponic and geoponic vegetable cultivation as well as the aquaculture pond with fish shows the most promising potential in my opinion to be integrated and cross programmed with other inhabitation spaces. Mushroom and insect farming are sensitive environments with is more challenging to mix with other functions.

Conventional agricultural methods like geoponic cultivation are still relevant for food production and the solid compost of soil serves as a valuable process in the system.

The buildings have diverse functions such as agricultural spaces, apartments, and social spaces which add not only complexity but also flexibility to the design. For instance, in this example aeroponics greenhouses can mediate the problematic aspects of the highway to the west of the context.

The buildings have diverse functions such as agricultural spaces, apartments, and social spaces which add not only complexity but also flexibility to the design. For instance, in this example aeroponics greenhouses can mediate the problematic aspects of the highway to the west of the context.

The inhabitation concept connected to architecture is an active and social way of life in city where interactions between neighbors are frequent and of the kind more to be expected in a rural village.

The lifestyle in a home with substantial resource generation is a lifestyle where the resource production will require space, time and work that is not needed in a conventional setting.

As a resident of the Urban Earthship you will probably know the names of almost all the people that live in the building. The social and participatory element in the prototype is significant. This can raise speculation regarding responsibility and how to approach and to deal with the dynamic aspects regarding human relationships and collaboration

Food production is this example dependent on external resources such as nutrients and fodder.

Even though insect farming provides feed for the fish and chickens, the production output is presumably not sufficient in this example. Further iterations of the concept can also develop the in-situ resource harvest and management of water and energy which are not fully investigated in this thesis.

Other architectural compositions, further material investigations and operational factors like passive environmental strategies are also welcomed.

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