URBAN ECOSYSTEMS

Closing the loop with a rooftop greenhouse

Urban Ecosystems is divided into six main sections arranged on two levels, each playing an important role. At its heart, you will find a café/restaurant that serves fresh dishes with nutritious produce from the greenhouse. Here, our tour starts which leads into our tropical section where you can, on special occasions, pick your own fruits when in season. In some UE facilities, tomatoes, peppers and strawberries are grown instead of tropical fruits, why not stay a bit longer and have a tomato tasting before continuing with your shopping. Throughout Urban Ecosystems, KOI fish swim in canals to provide both a relaxing environment, as well as the nutrients for the plants.

Waste from the café and greenhouse is being shredded and put to use feeding black soldier fly larvae, which in turn will feed the fish, closing the nutrient loop. In the leafy greens section, grow leafy greens vertically, saving much needed space and making harvesting easy. Efficient lights provide supplemental lighting for the darker months which enables year round production. The novelty of Urban Ecosystems (UE) is connecting the four pillars of sustainability: the social, environmental, economical and the cultural aspects together in an integrated way. Let’s begin the journey...
BENEFITS OF A ROOFTOP GREENHOUSE

Success through clever technology and partnerships

One of the main challenges in creating a new Urban Farm is branding and awareness. As stated in our marketing plan, attracting new customers will be done mainly by events and marketing these through social media. This, however, will only cover a small portion of the customers needed to make Urban Ecosystems viable. In order to reach the visitor numbers and sales required, collaborations are needed. Within the city limits there are several potential partnerships that can be made. One restriction is size. According to our figures, at least 1500 SQM greenhouse cultivation/presentation area is needed to make production viable. This rules out partnerships with hotels, as their roofs are too small in most cases. Urban Ecosystems is foremost a rooftop greenhouse. It can be built as a two-storey building with a storefront at the bottom and greenhouse on top, but our recommended configuration is on top of an existing building. We’ve found that rooftops of larger supermarkets and commercial/office buildings have the best fit, and where there is most to be gained by a collaboration. Further down, we present two examples of how this could work with a commercial building and a supermarket. Every location offers unique opportunities but here are some common ones for a rooftop greenhouse:

Energy efficient

Producing vegetables year-round in Sweden requires both heat and energy. With Urban Ecosystems we can complement both of these using smart and energy-efficient technologies. If residual heat is available this can be used to heat the waterways in the temperate/tropical section for long time heat storage. The large volume of water acts as a heat-sink during warm summer days and as a heating buffer in wintertime.
Requires no extra space

In cities, good farmland is hard to come by. By using vertical hydroponic techniques there is no need for soil and the growing of vegetables can take place anywhere. We can use this to our benefit by using rooftops without having to rely on a thick layer of soil in order to be able to grow crops.

Free fuel for plants

Carbon dioxide enrichment is often times used in greenhouse production to boost production and get better yields. The biggest problem with this practice is the use of natural gas. The benefit with being on top of a “host” building is that we can use the carbon dioxide that we humans produce all the time. By ventilating the CO$_2$ into the greenhouse from the underlying building we create a better environment, both for plants and people. This without the need of having to extract CO$_2$.

Steady stream of visitors

Starting a new business and brand is challenging, especially if it requires new customers to travel to the location without any prior experience. By possible collaborations with the business beneath Urban Ecosystems, new customers are more likely to try a new concept located in their own environment. Any urban farm needs people who participate in activities and gain cultural and social enrichment as well as the opportunities to eat fresh produce that is grown under conditions acceptable to them.
Flexibility in configuration

Urban Ecosystems is divided between a leafy greens production section, a tropical/temperate vegetable section depending upon the host building scenario, a café/restaurant section, a microgreens production section and a food waste recycling section. Depending on the location and the market potential these sections can be configured differently.

For instance, a location on top of a supermarket can have a larger unit of leafy greens and a smaller café/restaurant/market section, while a location on top of a commercial building can have larger tropical and café/restaurant sections.

New availability of productive dwarf fruit trees

Many commercial nurseries based in European countries of the Mediterranean Basin now supply grafted dwarf versions of subtropical and tropical fruit tree species. This applies particularly to citrus, pomegranate and mango, meaning that comparatively large numbers of small flowering and fruiting trees can occupy the limited spaces within a rooftop greenhouse alongside a range of exotic salads and herbs.

CLOSING THE LOOP

Producing year round sustainably

In Sweden, low light levels and cold temperatures makes production during six months of the year difficult. The result is that leafy greens and other fruits are imported from countries with warmer climates, not just during the winter but all year round. When we look at resources it is important to have a holistic approach. The needs of workers are as important as the type of energy being used for example, or where the nutrients for the plants come from. With Urban Ecosystems we believe we’ve managed to close the loop and by doing so making production sustainable all year round eliminating, reducing the need of importing. This is how:
Heating

When building a greenhouse made of glass there will always be some heat losses, but also gains from the sun’s radiation. Using glass with a low U-value of 1.1 we reduce heat loss and get a fair amount of radiation from the sun. Using glass with a low U-value is preferable under Swedish climate conditions where we do not have a high sunlight radiation on average over the whole year. Since we aim to grow all year around and there is not much sun in the winter, we can benefit from using supplemented light as both light and heat source. A low estimate of heat addition to the structure, due to sun radiation, is 100 kWh/m² and year. This gives us a total of over 250 to 670 MWh/year of free heating from the sun depending on layout.

Adding all additional heating from Urban Ecosystems to the total heat loss we can see that we only need a low amount of extra heating on average over the whole year. In these calculations we do not account for the heated air and floor from the underlying building, but this air further decreases the overall heating need. There will be a need for a fair amount of cooling during the hot summer days but for most of the summer, circulating outside air would be enough to cool the greenhouse. The circulated “cold” air would come from the structure underneath and in that way reuse otherwise ventilated warm, high CO₂ air. Warm air from an office or supermarket is considered cold air in a greenhouse environment and the high level of CO₂ could decrease the need for CO₂ supplementation. The hot air leaving the greenhouse would be reconditioned or ventilated out.

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2 Reusing the underneath air and CO₂ is a new (and as far as we know) untested technique.
Water acting as a buffer

Having a lot of open water in the greenhouse would store some of the radiated heat from the sun thus helping to keep the overall temperature from increasing too much during the days and keep the temperature from falling too much during colder nights. The need for heating during the winter would dominate the heating requirement.

Saving even more energy

By using the air from the underlying structure to heat the greenhouse we waste even less energy, as the warmer “bad” high CO\textsubscript{2} air would otherwise be ventilated out from that building. This heating is not sufficient on its own, but a small amount of additional heating would be sufficient to keep the temperature up. The overall yearly cost of heating and cooling would be no more than 60 to 350 tkr, depending on structure size (1500 to 5000m\textsuperscript{2}), since most of the heating would come from lights and electronic equipment.

Using residual heat

Depending on the site location, access to residual heat varies depending on the type of industry present. Infrastructure in the form of pipes also differ, where the most common temperature sent out in the grid is between 80-100\textdegree C. Lower temperatures are sometimes also available. Connecting Urban Ecosystems to the residual heat grid requires the collaboration with the local energy company invested in the area, such as Kraftringen or EON. Depending on the available heat source, we can either use a heat-exchanger to feed the right temperature to underfloor heating within the greenhouse or use it in combination with underlying structures current heating system. The residual heat can also first be used for the conversion to electricity using ORC (Organic Rankine Cycle). This is a process using the entropy changes at low temperature in different liquid/gas media by first heating up the media with residual heat then expanding it to gas through a generator and then cooling it back to liquid and repeating the process.

Automation

Greenhouse automation is key to creating an efficient interior-based ecosystem. With extended sensor use throughout the building we can discover and utilize all heat sources and transfer that energy in the

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3 This is a proven technique used in various greenhouses, often with a separate water tank outside of the greenhouse.
4 ORC, proven technology to produce electricity from residual heat. [http://againity.se/applikationer/industriell-spillynranke/](http://againity.se/applikationer/industriell-spillynranke/) is a Swedish company producing these systems.
form of heated air to where it's needed. With smart building control, HVAC systems (Heating, Ventilation and Air Conditioning) can work together with greenhouse climate control systems. The ORC is a system that could increase the use of external heat available but is also a large investment and maintenance cost. We would not start with these systems but use them as a possibility to increase efficiency later on as an add-on to the control system. By using sensors, control systems and expertise from companies like Regin and other HVAC system designers, we will create a functional system which utilizes all aspects of residual heat and gases generated within the building.

Heating and cooling the underlying building, and the greenhouse on top can be achieved using standard HVAC systems by cooling and heating recycled- and fresh air. The hot air can be recycled together with fresh air to preserve the heat. Excess humidity will be condensed to water and returned to the growing sections. In the growing sections of the greenhouse we need a high level of CO₂ to promote growth. By using the the exhaust air from the underlying building we get free CO₂ and also added heat. Since we have a higher climate temperature in the greenhouse then we have in the underlying building, the warmer air, will help us keep the temperature up. In the café/restaurant section we use conditioned air from the HVAC systems which are not mixed with the reused, high CO₂ air. Residual heat from the grid can be used in combination with the boilers to heat inlet air to get temperate air and also to be used together with the coolers to dehumidify the greenhouse air.

Light

By building a rooftop greenhouse we can provide our plants with sunlight for a large part of the year. During the darker months we need to use supplemental lighting. The electricity used for lighting will initially be bought from the grid using renewable sources. Once in place, electricity from the ORC system can be used. Using a equation that determines lighting needs for plant we’ve estimated how long we need to supplement light to minimize energy usage.

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5 [www.regincontrols.com](http://www.regincontrols.com)
6 HVAC systems are used in almost all commercial and industrial buildings.
7 Average DLI per month in Sweden based on figures from [http://msue.anr.msu.edu/resources/daily_light_integral_dli_maps](http://msue.anr.msu.edu/resources/daily_light_integral_dli_maps) with the same latitude.
Lighting needs

By looking at the light demand for fruiting and leafy vegetables over the year we can estimate the lighting demand. In the chart below one can clearly see that the need for extra lighting diminishes when approaching summer and increases during autumn and winter. The need for the fruiting crops is also much higher since the large trees require more light over the course of the entire year.

![Graph showing lighting requirement for fruits and leafy greens over the year.](image)

*Lighting requirement for plants over the year.*

Leafy greens

For leafy greens we can use energy efficient LEDs positioned close to the sides and above plants. They generate less heat than older lighting techniques and we only need to supplement 4 months of the year. The initial cost is higher than using other sources of lighting, but it becomes more cost-effective in the long run.

Tropical / Temperate section

This section allocation depends upon which host building is being serviced. If on top of a commercial building, a tropical section usually is the best fit, and on a supermarket a temperate vegetable facility will apply. Some of the tropical plants and vegetable vine crops like tomato, strawberry and peppers require more energy to produce large volumes of foliage and fruits. Crops like these though respond
well to raised supplementary light levels for ensuring good fruit quality and yield. By using state of the art double-ended HPS lamps and positioning them high above the canopy, we can stimulate fruiting for tropical fruits and temperate vegetables, in most cases all-year round. We’ve estimated that we need to supplement light for the tropical and temperate vegetables 6-8 months of the year. We know that this activity is feasible and technically achievable since Urban Ecosystems partner Nakhlatec has collaborations with the teaching and research greenhouses of Aarhus University in Denmark (located at the same latitude as the Skåne Region) which holds successfully large tropical herbaceous and tree collections for teaching and research. Furthermore, the normal growth and development of many tropical tree species like papaya, banana and passionfruit have been successfully demonstrated in recent years using aquaponic systems in the USA and Australia.

Humidity

In Urban Ecosystems we need to handle a high internal humidity. A standard solution to keep humidity levels low is to ventilate and/or use larger hygroscopic dehumidifiers. However with a large HVAC (heating, ventilation, and air conditioning) system already needed for this type of commercial building, we can design the cooling unit in such a way that it can be used as a condensing dehumidifier, by cooling the hot air and let it condensate to water on the cold surface of the cooling pipes. The heat generated to cool the pipes is ventilated away in the condensers on top of the building. The high humidity air can also be used to humidify the underlying building and in this way reuse resources that would have been discarded or supplemented to the climate in the structure. One system’s excess energy could be used by another and in that manner this helps Urban Ecosystems close the loop.

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8 Temperate crops in the EU like tomato, strawberry and chillies are widely cultivated in greenhouses using soilless culture techniques for better vegetable quality and as a means for improving water use efficiency viz http://www.drainuse.eu/documentos/DAL_2%20DRAIN%20LIFE.pdf
10 Using humidifier in greenhouses is not new but combining with commercial structure HVAC system is a new approach.
Water

Water is our most valuable resource for the aquatic environment, and in Urban Ecosystems we make sure to collect it. Most of the water taken up by plants is transpired through the leaves. Using internal water gutters positioned in the greenhouse roof we can collect some of this water and use it for irrigation. When it rains, the V-shape of the greenhouse creates many natural gutters where rainwater is collected and used within the system. From rainfall and water collected from transpiration we can save up to 30 percent of the yearly consumption.

Nutrients

All plants require nutrients to grow, and in order for us to have a sustainable production we need to use organic methods. Using soil is difficult due to its weight and need for frequent replacement. It’s also hard to use soil when using vertical growing techniques. In hydroponics we grow using water and substrates, these have very little nutrients in them so we need to add nutrients so the plants can grow. In conventional hydroponics, mined mineral nutrients are added. This is not optimal since these nutrients are not a renewable resource, and oftentimes both the environment and the workers mining the minerals are affected negatively.

Finding a stable and local organic nutrient that works in an hydroponic environment is not an easy task. The nutrient needs to be soluble and contain all the nutrients the plants need. Thankfully the organic waste produced by fish in an aquaponics system can provide all of the nutrients required by plants for healthy growth and development especially when the food used to feed the fish is also derived from recycled waste food residues. In aquaponics the growing of fish with hydroponics is combined. By calculating the number of fish needed to grow plants and how much we need to feed the fish we have a stable source of renewable nutrients. Good fish health and quality of water is vital for success. Water tests are done every week and real time values from sensors placed in the tanks tell
us on a real time basis (by continuous monitoring) if we need to take any remedial action to maintain an optimal nutrient balance and a healthy proportion of reduced and oxygenated forms of nitrogen.

Black soldier fly larvae

But, in order to truly close the loop, we also need to consider where the fish feed comes from. Often less “valuable” fish is used to feed the fish in an aquaponics. We’ve chosen a different approach. Instead of buying commercial fish feed that contains other fish, we produce our own fish feed using BSF (black soldier fly) larvae. These grow very fast and are high in protein, something that is required in an aquaponics system to provide the nitrogen and other nutrients for plant growth. The waste recycling system is designed in such a way that larvae feed on green waste material and food scraps from the café. There is even a possibility to use external food waste from restaurants and households. The leachate created in the process is used as a plant nutrient supplement added to the circulating nutrient media feeding the plants.\(^{11}\)

The amount of larvae required depends on the number of fish needed to feed.

\(^{11}\) BSF production is a proven technology and used in fish feed production, [https://www.researchgate.net/publication/222637862_Black_Soldier_fly_larvae_as_a_feed_in_commercial_fish_production](https://www.researchgate.net/publication/222637862_Black_Soldier_fly_larvae_as_a_feed_in_commercial_fish_production).
For every 10 kg of organic waste, 1 kg of larvae can be produced, and 10 kg of larvae can be sustained per m² per day.

By stacking production units we can fit in our total BSF production in only 134 m² (3000 SQM example). This leaves room for the machinery for producing the BSF pellets. Most of the organic material needed for the larvae can be sourced from within the greenhouse and café. Through collaborations we hope to find a way to collect the remaining waste needed for production. If we have too little green waste, commercial fish feed will be used to make up for deficiencies. Additionally, there will be a dedicated air filtration system to control air quality in the room.

Workplace

All employees have good opportunities for personal career growth and development. Urban Ecosystems also have an intern and student programme. In this, we provide training in modern urban agriculture practices over a 3-6 month period. Urban Ecosystems also aims to employ from all age groups and operate a gender equality policy.
Why we choose KOI

In an aquaponics (crop-fish production system), edible fish can be used to an advantage. There are some aquaculture companies producing trout, tilapia and clarias. We investigated the possibility of using, for example, rainbow trout, a salmonid species palatable to Nordic tastes, in the Urban Ecosystems concept as a productive alternative to ornamental KOI carp. We calculated, however, that in order to reach a good profit, one needs to stock fish at least 50 kg per m³, i.e. allowing only 20 litres per fish compared to our required stocking density need of 50 litres per fish. Besides the cruelty and stress for fish when pre-starving prior to culling (a procedure many Nordic consumers find unacceptable), the energy requirements are quite high (in terms of aeration) and the feasibility of generating sufficient fish feed through black soldier fly larvae production is challenging.

Plant focus

We are convinced that a plant focus is more suitable, appropriate and profitable in a Nordic city food production unit than one operating a combined fish protein/crop production function. Nevertheless, fish (in the case of Urban Ecosystems, KOI carp) still play a vital role in feeding the microbes that create nutrients for the plants and they also have a valuable social and educational role. Instead of harvesting the fish with all the requirements associated to ensure hygienic production, the use of KOI carp helps visitors and customers understand the role they play in closing the loop and creating a sustainable source of nutrients for the plants.
Urban Ecosystems aims to recover as much waste as possible and reintegrate it. Since a great portion of the organic waste produced contains many nutrients, it makes sense to recycle them for the production of black soldier fly larvae which will serve themselves as fish feed. While these insects can survive on a wide range of diets, it is still important to reduce their exposure to non-optimal organic waste and focus on organic waste that will promote their growth and development associated with increasing protein content. The waste processing unit on the service under-level floor will be located in separate contained rooms, with smell-reducing measures and isolated air circulation to allow for waste recycling activities, and population control of the black soldier fly in all its life cycle stages, coupled with active employee clean-up when entering and exiting the contained room. Waste produced from the café/restaurant’s organic waste, as well as vegetation derived from harvesting operations, will be collected and sent to the hatchery. Non-optimal organic waste, such as citrus fruits, would be sent to non-organic waste for collection via the communal collection system, who use such waste to produce plant growing substrates and thus bring about a recycling function. This way, it is ensured that the majority of the nutrients are recycled and remain in the system.
Environment

With climate change happening right now, we need to be able to produce food with much reduced external inputs - preferably with neutral carbon footprint levels. By growing in a resilient urban area, locals will gain a better understanding of how food is being produced and what is required to do so. This understanding can lead to less waste as an increased respect for the produce is gained. Having locally grown food also means less transportation of fruits and vegetables, lowering the exhausts and noise in the nearby community. We want to:

Encourage sustainable consumption

Increasing locally produced food will help the issue of sustainable consumption by letting the consumer be closer to the production and therefore learn more about the process. This will strengthen the bond between producer and consumer to gain a better understanding of each other. This will raise the value of the food produced and in the long term to less food waste.

Have less waste

Putting the producer and consumer closer together will lower the external waste like packaging and food waste. If the consumer goes to the producer to buy their product there will be no need for packaging from the producer to the market. In a world where plastic and other one-time use packaging is overflowing, this can be one solution for the growing global problem.

Reduce chemical loading

Using fish waste as a nutrient source for crops reduces the use of mined minerals and synthetic fertilizers. The closed nutrient cycle will limit the effects of over-fertilization by modern
large-scale agriculture. When using aquaponics as a growing technique, we use only biological controls (meaning no chemical spraying) to negate the risk of toxicity to the fish, the plants, and ourselves in the system.

Ensure safe and secure food production

Producing food in a greenhouse makes it easier to protect crops from extreme weather conditions. This way of growing could become an effective way of ensuring food security and food safety for future generations facing the uncertainties of climate change and dwindling productive uncontaminated land with human effluents and other pollution. This increased resilience is especially important in view of the fact that current trends indicate that by 2050 as much as 80 percent of the world’s population will be living in cities.

SECTIONS

Three crop production units on two floors with enhanced flexibility

Urban Ecosystems consists of three main crop production sections divided between two floors - the leafy greens, the tropical/temperate vegetable section, on the rooftop greenhouse level, and the microgreens on the under service level, as shown in the perspective presented to the right. The greenhouse area provides for photosynthesis in plants and the well-being of people with an abundance of natural sunlight supplemented during cold dark winter months by electric light. Urban Ecosystems can be established to support an expandable leafy greens section combined with either a tropical or temperate vegetable/fruit production option producing a
range of tropical and temperate fruit, fresh salad vegetables and herbs.

Underneath, out of sight, and with restricted access to visitors, is the underfloor service level which contains the black soldier fly larvae and microgreen sections, essential operations for waste handling, an administration office for the management team, a produce sorting and preparation area below the leafy green section, fish water recycling apparatus, and cafe/restaurant storage facilities.

Side view of the upper greenhouse and service under levels from a southern perspective.

Top view of service level.

Combining greenhouse production with aquaculture and tropical vegetation together with BSF production are all proven separate techniques, but may not have been combined as in our proposal.
To the left (west side of the upper floor) is the leafy greens production section, to the right upper centre is the main entrance served by lifts and a stairway from the lower level which houses the sorting area for the leafy greens, the BSFL unit, the microgreen production section and the administrative offices as well as other important maintenance services like the filtration and pump room and a storage area below the cafe/restaurant (upper right). Under that to the right is the tropical section adjoining the cafe/restaurant. Both of the latter house a circular canal and pond system in which Koi swim. The service lifts to the lower floor are shown by the two white areas in the leafy greens and the cafe/restaurant sections.

Café/restaurant (top floor)

The café/restaurant section is intertwined with the fish canals running from the tropical section to create a playful and harmonic environment for guests to enjoy. Whilst sitting and sipping on a freshly made smoothie conjured up from our tropical fruits, visitors can see Koi swimming in the canals. If a visitor wants to find out where the food is coming from, they can take one of the tours beginning and ending in the foyer.

When there are synchronous flushes of flowering and subsequent fruiting, tropical fruit can be picked directly from the tree. If one is a supporting member of Urban Ecosystems, they will get first pick. This can also extend to memberships that the host building may already have in place, such as a gym membership or a supermarket membership. All meals will specifically aim to highlight fresh food from the leafy greens, microgreens and temperate vegetable/tropical sections. Our vision for the café/restaurant is a vegetarian venue where we can promote a sustainable nutritious cuisine in support of a healthy lifestyle. The menu is changed with the natural seasons as different fruits and vegetables will mature at different times (see table below of planned fruit and vegetable production). Of course, there will be ingredients that the greenhouse may not be always able to provide and those ingredients will be bought from local suppliers.
During the day, smoothies, salads, and veggie burgers are for sale in the café. In the evening, the café switches to a restaurant mode where visitors can enjoy a tropical drink with friends or eat from a selection tasty menus created from products of the greenhouse. The restaurant is also intended to develop as a gathering and meeting place for Scandinavian restaurateurs and chefs who can discover fresh new ingredients for their recipes from the herbs, salads and exotic greens produced.

More than just fresh food

Being a part of a culture is being part of a collective of like-minded individuals. We believe by tapping into the interests of our target customers we can gain their trust and make them potential ambassadors for our brand. Promoting healthy local food will be at the heart of all the activities during events such as: tomato and tropical fruit tasting, concerts, theatre/stage performances and cooking classes.
Tropical / temperate production section (top floor)

The alternative tropical/temperate section is designed to create a truly immersive experience to activate all of the five senses in the heart of the city. Here, an extensive range of dwarf to medium-sized tropical and subtropical fruit trees, as well as exotic or diverse temperate vegetables provide year round fresh nutritious foods and fruits, many of which may not normally be available in supermarkets in Nordic countries. Because many tropical and temperate fruits are soft when at peak ripeness, many Nordic customers will not have been able to taste the full retinue of flavours that are deemed special to a particular vegetable or fruit picked straight from the mother plant. The perishability of many tropical fruits like mangosteen is a barrier to broadening Nordic taste experiences. Then there is the problem of having to harvest fruits prematurely to avoid fruit perishing on their long heavy and negative carbon footprint way to Nordic supermarkets.

The taste and smell experiences of sampling fruit just removed from trees will be totally unique to many visitors.

The fruit of the mangosteen shown above, for example, is rarely seen in Nordic supermarkets because its shipping and storage capacities are extremely poor: the only way to experience its flavours and aromas is by picking a fresh sample straight from the tree or at a nearby market stall. Customers willing to pay for an exotic fruit or even a splendid coloured temperate fruit/vegetable on offer in a supermarket are often disappointed and fail to enjoy the actual full retinue of smells, flavours and textures of the same fruit type perhaps sampled on a recent holiday. This deficiency in flavour, smell
and texture is because many of the natural ripening compounds needed for aroma and taste development are only able to be truly manifested when the ageing fruit matures \textit{in situ} on the mother plant. A mango fruit bought in a Nordic supermarket (having been picked prematurely in an orchard somewhere in the Norte Este, Brasil a few weeks earlier) fails to produce the evocative unforgettable experience of smell, taste and texture of a freshly plucked fruit.

**Tomato/peppers and strawberries**

The temperate vegetable option, replacing the tropical production for example in the case of a supermarket host building, where supermarket operations are being supported and extended to the rooftop production facility, has led Urban Ecosystems to choose three temperate crops that are particularly amenable and profitable for production under glass in temperate regions: tomato, strawberries and chilli peppers. This facility, as with the tropical section, will allow customers and visitors to sample fruit picked only a few minutes after picking from the vine, bush or fruit truss. One aim of the temperate fruit/vegetable section is to promote new and interesting varieties of tomatoes, strawberries and chilli peppers with the objective of diversifying food sources. For example, there are over 10 000 varieties of tomatoes, at least 600 varieties of strawberries, and over 500 members of five genetically distinct \textit{Capsicum} species for chilli peppers. Not all mainstream varieties currently available give sufficient taste and flavour satisfaction to the consumer because the drive in profitable glasshouse production prioritises yield at the expense of taste, aroma and texture. The production of unusual types of these three mainstream temperate crops will enable the supermarket host to assess the
popularity of certain varieties from these customer satisfaction perspectives as a guide to subsequent fruit and vegetable intake requirements. Local restaurant chefs will also have the benefit of assessing the culinary merits of many diverse forms of fresh ingredients. Below is a perspective showing how the three glasshouse sections are juxtaposed to each other. The three greenhouse sections: the leafy greens section (upper), the tropical/temperate vegetable section (left lower) and the cafe/restaurant section (right lower), are designed in such a way that entry will be by way of a common point (the stairwell and lifts located in the foyer) for customers and visitors or directly into the service under level from the stairwell or service lifts (for staff and technicians servicing equipment). The canals containing KOI carp swimming in pond water of 0.5 metres depth meandering through the café/restaurant section will form a continuous network linking a series of wider ponds flowing also into the tropical section. The perspective below is a transverse across the tropical section showing the different levels:

Cross profile sketch of tropical section showing different levels of canal, walkways, raised pumice beds and exhibits

The foam concrete raised floors also contain ducting through which water is returned back to the filtration room on the under service level. The canals not only provide a good habitat for the fish, but their scattered distribution also helps to spread the weight load of water on the top floor. The trees and vegetables are held at the same level above the canals and ponds in a series of different platforms. The canals and other water features are located at floor level while the walkways, amenity areas and the growing beds are located on a raised floor, 80 cm in height, made from lightweight foam concrete protected with water resistant recycled rubber tiles and carpets (e.g. Dinoflex tile products\textsuperscript{13}). Within

\textsuperscript{13} The use of tough recycled rubber products such as those supplied by www.dinoflex.com and the use of light foam cement for raising the levels of a growing floor above a system of canals and walkways is a new concept using manufactured and suitable waterproof materials for the purposes described. Production of flowering and fruiting papaya, citrus and banana in liquid soilless culture systems

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the raised floor there will be a network of ducts (achieved by mould inlays) to accommodate inlet and outlet piping for delivering and draining aquaponic media, respectively, in the pumice beds (0.5 m wide x 0.4 m deep made from lightweight, strong plastic.

**Perspectives in the tropical section**

**Supporting small and large trees**

Small tropical trees, bushes and vines will be positioned in pumice, and plants over one metre in height will be supported using brackets bolted into the raised foam concrete bases. All dwarf trees, medium and pioneer trees, bushes and vines will be positioned in pumice beds and fed by a system of liquid feed pipes (drip/trickle irrigation type) that release aerated aquaponic nutrient media (produced by the fish cultures held in the ponds and canals) around the stems and roots. Mature flowering trees of different stature (dwarf, medium and pioneer status at average heights of 1.0, 2.5 and 4.0 m, respectively) will be brought in at the beginning of the project from commercial nurseries in the EU.\(^\text{14}\)

\(^{14}\) In the EU countries in the Mediterranean Basin eg. dwarf citrus from [www.citrina-plants.com](http://www.citrina-plants.com) in Portugal. Nursery listing at [www.europages.co.uk/companies/Fruit%20plants.html](http://www.europages.co.uk/companies/Fruit%20plants.html).
Through adopting this approach, only EU-passport certified disease- and pest-free stock will be used to ensure that the risks of disease and pest introduction and subsequent outbreaks are minimised. Most trees will be grafted/budded specimens that have been seedling tip-grafted or top-worked using a variety of rootstock/scion combinations designed to reduce tree stature and shorten the time taken for trees to reach flowering and fruiting stages. Established trees will therefore be able to flower and begin fruiting during their first season in the tropical greenhouse. The exotic fruit tree and vegetable species selected for the tropical/temperate fruit/veg section are shown in the table below.

Table showing most of the tropical and temperate fruit/veg which will be grown:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Species (Final nos. trees) Total 520 in 980 SQM</th>
<th>Fruit size</th>
<th>Growth habit (height) Dwarf: 1 - 3 m Medium: 3 - 5 m High: 4 - 7 m</th>
<th>Harvests / year*</th>
<th>Which months harvested*</th>
<th>Average retail price (kr/kg)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrus group exotic oranges Tangerines Limes Lemon</td>
<td>Dwarf grafted trees <em>Citrus sinensis</em> (50) <em>C. tangerina</em> (40) <em>C. hystrix</em> (40) <em>C. limon</em> (40) <em>C. japonica</em> (30)</td>
<td>50 - 250g</td>
<td>Dwarf trees 1-3 metres in height</td>
<td>1 - 3</td>
<td>Continuous in some, seasonal in others (mainly July - November)</td>
<td>50 - 250</td>
</tr>
<tr>
<td>Mango</td>
<td>Mangifera indica (25)</td>
<td>200 – 400g</td>
<td>Dwarf - medium</td>
<td>1</td>
<td>July - Oct</td>
<td>260</td>
</tr>
<tr>
<td>Guava</td>
<td>Psidium guajava# (25)</td>
<td>60 – 80g</td>
<td>Medium</td>
<td>1</td>
<td>July - Oct</td>
<td>200</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>Punica granatum (30)</td>
<td>250 – 400g</td>
<td>Grafted dwarfs</td>
<td>1</td>
<td>May - Sept</td>
<td>160</td>
</tr>
<tr>
<td>Passionfruit</td>
<td>Passiflora edulis (100)</td>
<td>30 – 50g</td>
<td>VineS on trellis</td>
<td>2 - 3</td>
<td>Jan - Dec</td>
<td>200</td>
</tr>
<tr>
<td>Papaya</td>
<td>Carica papaya (30)</td>
<td>300 – 700g</td>
<td>Dwarf - medium</td>
<td>2</td>
<td>Mar - Aug</td>
<td>170</td>
</tr>
<tr>
<td>Babaco</td>
<td>Carica pentagonia# (20)</td>
<td>100 - 300</td>
<td>Medium</td>
<td>1</td>
<td>Mar - Aug</td>
<td>240</td>
</tr>
<tr>
<td>Dwarf banana</td>
<td>Musa acumunata# (30)</td>
<td>350 – 700g</td>
<td>Dwarf - Medium</td>
<td>1</td>
<td>July - Nov</td>
<td>250</td>
</tr>
<tr>
<td>Feijoa</td>
<td>Acca sellowiana# (30)</td>
<td>30 - 60g</td>
<td>Medium</td>
<td>1</td>
<td>Aug - Dec</td>
<td>280</td>
</tr>
<tr>
<td>Mangosteen</td>
<td>Garcinia mangostana# (30)</td>
<td>80 – 130g</td>
<td>Medium</td>
<td>1</td>
<td>Feb - May</td>
<td>250</td>
</tr>
<tr>
<td>Tomato</td>
<td>Lycopersicon esculentum</td>
<td>Fruit</td>
<td>Vine</td>
<td>1</td>
<td>Feb - Nov</td>
<td>160 - 240</td>
</tr>
<tr>
<td>Strawberry</td>
<td>Fragaria × ananassa</td>
<td>Fruit</td>
<td>Low herb with hanging fruit</td>
<td>1-3</td>
<td>Apr - Oct</td>
<td>150 - 250</td>
</tr>
<tr>
<td>Chilli Peppers</td>
<td>Capsicum frutescens and related species</td>
<td>Fruit</td>
<td>Bush</td>
<td>1-3</td>
<td>Apr - Nov</td>
<td>140 - 220</td>
</tr>
</tbody>
</table>

* Depends upon variety; ** Depends upon season; #Unusual status in that these fruits are not commonly found as fresh fruit in Nordic supermarkets so for many prices based on prices offered by [www.heb.com](http://www.heb.com), [www.bigbasket.com](http://www.bigbasket.com), [www.mysupermarket.co.uk](http://www.mysupermarket.co.uk), [www.firstwefeast.com](http://www.firstwefeast.com), [www.cbi.eu](http://www.cbi.eu), [www.waitrose.com](http://www.waitrose.com)

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Pollination and pest control

To aid pollination and fruit setting, bumble bees and other insect pollinators will be released under controlled conditions and insect proofing of ventilation outlets will be installed so as to avoid outward migration as well as intrusions of external insects and flying animals like birds. Pests will be controlled by deployment of standard integrated pest management using biological control agents that can be supplied by Binab of Sweden.¹⁵

Ever shifting landscape

Regular landscaping of dwarf stature trees, bushes and vines will be carried out from Year 1 onwards and new varieties will also be gradually introduced from Year 2 onwards to promote visitor interest and to exploit new market trends in the fresh produce sector.

Leafy greens section (top floor)

The market for leafy greens and herbs is very large, especially if one can provide it year-round and locally. We can grow a combination of cut-and-come-again crops like chard, kale, basil, arugula and mint together with full harvest crops like lettuce and pak choi. Instead of shipping in lettuce and

¹⁵ [http://www.biobasiq.se/produkter/mikrobiologi/binab.aspx](http://www.biobasiq.se/produkter/mikrobiologi/binab.aspx)
chard from Italy, we can produce it very effectively using vertical growing techniques. This can be achieved using plastic towers called ZipGrow. They are very low weight and one can grow as much as 12 herb plants or 8 heads of lettuce in one tower measuring 1,5 meter in height. In a normal configuration one can stack 3 towers per square meter, making them very space efficient. **This means almost 1 kg of produce every week per tower.** Having 36 large herb plants per square meter or 36 heads of lettuce is not feasible using standard non-vertical techniques. This section like the microgreens section is not accessed by the public. This is to avoid problems with health and food safety as well as outbreaks of pests and plant viruses which can have a huge negative impact on the yields of fast growing leafy greens and microgreens. By limiting entrance and putting in place protocols to ensure a clean environment, we hope to eliminate the need of biocontrols to control pests.

*To stimulate worker interests, workers switch between sections, one day working in the tropical/temperate vegetable section, another in the leafy greens section.*

**Experienced partners**

We’ve partnered up with Re: Farmers, a distributor of ZipGrow towers based in France. They can provide support and training and have a proven track record under large scale commercial horticulture operations. Besides being low weight, ZipGrow towers are perfect for aquaponic production since their biofilters have a very large specific surface area. This is needed for microorganisms to establish themselves and break down through a natural process the fish waste into plant ready nutrient. For example the nitrification of harmful ammonia into nitrate. Plants will be in different stages of harvest and moved forward towards north as they grow, avoiding problems with having to store harvested crops. During the winter months when light levels are too low for good production values, LED lights will be used to supplement the natural daylight with light levels required for healthy plant growth. Overall temperatures will be kept lower in this section to avoid bolting and increase overall quality.
Microgreens production section (service under-level floor)

All new plant material needed for the leafy greens section is grown from seed in the propagation section located with the microgreens. The microgreens and raised in a 4-tier stacked misted seed germination shelving system where seeds are germinated in 25 x 85 cm trays. Throughout the year, seedlings are allowed to grow to required sizes on coco-mats. Most seeds germinate at 20°C using a 7 - day period of semi-darkness under supplemented misting followed by a 7 - 10 day sequence of controlled spectral LED lighting to stimulate pigmentation. Germinated seedlings are harvested by cutting the shoot parts away from the roots embedded in the substrates. The remainder of the space in the section is allocated to propagation benching used for the production of seedling plugs to supply the leafy greens section and for occasional routine plant propagation work involving cuttings or grafting. Common microgreens are cabbage, radish, beet, kale, kohlrabi, mizuna, mustard cress, bean, chickpea and which produce young shoots that are grown for only two-three weeks and then harvested. The approximate allocation of space in the section is as follows: seed plug formation for leafy greens (10%), microgreens (80%) and propagation benching (5%) with the remainder for alleyways and the central work area. Microgreen harvesting and sorting will be carried out in the sorting and quality control area under the leafy greens section.
Implementations

Envisioning how Urban Ecosystems could be implemented

Example - Commercial/office building

Placing Urban Ecosystems on top a commercial building, like a sports activity center has many advantages. In our example we’ve used a popular venue in Malmö, but it can be any building of about the same size placed in an urban setting. We’ve located several buildings that would be ideal to hold a rooftop greenhouse, providing the owner is willing of course. If the building itself isn’t too high it’s even possible to provide an external entry with stairs and lift. Depending on the type of business activities taking place within the building, partnerships can be made. For example: providing workers with vegetables and discounts in the café/restaurant.

The benefit of using an existing commercial building is that during the day, carbon dioxide can be vented to the greenhouse, providing a free source of fuel for the plants to use for photosynthesis.
Possible placement of Urban Ecosystems on top of a commercial building.

Layout

Based on expected customer demand, Urban Ecosystems different sections (explained under sections) can be arranged in different ways. For this type of commercial building we’ve focused more on the
tropical section, microgreens, café/restaurant and less on the leafy greens section.

In our example, the sports activity center alone has 400 000 yearly visitors. Combining this with tourists and residents in the area we see a large potential for social activities, and gaining additional revenue this way. Using a low estimate, we’re expecting 20 000 yearly visitors, which is only 5 percent of the total visitors to the host building. If only 60 percent pay for admission or tour we see a profit with only a half time worker. If tours aren’t given, the workforce can otherwise focus on the tropical section.

The café/restaurant serves an important role as the social hub for all cultural and food related activities. In this example, the café/restaurant footprint is 150 SQM and functions both as a café during lunch hours and then as a restaurant in the evening. By serving on average 70 people per day we make a small profit with the suggested staffing of five people.

Tours and admission

For visitors to truly benefit and enjoy the tropical section, we will provide guided tours which will explain all the components of the tropical section. The guide explains how everything is linked together beginning with the fish and ending with the fruit visitors pick from the stall and eat. Entry fee with a guided tour will be 150 sek for adults, 40 sek for children, students and pensioners. The customer can also choose to walk around by themselves and let the surroundings speak for themselves with an entry fee of 100 SEK (no cost for children). We will also have a yearly Urban Ecosystems Friends membership for those who wish to visit the tropical section several times throughout the year. This will allow the member to come and go as often as they like for a price of 350 SEK sek a year. In the yearly members fee, there will also be invitations to special events and picking of fruits in season.

Example - Supermarket

Placing a Urban Ecosystems on top of a supermarket has several advantages. The rooftops are very large and flat which enables footprints for greenhouse structures of up to 5000 SQM. There is a good flow of visitors even if the building itself might be placed outside the most central part of the city. In collaboration with the store owner, Urban Ecosystems can be configured in several ways depending on the local market and is meant to complement products already offered by the supermarket itself. As
demand for local and sustainably grown products increase, Urban Ecosystems is positioned to be the perfect partner to a supermarket building as customers seeking local fresh products will be able to do so in their usual grocery establishment.

Possible placement of Urban Ecosystems on top of a supermarket.

This supermarket will be both seller and producer and take a huge leap towards more sustainable food production.

Layout

To achieve this, Urban Ecosystems will focus on the production of high quality fresh fruit and vegetables through a production unit comprising 55 percent leafy greens, 10 percent temperate fruit and vegetables (tomatoes, strawberries, chillies) and 8 percent microgreens. The remainder of Urban Ecosystems space will be allocated to 10 percent market (instead of the cafe/restaurant section), 12 percent fish ponds and canals and 5 percent BSFL hatchery.
The demand for locally grown fruits and vegetables is increasing and small scale farmers are now popping up all across the outline of many cities. To put a Urban Ecosystems on top of a supermarket would solve one issue that the small farmers have a difficulty to solve: customers need to seek them out or they have to seek the customer out. With the steady stream of customers to the supermarket, the customer is already at the local farm and able to engage with producers.

**Own label**

Urban Ecosystems produce would be placed alongside other produce in the supermarket and labeled in a special way to advertise its novelty. For the customers that want an experience of a more market based feeling there will be market stalls and a small café in the temperate section. Here customers will be able to have tastings of unique produce, prepared food and buy newly picked vegetables. The store can later expand to have more exclusive events for their members and raise the value of the produce even more.
By placing market stalls in the cafe/restaurant part of the greenhouse over the supermarket, customers can easily find produce freshly picked from Urban Ecosystems.

Package free

Having the production and consumption at the same place will also be beneficial from a packaging point of view. The employe who picks the vegetables won’t need to use any single-use packaging to deliver to the customer. The customer will already have a bag to carry their other products and can just place the vegetables in the same bag. Not needing to use extra packaging just to transport the vegetables to the customer will help mitigate environmental issues that traditional plastic packaging has, as well as decrease the overall production cost.

Impact on neighbourhood

Supermarkets are often put on off site positions to minimise impact on residents, Urban Ecosystems will therefore not have any negative impact in any residential area. If the supermarket is placed in a denser residential area Urban Ecosystems might need to blind off the grow lights in the windows to prevent light going in the direction of the residents. Having a Urban Ecosystems in a dense urban setting could of course have a positive impact as well, it can stimulate curiosity when seeing the
structure on top of a supermarket and enhance the social interaction between the consumers and the producers. Using the café as a meeting point for different events will also increase the social values in that neighbourhood.

**Business model distribution**

With the largest part of the Urban Ecosystems being leafy green production, the supermarket will have a steady stream of fresh greens and also have an economically reliable concept. The leafy green section will provide Urban Ecosystems with most of its revenue calculated over four years.

To enhance sales even further, production of tomatoes, strawberries, chillies and microgreens by aquaponics will be a great way of doing so in the case of a supermarket, since these crops have proven markets and require relatively standard practices to produce. Tomatoes take slightly longer to bear fruit, and occupy a slightly larger area, but it’s a product with a high demand and with all kinds of new variates tomatoes has become a high value fruit. Tomatoes is a perfect vegetable to grow in greenhouse in Sweden. With 75 percent of all tomatoes being imported in Sweden, there is an opportunity for creating a large market for locally grown alternatives. By specialising in growing more unique species, Urban Ecosystems can follow a already upward going trend where consumption of fruits and vegetables are increasing. Tomatoes are one of the fruits that has the highest increase in Sweden and the increase is specially large with more unique kind of tomatoes. By using the café as a meeting point Urban Ecosystems can hold tasting events were the customers can experience more varieties and be more involved in Swedish tomato production. Even if the temperate section is a smaller part of the greenhouse area, it would still boost revenue and help to get customers.

Microgreens grow quickly and do not take up much space. Microgreens also have a high value (sek/kg) which makes it a lucrative production activity. Microgreens do not need much energy in form of nutrient or light which makes them a great product for indoor production. In this scenario with just a small percentage of Urban Ecosystems area it would help to diversify and boost revenue as well.

Lastly, the café and market stalls have limited space to make space for production and will bring revenue in the form of selling food and beverages, but will also bring revenue by hosting tasting,
growing, and cooking events. This will strengthen the social factors of the neighbourhood and increase the value of Urban Ecosystems produce. The café and market stalls are also selling Urban Ecosystems produce but without any added value, the profit for which has already been taken into account in other sections.

After considering all the maintenance costs, running costs of electricity, heat, staff, material, and revenue from all sections we would see a profit margin of around 3-4 percent yearly. This can shift depending on staffing needs. In this example we’ve used an extra strong workforce to make sure production runs smoothly in the beginning. When efficiency is greater, we can reduce the cost of labor and increase overall profitability.
Macro process chart

The overall process chart shows the different sections of Urban Ecosystems, incorporating both vegetable production and customer experience, bringing all together in a social arena where fish are a part of the nutrient cycle and, at the same time, an educational tool, thus closing the loop between humans and nature.
Logistics flow for produce

Almost all production within Urban Ecosystems is planned production. Through an online ordering system, the customer, be it either a restaurant or a supermarket will sign up for a minimum period of buying a certain amount of produce during the period. The contract-based deal is to minimize waste and create longer lasting sustainable customer relationships. The customer will be given three options regarding the pickup/delivery of the produce:

1: By offering a discount the customer/clients handle the pickup from the Urban Ecosystems.
2: The customer is given the option of a third-party delivery company handling the logistics.
3: The delivery is taken care of by the staff of Urban Ecosystems utilizing public transportation or carbon neutral transportation alternatives such as electric bikes or cars/vans fitted with electric hybrid engines.

There is also a possibility for non-contract customers visiting to purchase produce through:

1. The café/restaurant - fruits, microgreens, vegetables and leafy greens used for food and drinks.
2. Direct sales at the fruit/vegetable market stall in the foyer section.
3. Through a host supermarket via market stalls.

Since production is taking place in the proximity of the end consumer, there is no need for long shipping and special ripening considerations. The products will be grown in optimal conditions promoting a more fresh and nutrient-rich end product compared to their conventionally grown and imported counterparts.
Efficient water use is key for a sustainable production. In order to reduce our footprint, we will collect rainwater from the greenhouse to supplement the leafy greens production. This will supplement “topping-off” from tap water and be used directly once filtered. This will help save 10–30 percent of the total water consumption per year depending on layout. Sensors for water sprinkles will be used for the cleaning of the greenhouse windows. This will enhance the visual contact with the outdoor space and the efficiency for heating and cooling. The table below shows the water collection and water usage, excluding condensation of the humid air from the vegetable transpiration that will help us to save even more water.

<table>
<thead>
<tr>
<th>Example water calculations based on 1500 to 5000 SQM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transpiration per day/plant</td>
<td>0,5 - 2 litre on average</td>
</tr>
<tr>
<td>Total transpiration</td>
<td>4600 - 34000 litres</td>
</tr>
<tr>
<td>Transpiration per year</td>
<td>1700 - 12300 cubic metres</td>
</tr>
</tbody>
</table>
### Business plan

### Market overview

There is a good potential for the growing of temperate fruits such as tomatoes, strawberries and peppers as much of these are being imported today. The market is far from saturated, especially when it comes to tomato production where we only grow one third of our own tomatoes. The market for leafy greens is also increasing, with more fresh herbs being sold every year. By having a reliable source all year round we can fill a gap in the market where business usually have to import from countries further south. Swedes are some of the leading buyers of lesser known tropical fruits\(^{19}\). Strong links with SE Asian cultures through a popularity among Swedes for SE Asia as a winter holiday destination, backed by a predominant immigration trend from these countries and an increasing awareness of the nutritious food values of tropical fruits, enforce such preferences.

Looking at the tourist and supermarket fresh vegetable trades alone, there is a good potential to gain substantial market share. Our supermarket host building option includes a special fresh vegetable

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\(^{19}\) Over 70% fresh fruit consumption in Sweden is imported and less than 30% is produced locally. Currently, it also imports 522 thousand tons of fresh vegetables per annum valued at €627,4 million and 769 thousand tons of fresh fruit valued at €1,03 bn (Eurostat sources).
market in a greenhouse setting where tomatoes, cucumber and other temperate vegetables are being cultivated in soilless culture systems similar to the ones in which supermarket vegetables are increasingly being produced in Nordic countries. Customers will enjoy a different environment close to production where they can purchase fresh fruit/vegetables in an urban garden environment.

Target customers

Our primary customer segment are supermarkets, restaurants, organisations and municipalities pre-ordering leafy greens, temperate and tropical fruits. Secondary include business companies wishing to use a stimulating environment for meetings and events; residents and cultural groups choosing to hold special events such as music recitals or community social gatherings (after hours - evenings/night times); gardening enthusiasts desiring new and exciting venues, culinary- and restaurant-interest groups wishing to accommodate cooking classes, and even community services desiring the therapeutic qualities of growing plants etc. All will have an optional full catering service and, at the same time, ample opportunities to take full advantage of the aesthetically pleasing environments provided by flowering and fruiting trees, bushes and vines arranged to optimal visual effect in the cafe/restaurant and tropical sections.

Customer preferences

Different target customers have different needs. For individuals and small groups, these will tend to focus interests on sustainability (low carbon footprint from seed to plate on one’s doorstep), quality (comparable to, if not superior to, some local supermarket alternatives) and comfort (how close from their normal supermarkets, how pleasing and exciting is the overall experience, either just to buy, or to bring their family for a visit). Nobody entering Urban Ecosystems should feel that they fail to experience something new and do not get what they want or envisage in anticipation of their visit.

Direct competitors

When it comes to production of exotic and tropical fruits in Sweden, there is no competition. In the spring and summer months, competition from local farmers will be expected, at least for the leafy greens and temperate production of tomatoes. The tours that are held in the tropical section have competition from other tour and experience based activities.
Indirect competitors

Growers and importers offering the same products at a lower price are examples of indirect competitors. What most of them cannot offer, however, is locally produced, pesticide-free greens and fruit picked fresh from the tree, bush or vine. Other indirect competitors are supermarket chains and large fruit importers. Their strength is the extended economies of scale which allow them to keep prices low, while their weakness is that they cannot ensure a sustainable source for every single product. Other restaurants and brewing companies also provide tour-based activities but in quite different food and beverage commodity segments.

Competitive advantage

1. The assured freshness and genuine taste and nutritious qualities of Urban Ecosystems greens and tropical fruits;
2. Closeness to consumers, meaning minimal carbon footprint;
3. Out of season production of valuable produce which would otherwise be in short supply and which so often relies on the need for importation. This opens up a window of opportunity: we can produce fresh salad and fruit crops of high quality which command premium prices;
4. Use of organic approaches, where minimal land and other natural resources are used for production of nutritious foods (incurring minimal waste and harm to the environment); and
5. Our greatest advantage is the way in which the project closes the loop to make a self-sustainable production entity. Produce which is not sold in our fruit/veg stall or used in the dishes and drinks served in the cafe/restaurant or used for cooking classes, will be collected and processed into a form suitable to feed the black soldier fly larvae, which after defatting will be used to feed the fish. By creating a closed loop we don’t have to pay for shipping valuable resources to- or off-site.

Produce

Urban Ecosystems can grow high quality fresh leafy green vegetables, temperate vegetables and a specific range of tropical fruit that deliver high value per kg and some of which are rarely available in Nordic supermarkets. In most cases, the revenue obtained by Urban Ecosystems, across the product range, will be 50 percent of those currently posted (based on jämförpris per kg) by the leading Swedish supermarket chains (ICA, COOP, Hemköp, City Gross and Willys). To achieve
competitiveness in terms of the temperate green leafy vegetables (salads and culinary herbs), the Urban Ecosystems commercial production strategy will be to grow varieties which would otherwise not be available in established Swedish outlets at certain times (market seasons) of the year. The table below contains information on the reduced availability of different types of leafy salads and tropical fruit imports in Northern Europe based on an all EU survey in 2015 and moreover confirmed by a recent fresh fruit and vegetable import market trend assessment.  

<table>
<thead>
<tr>
<th>Fresh produce</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
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<th>Nov</th>
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Shaded cells indicate where maximum revenue returns can be generated. In those where there is a single ‘x’, returns can be expected to be better than at times of maximum availability (ie cells in which there is no ‘x’).

By receiving a premium price for produce during off-peak availability seasons, we can compensate for dips in revenue when competitors are able to offer the same produce for a much lower retail price.

Our ability to even out production using supplementary lighting and heating, without the influences of extreme weather conditions, is a strong competitive advantage. There will be also be a choice for our customers in that although they can “shop around” at such glut times, many we are convinced would

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https://www.cbi.eu/market-information/fresh-fruit-vegetables/trends/
wish to purchase fresh products from a reliable source able to produce all year-round. In other words, Urban Ecosystems with residual heat opportunities at its disposal will be able to produce a more extensive range of high quality fresh green leafy vegetables at any time of the year without being constrained or penalised by either adverse energy input costs associated with negative growing conditions, or seasonal variations in light quality and intensity and sub-optimal plant raising temperatures.

Distribution plan
Direct customer sales (food and experience), through collaboration with host-building, in-house café/restaurant, external restaurants or using third party distributors (wholesalers).

Financial - Microgreens
The fast growth rate of microgreens and the relatively compact space they require makes them very profitable. Since they only grow for a few weeks, the lighting requirements for seedling development are low, making it possible for us to produce them on the under level floor all the year round. Most of the space for the microgreens production section is used for microgreens. A small portion of the total space is used for the propagation of seedling plugs for the leafy greens section. We have calculated that buying them from another producer is not cost-effective and additionally, the transport from outside the city is a less environmentally friendly option.

Financial - Tropical/temperate vegetable section
It takes time (at least one year) to establish the tropical section to its full production potential. For most of the grafted trees, full yields would not be expected until year two. The tropical section costs more to run than the leafy greens and temperate vegetable option since the light demanded by tropical plants is much higher. The higher light levels, however, will allow the cultivation of faster growing herbaceous tropical vegetables in raised beds between the trees and this activity is intended to increase early revenues in the section. If temperate production (tomatoes, strawberries and peppers) is used instead of tropical, there is less focus on the visitor experience and more on production. These produce from year one and is a viable option, especially when a supermarket is a host building. Tours are a part of the day-to-day activities and the income from these (in the case of the tropical section) will help increase the value per SQM. It’s important to note that when looking at just the value per SQM,
it’s clear that the leafy greens section is much more profitable. However, these values do not take into account other activities that can take place in the tropical section, for instance business companies and other groups holding meetings and events. Adding this together with the added value of producing for the café/restaurant as combined attractions will increase overall ROI for the tropical section.

Financial - Leafy greens section

The leafy greens section has the most potential when it comes to revenue per SQM coming in around 4200 SEK per year on average. This is achieved through the use of vertical growing techniques which helps us maximise the harvest per SQM, which is vital in an dense urban setting. Likely, the tropical section pricing will be seasonal, charging up towards 150 kr/kg during the wintertime and around 120 kr/kg when competition is higher. This puts us on an average of 135 kr/kg year-round. Calculating the time to do tasks required in the leafy greens section has shown us that we need one person per every 200 SQM of active growing area.

Promotions plan

Our wide range of customers demand different types of promotion. Our main marketing will be focus on fresh plant food sales, in some cases through a supermarket if that is situated below. New customers and visitors will be encouraged through business collaborations and the mounting of special events, e.g. tomato and tropical fruit tasting, chef gatherings to taste new vegetable produce, cooking classes and performances. Connecting the food we produce with themes that we can promote as suitable, such as think-tank/team building-type activities for companies, will attract further business clientele. A good website with upcoming events and a calendar to see and book via a virtual booking system will be a major priority for marketing.
Building guidelines and construction features

The mounting of a standard greenhouse construction footprint on an existing building is expected to have minimal retrofitting and weight loading implications, especially since there will be a service under-level that can be adapted to accommodate specific extra weight loading requirements through the use of strategically positioned I-profile steel girders and appropriately positioned load bearing walls. The accessibility of aquaponic piping and other services will be facilitated by the fact that much of this infrastructure will be slung under the toughened intermediate flooring laid between the two floor levels (see diagram) facilitating routine inspection, service and repair work. The under-level floor, as well as the intermediate strengthened floor between the greenhouse and service levels, will be water tight and sealed with appropriate epoxy floor compounds so as to reduce impacts of noise and possible intrusion by biological agents and accidental chemical spillages to the host building. It is acknowledged that all final designs and drawings of the different forms of the Urban Ecosystems concept should ensure that the strength, stability, safety and serviceability requirements of the building work meet the latest European and Swedish Codes of Practice as defined in the Boverket mandatory provisions and general recommendations (§2011:10) on the application of European Design Standards (Eurocodes), EKS BFS §2015:6 EKS 10.3 and any other special regulatory and statutory requirements. Imposed loading of the two levels will be based on professionally conducted calculations. The maximum load criteria (D2) for shopping center floors are 5.0 [kN/m²] or 500 kg/m². The bearing of a roof construction is at least 200 kg/m² if beam rule (A) is used. Strengthen this roof so that it can hold the Urban Ecosystems structure and an equipment by the use of above methods would make sure that even the heavy load of Urban Ecosystems fish water canals can be supported. Maximum load of the water will not exceed 500 kg/m². The water canals also make sure we do not have a single loadpoint in the structure but rather a spread out load over multiple load bearing pillars and walls. Normal load bearing criteria (C1) as for restaurants and public places are 250 kg/m². This means that we do not have to strengthen the entire roof to meet shopping centre criteria (D2), but just
certain points, and the rest can be strengthened with just a minimum effort. Emergency exits will be constructed exterior to the rooftop greenhouse and to the host building in consultation with the relevant local authorities.

Urban Ecosystems consortium members

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Sinclair Mantell (Tropical, Propagation and Microgreens)
Henrique Sanchez (Water treatment, fish feed production)
Andreas Sörensen (Technical lead, automation, HVAC and sensors)
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