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The feasibility of constructing or installing a vertical farm in Suurpelto

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Laurea University of Applied Sciences **Abstract**
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Global population growth and urbanization are presenting challenges for future food production and accelerate climate change. Traditional farming requires land mass, consumes natural resources and causes runoff, which is harmful since pesticides, fertilizers and other chemicals that flow from crops and soil and make their way to the sea. Vertical farming is being looked at as a solution for future food production minimizing damage to the environment. Vertical farming is practiced indoors using new technologies that support sustainable development. A vertical farm can be built as new structures or in many cases, can be installed in existing structures or buildings breathing new life into otherwise nonfunctioning premises. Other closely related initiatives are vertical gardens and also roof top gardens.

This thesis will explore the possibilities of different forms of vertical farming that could be installed into a smart living district, Suurpelto, which is located in the City of Espoo. The study is carried out through a process of analyzing the relevant theory on Suurpelto's area development project and the infrastructure in comparison with the requirements and principles of vertical farming. Interviews were conducted with authorities from the City of Espoo; A project manager of Suurpelto area development project Pekka Vikkula, a development manager from the Mayor's office Kaarina Salonen, a specialist from City's technical- and environment department Jaana Junkkari and the residence association of the area to obtain realistic information.

The final result of this research was that vertical farming was recognized as a potential future installation for the smart district, Suurpelto. The idea of vertical farming was met with positivity and warm encouragement to materialize this initiative. As is almost always the case, the conversation boils down to finances. Different funding mechanisms that include private investment or public and perhaps even a mixture of both are needed and suggested in order to take this further.

This thesis work managed to bring the topic of vertical farming to key decision makers within the city administration whilst at the same time informing and inspiring city planning authorities to begin planning for installation of such a project for the future development of the region. The author works in the marketing company of the area and the results are affected by the impact of the author's own experiences and the position. The conclusions are based on the data obtained from the interviews and other collected theory.

Keywords

Research, Vertical Farming, Innovation, Sustainable solutions, City planning, Infrastructure, Funding, A pilot project, Suurpelto, City of Espoo

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Vertikaalisen viljelyn rakentamisen ja integroimisen soveltuvuus Suurpellossa

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Maailman väestön kasvu sekä urbanisoituminen asettavat haasteita tulevaisuuden ruoantuotannolle ja kiihdyttävät ilmastonmuutosta. Perinteinen maanviljely tarvitsee paljon maata, kuluttaa luonnonvaroja ja aiheuttaa haitallisia päästöjä ympäristölle. Vertikaalisen viljelyn on arvioitu olevan ratkaisu tulevaisuuden ruoantuotannolle vahingoittamatta ympäristöä. Vertikaalinen viljely tapahtuu sisätiloissa käyttäen uusia kestävää kehitystä tukevia teknologisia ratkaisuja. Vertikaalisen viljelyn eri muotoja ovat uuden tilan rakentaminen, viljelyn integroiminen käyttämättömään rakennukseen tai osaksi jo käytössä olevaa rakennusta. Vertikaalinen viljely on myös mahdollista puutarhamuodossa.

Opinnäytetyö keskittyy vertikaalisen viljelyn eri muotojen mahdollisuuksien selvittämiseen Espoon uudella asuinalueella Suurpellossa, joka on rakennettu kestävä kehitys huomioon ottaen. Tutkimus perustuu Suurpellon aluekehitys projektin ja alueen infrastruktuurin teoreettiseen analysointiin vertikaalisen viljelyn perusteiden ja vaatimusten pohjalta. Realistinen käsitys vertikaalisen viljelyn mahdollisuuksista Suurpellossa saatiin haastattelemalla Espoon kaupungin Suurpellon alueen projektinjohtajaa Pekka Vikkulaa, Espoon kaupungin kehittämispäällikköä Kaarina Salosta, Espoon kaupungin teknisen- ja ympäristötoimen edustajaa Jaana Junkkaria sekä alueen asukasyhdistystä Suurpelto-seuraa.

Vertikaalinen viljely todettiin potentiaalisena tulevaisuuden ratkaisuna Suurpellon alueelle. Hankkeen käynnistyminen edellyttää rahoitusta. Yksityiset sijoittajat, julkisen sektorin rahoitukset sekä näiden yhdistäminen ovat mahdollisia ratkaisuja hankkeen rahoittamiseksi.

Opinnäytetyö tarjoaa Suurpellon aluekehitysprojektille kattavan tutkimuksen alueen mahdollisuuksista vertikaaliselle viljelylle, jonka pohjalta projektia voidaan viedä eteenpäin. Opinnäytetyön laatija työskentelee Suurpellon alueen markkinointiyhtiössä, hänen kokemuksensa ja asemansa vaikuttavat tutkimuksen analysoinnissa. Johtopäätökset perustuvat haastatteluista saatuihin aineistoihin sekä muusta kootusta teoreettisesta aineistosta.

Avainsanat

Tutkimus, Vertikaalinen viljely, Innovaatio, Kestäväkehitys, Kaupunkisuunnittelu, Infrastruktuuri, rahoitus, pilottiprojekti, Suurpelto, Espoon kaupunki

Table of contents

1 Introduction

Currently the population on Earth is 7 billion and experts predict that within another forty to fifty years, there will be another 3 billion of us (Worldometers, 2015). Rapid urbanization brings several challenges for the growing cities of the world. Today's urban health hazards come in many forms; air -, water -, and noise pollution. Cities will have to build and implement new strategies to provide healthy living conditions for its citizens. This affects the very fabrics of life's essential resources, such as food, water, hygiene and waste management (Despommier, 2011). On a bigger scale, we must come up with solutions for the planet to accept the population growth with depleting resources, climate change and less land to use to grow our food. Vertical farming will be studied and researched more and more as these global issues heightens.

Vertical farming is bringing traditional farming practices into urban areas using technology and innovation to create crops, food, water, flora and fauna in an ecological and sustainable manner whilst eliminating costly logistic operations and reducing wastage and spoilage of the production.

The practice of vertical farming takes place indoors preferably in a multi floor structure. It can be a newly constructed building, integrated as part of an existing building or can be retrofitted to an unused structure. Vertical farms utilize new technologies in areas such as cultivations systems, hydroponics- and aeroponics irrigation systems and different lighting solutions.

The City of Espoo is Finland's leading city in innovation and sustainability and is economically the second strongest city in Finland (Espoo, 2015). Suurpelto is a new living district in Espoo where innovation and sustainability have been integrated into the area's infrastructure, and it is a way of living in there. The City of Espoo's technology and innovation focused strategy, which includes research and development stakeholders, such as VTT (Finland's high tech R&D institute) and Finland's largest innovation University Aalto, could be the perfect partners for Suurpelto to develop a vertical farming concept.

The different forms of vertical farming possibilities in Suurpelto will be explored using globally renowned experts' insights of current and future trends in vertical farming, local government's city authorities, research of the funding options and the community to determine the feasibility of installing/constructing a vertical in Suurpelto.

1.1 The concept overview

The author of this thesis is working for the development project of Suurpelto where sustainable living and sustainable solutions are key elements. Vertical farming was introduced to the author when doing research about sustainable living solutions for smart cities. This innovation attained instant interest in the author and started the research process to find out about the possibilities of bringing the concept to Suurpelto.

Professor Dickson Despommier from Environmental Health Science at Columbia University in New York planted the seeds for the vertical farming concept. Vertical farming is a second generation's greenhouse where farming takes place in multiple stories of a building, instead on a horizontal level. This is a system where plants and animals are cultivated for food, fuel, or other products and services by artificially stacking them vertically above each other. A vertical farm is located in the middle of a city to offer food for citizens whilst making more efficient logistics. A vertical farm creates an environment that supports sustainable urban life; it promotes good health and clean food for citizens, brings community closer together and educates people about sustainable living.

1.2 The objectives of the thesis

The objective of the thesis is to identify the key issues needed to be taken into consideration in order to make a thorough research for the possibilities of vertical farming in Suurpelto. Technologies and other requirements needed for a vertical farm will be studied. The main objective is to examine the possibilities of establishing a vertical farm in Suurpelto. To cover this research the sub objectives of the thesis include the requirements and different forms of vertical farming, a thorough research of Suurpelto's infrastructure and mapping out the funding options for such a project.

A vertical farm is a solution to grow food in places where there is no available land left, a vertical farm requires a small piece of land since the farming happens vertically instead of a traditional horizontal way. In Finland, we have plenty of land for agriculture but our challenging climate has negative effects on the crops and the income of agriculture business. A research of Finland's agriculture will also be held on the thesis in order to show the amount of funding it annually receives and to show the reasoning of integrating vertical farming as a part of Finland's agriculture. This thesis will provide a comprehensive research in order to make vertical farming a part of the innovative scene of Suurpelto.

1.3 The key concepts of the thesis

Vertical farming is bringing traditional farming practices into urban areas using technology and innovation to create crops, food, water, flora and fauna in an ecological and sustainable manner whilst eliminating costly logistic operations and reducing wastage and spoilage of the produce (Own definition, 2015).

Aeroponics is an irrigation system that uses minimal amount of water. It is the application of the plants of a fine mist of water laden with plant nutrients onto the root system of a given crop, without using any soil or pesticides. The roots are enclosed in a chamber that keeps the humidity at a maximum level (Despommier, 162-166)

Hydroponics is an irrigation system that uses less water than traditional farming. It is a method of growing plants using mineral solutions in water that runs through the irrigation system reaching the roots of each plant, without using any soil or pesticides (Despommier, 162-166).

Infrastructure is the base structure of a city, which includes all the functions it has. An infrastructure includes buildings, roads, parks, railroads, underground transportation, water- and wastewater systems, electronic networks, etc. Infrastructure is planned by the city and it requires highly trained professionals to handle the budgeting, knowledge of the environment and the planning of the infrastructure. The main idea behind the infrastructure is to make sure everything in a city functions (Vikkula, 2015).

A Pilot project means testing and developing a new concept to learn possible potentials, development areas, and risks before starting a bigger scale project. A pilot project is a smart way to try out an idea without making large investments, and learning from the experience (Tekes, 2015).

Funding can be granted by public sector, private investor or organizations to financially support a business idea, a research project, or a project of the public sector (Own definition, 2015

1.4 The delimitations of the thesis

The result of the study is limited to one living district, so the results of the thesis can only be used as a foundation for Suurpelto in order to establish a vertical farm. The other districts of the City of Espoo will be able to use this study to learn about the requirements of vertical farming and the general research process. The other districts will have to make a research of

their own of the areas' infrastructures to find out more specific information about the possibilities to establish vertical farms.

The feasibility of different vertical farm configurations will be explored from the infrastructural point of view. The research study will provide information on a general level, not on a detailed level. Changes in economic development may affect Suurpelto in the future, so the results of this study may not be specific after some period of time and therefore cannot offer a long-term operational plan.

1.5 Theoretical framework

The theoretical framework of the thesis focuses on the requirements and operational models of vertical farming. Irrigation systems, cultivation systems and lighting solutions were studied and described to make the research as accurate as possible. This thesis refers to the general and analytic theory enabling the use of practical implementation strategies for different vertical farm configurations. Theoretical literature and sources about vertical farming and sustainable agriculture create the basis for the study.

To capture the possibilities of the area, infrastructure, vision and requirements of the area were studied. Research on publications and current articles about funding options were done to gain full understanding of the possible business opportunities for Suurpelto. These theoretical sources also provided the foundation for the interview questions.

1.6 Research methods and analysis

The data for the thesis is gathered by literature such as books, publishments, videos and articles about vertical farming. I chose the qualitative research method because it fit better for the nature of this research. I'm interested to find out how to establish a vertical farm in Suurpelto, which indicated I would choose qualitative research method for my study (Silverman 2013, 12-14).

The actual research data of the possibilities was gathered by interviewing authorities from the City of Espoo, the project manager of Suurpelto area development project, Pekka Vikkula, who was a key person for this research. Interviews were also conducted with the development manager from the Mayor's office of the City of Espoo Kaarina Salonen and an environment specialist from the technical and environment service department of the City of Espoo, Jaana Junkkari. These two ladies are part of a cross administrative development program called "a participatory Espoo", main goal of which is to make the citizens to participate in developing the city and Suurpelto is the testing environment for their program. Their

knowledge of Suurpelto is excellent, which made the interview very useful. A small get together was arranged with the residence association of Suurpelto to hear their inputs and thoughts about the topic.

The interviews were done face-to-face, starting by presenting the concept and explaining the purpose of the research with a power point presentation. The interviews were carried out in an informal and open way by presenting relevant questions and encouraging for free conversation (Eriksson & Kovalainen: 82). The questions for each interview were planned beforehand based on what the author wished to find out from the interviewees. Also more specific questions about the discussed issues came up during the interviews. The qualitative results of the interviews were analyzed thoroughly by using methods of expertise interview analysis, such as thematic comparison and scientific conceptualization using transcripts from the interviews. The results of each interview are shown throughout the chapter 4 and 5 as facts, examples and references, and they work as the foundation for the conclusion and discussion parts of the thesis.

2 Vertical farming

Vertical farming is practiced in multiple floors inside a building. There are machineries and technologies that enable farming this way. Such technologies are hydroponic and aeroponic growing systems that don't require any soil to grow the crops and don't produce any runoff. Ideally a newly constructed vertical farm building doesn't produce any waste outside the building and is run by renewable resources (Despommier, 191-195). In most cities, there is not much land available and the price of the land is very expensive and this is why one must go vertical. The other reason behind this is to have smaller ecological footprint. Vertical farming is a long-term solution for future's food production and sustainable living, in goals to reduce our ecological footprint on Earth (Despommier, 2014).

Since vertical farming takes place inside, one can control everything and therefore have a successful harvest each time. Vertical farming can be directed for different purposes, commercial farming, vertical gardening and other purposes such as educational operations. There are several vertical farms around the world and organizations specialized in vertical farming industry with different services and products. Vertical farms for commercial purposes are used in South-Korea, Japan, Singapore and several locations in the United States of America. Many new vertical farms are in a construction process around the world, the nearest one in Linköping, Sweden. These vertical farms have been built as solutions for high prices of imported food, decreasing areas to grow food and to revitalize economic development. Other purposes for these farms are innovation centers for alternative farming and technology devel-

opment, urban agriculture R&D centers, ensuring food supply resilience, to repurpose undervalued industrial buildings, for educational purposes and to gain profitability.

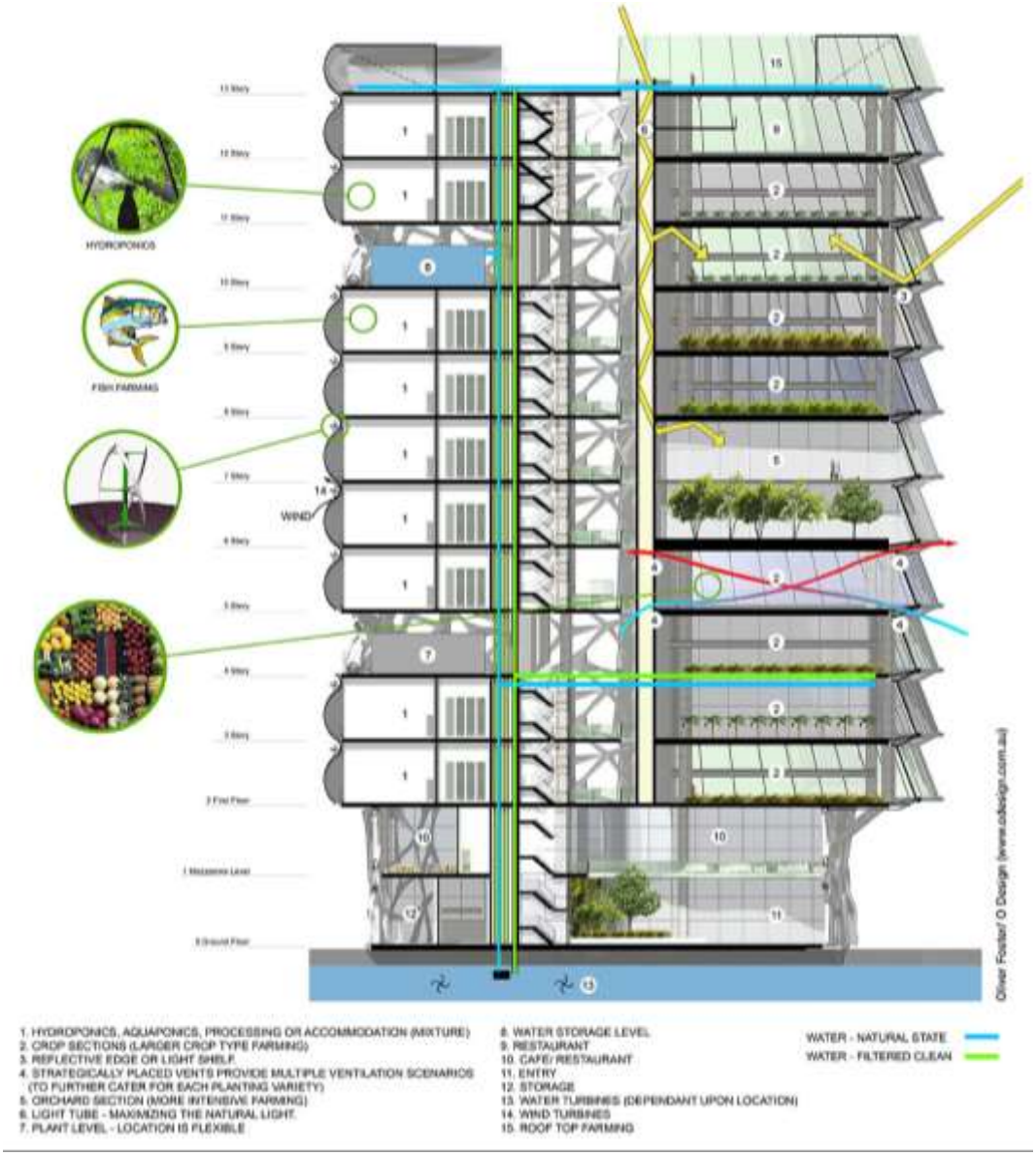

Illustration 1: A demonstration of a vertical farm (Dr. Despommier, 2015)

2.1 Advantages of vertical farming

Vertical farming has several advantages for a farmer, for an individual, for a country and for the environment. Weather has a huge impact on traditional farming practiced outside but with vertical farming, there are no weather-related crop failures. Dr. Despommier explains in his book that the catastrophic weather events over the last years have been speeding the process of finding new solutions to produce food (Despommier, 148). A year-round production of any crop is possible in a vertical farm and isn't depended on the seasons like traditional

farming is. This enables the farmer to grow crops in a smart way to make the ideal amount of production and to gain maximum profit (Despommier, 175).

The safety of our food is a big topic in today's world because of the growing population and growing demand for food, farmers must use different techniques to grown their crops to match the demand. In doing so, the usage of fertilizers and other chemicals, and even genetic manipulation of vegetables and fruits is common in the demanding markets of today. There is no agricultural runoff in vertical farming because of the revolutionized agricultural technologies, hydroponic and aeroponic irrigation systems. These irrigation systems use 70-95 percent less water than traditional farming does and they enable the plants a clean and safe environment to grow inside without any usage of fertilizers, pesticides, or herbicides. Vertical farming gives more control of food safety and security (Despommier, 151-162).

The ideology of vertical faming is that the farm will be located inside city limits to provide a local food production. The crop will be planted, harvested and sold from the same place and this will reduce the use of logistic services and allow cities to be able to reduce its carbon emissions (167-168). On a global scale, the ideology of farming in the cities will allow the footprint of agriculture become smaller and let the forests to regrowth. Regrowth of forests has several benefits, "the main one being sequestration of carbon in the form of cellulose, and other restoration of biodiversity" (Despommier, 154). Establishing vertical farms will have benefits for the local economy by creating different kinds of employment opportunities. A vertical farm will also be an excellent way to educate children about sustainable food production and possibly this way create a new generation of future farmers. (Despommier, 171-172).

As mentioned before, one can grow whichever plant they wish in a vertical farm and for whichever purpose, for example to grow plants for ethanol, or cotton for clothing industry or to solve big issues like waste management. Waste is causing planetary damage and is one of the greatest urban health challenges causing human deaths in poor countries because of unhealthy living conditions (Hoornweg & Bhada-Tata & Kennedy, 2013). It is possible to establish a vertical farm that has a primary function to remediate grey water by using plants. Grey water is household waste water that includes laundry or shower water for example and hasn't been in contact with human feces. Dr Despommier explains in his book how this revolutionizing solution could be achieved through plant activity; "Capturing the grey water of transpiration can be accomplished after the plants have pumped the grey water through their tissues, purifying it before releasing pure H_2O into the enclosed atmosphere of the vertical farm. Dehumidification of the indoor air is all that would be needed to get back the water we produced by eating and drinking" (Despommier, 175).

2.2 Technologies

There is a wide selection of technologies for commercial vertical farming and for vertical gardening. This is because hydroponics is not a new innovation but the twist is it has been changed into a vertical form from horizontal models. Technology and machinery is unattached from the building itself, so one can choose the equipment to match the size, function and requirements of a farm. To be able to grow crops a growing system is needed, which can be either a hydroponic system or aeroponic system. The market for these systems is large. Lighting is the other requirement for the crops to grow. Depending on the structure and size of the farm, taking advantage of sunlight is ideal but in case this is not possible. There are lighting systems designed for vertical farming purposes.

There are many companies, and entrepreneurs providing different kind of technological solution and configurations of growing systems. Since the vertical farming is a relatively new innovation, the prices are from affordable to expensive. These machineries tend to pay themselves off very quickly.

2.2.1 Growing systems

Hydroponics is a system that was developed in 1937, where plants are grown in nutrient water that has been enriched with minerals and is used to optimize yields and quality of produce, especially for the indoor space. A hydroponic greenhouse uses low-cost plastic piping to hold plants in place for the delivery of plant nutrition. Nutrient film technology is the formal term applied to modern hydroponic growing systems, in which a thin stream of nutrient-laden water is run over the root system of crops (D'Anna, C, 2015). Hydroponics uses approximately 70 percent less water when compared with conventional irrigation schemes employed in outdoor soil-based agriculture. Hydroponic growers do not produce any agricultural runoff. Indoor farming allows for the complete recovery of the water of transpiration by dehumidification.

Illustration 2: A vertical hydroponic system (Free-stock illustrations, 2015)

Aeroponic system was developed in 1982 (Despommier, 165), it is the application of a fine mist of water laden with plant nutrients onto the root system of a given crop. The roots are enclosed in a chamber that keeps the humidity at a maximum level. This technique requires hardly any water and uses approximately 95 percent less water than soil-based agriculture (Phipps, N. 2015), making it a highly desirable method of indoor farming. Practically any plant can be grown in this way.

There are many different designs of crop growing systems using either one of these technologies, hydroponics or aeroponics system. There are several different configurations of growing towers, rotation growing systems, wall designs and several other designs for growing crops vertically. The systems are highly flexible and can be transformed according to the requirements of premises. The lighting is most often integrated as part of the growing systems. There is a great variety of technology for both, for a hobby gardener or for a professional farmer. The companies who offer such systems and technologies can be found in the United States of America, in Japan, in Singapore, in Europe, in the United Kingdom and in Sweden. There are also instruction on the internet on how to build your own vertical grow system for gardening purpose.

Illustration 3: Aeroponic system (Puro, R, 2015)

2.2.2 Lighting systems

A commercial vertical farm that has been constructed solely for the purpose typically has a glass surface to take advantage of the natural lighting. In many countries, such as Finland, this is challenging because of the lack of sunlight in wintertime and artificial lighting will thus

be required in Finland to grow the crops. There are different lighting options for indoor farming that are being used around the world.

LED (light emitting diode) lighting has been designed to grow plants. It exploits specific wavelengths of light for efficient photosynthesis, and it doesn't produce heat to the plant so it can be placed close to the plants to gaining better growth and productivity. LED is also very energy efficient and doesn't consume much energy (Despommier, 186-187). LEDs lighting solutions can be found in many configurations to match the requirements of different growing systems. The availability of LEDs on market is excellent and it is the most used lighting system for vertical farming. There are several companies offering this innovative technology in the United States of America, in Asia and in Europe.

Fluorescent lighting and borosilicate safety glass housing can also be used to grow any crop indoors. There are different types of lighting options, some of which are more useful for growing seedlings and houseplants, while others are more efficient to grow larger plants. Fluorescent lighting has small energy consumption and is used for vertical gardening (Phipps, 2015). Borosilicate safety glass housing lamps are not as common and are a slightly older innovation but works well for example for Omega garden's hydroponic rotation growing system. These lighting solutions can be found at almost any part of the world.

A New Zealand company, Biolumic, has an UV lighting system that is directed for seedlings to improve their growth. This system is directed for large scale producers to increase their yields and to improve the taste and color of indoor grown production. This system can also be integrated as a part of an already existing growing system.

OLED (organo-lighting-emitting-diode) is a more advanced version of LEDs, which allows for even more narrow spectra of light to be produced, and is even more energy - and cost efficient. "OLEDs are made of thin and flexible plastic that could be shaped to totally according to the plants configuration and requirements" (Despommier, 186-187).

2.2.3 Other technologies

The industry for vertical farming technologies is growing rapidly. A Swedish company Plantagon has a patented cultivation system, which transports the trays, where plants are placed, in a special trey elevator around the cultivation loop system. The trays will be irrigated regularly and have a light sealed nutrient solution reservoir, the excess nutrient solution will be reused after decontamination. After the crops have grown in the transport system they will be harvested by automatic harvesting machine (Plantagon, 2015). There are also other automat-

ed harvesting systems around the world, for example in Australia, in Asia and in the United States of America.

Plantagon also has another patented integrated urban solution “PlantaSymbioSystem”, which uses organic rest products from greenhouses for biogas and fertilizers production. The first symbiosis system project will take place in the vertical farm of Linköping, which is under construction at the moment (Plantagon, 2015).

Aquaponics is a system for raising fish indoors in specially designed tanks, a 5600 liter tank can provide up to 800 fish. The nutrient rich water developed from fish can then be used for the plants (Aquaponic Finland, 2015). This system is not new and is widely used in different parts of the world. An aquaponic system could be integrated as part of a vertical farm to build an ecosystem where the nutrient rich water from the fish tanks would be used to grow the crops.

3 Different configurations of vertical farming

In its simplicity, a vertical farm is a building more than one floor that grows food and in its most complicated configurations it consists of complex of buildings close to each other (Despommier, 179). There are different configuration possibilities to choose from to meet the needs and possibilities of different countries and environments. Some countries of the world are suffering from hunger, lack of resources, poverty or unstable situation within the country. Other countries might have a growing problem to provide enough food for its citizens with lack of land to grow the food. Also developed countries, such as Scandinavian countries, could have a need for vertical farms to help the countries become more sustainable, to grow the economy and to maintain a healthy lifestyle for the citizens. The food industry and the competition within it are global and the environmental chances caused by global warming affects this industry significantly. The reasons and values for establishing vertical farms vary from country to country but there is enough reasoning and demand to start building these new generation farms around the world.

Constructing a vertical farm building requires political will and acceptance, a lot of investments, an operator to take charge of a project, a permission to build or integrate a farm, professionals to plan, design and construct the building, a plan for plants and animals grown in the building and skilled and motivated people to run the facility. Installing a vertical farm into non-functioning premises requires less investment than building one but it still has the same demands otherwise. Integrating a vertical farm as part of a building can be done as a very minimal scale project or as a large project, this all depends on the operator of the farm.

Therefore the integration option has more flexibility and it can be carried out with less investment and less risks than the other configurations.

3.1 Constructing a Vertical Farm building

There are several matters to take into consideration before starting the construction process, like in any business, a planning process is vital to avoid errors and to ensure the success of the business. The goal of a research and planning process is to study the location and its infrastructure, needed resources, a production plan after studying the markets, a SWOT analysis, a preliminary plan for economics and a business model for the organization. This is a normal procedure when any company starts its operations but extremely important in this case in order to find a funding and the right location for a vertical farm. The organization model could be any form in this kind of project; an entrepreneur, a company, an organization that consists of different parties such as private investors, public sector and several companies. Possible partnerships could play an important role in this sort of a vertical farm project, especially if the operator of the project isn't financially prosperous enough. The partnerships can also help the business be more successful and open new channels once the vertical farm building is up and running.

Architectures and engineers must take certain things into consideration with the design of the building. Dr. Despommier explains in his book the key considerations in the design: a vertical farm should capture sunlight and spread it evenly among the crops, the building should capture passive energy for supplying a reliable source of electricity, employ good barrier design for plant protection and maximize the amount of space devoted to growing crops (Despommier, 181-205). Also a plan for symbiotic alliances should be considered in a highly developed and in a highly sustainable vertical farm building. In Finland, the architecture and design industries are well known around the world and Finns are pioneers in new technologies and design. The knowledge of the renewable energy sources and the usage of these have developed rapidly over the last years especially in the Scandinavian countries. It wouldn't be difficult to find skilled people to execute this level vertical farm project in Finland.

A building permission is required from the local government in order to construct the building. The process to get a building permission varies in each country and the level of demands can be very different. At this point one must be done with the thoroughly done planning process and must have a proper business plan, a funding or to have enough financial resources and be ready to take the next steps in the process. A land that an operator wishes to get a building permission can be privately owned or owned by the local government. A privately owned land can be purchased or leased from the land owner, while the purchasing option is

usually not an option if the land is owned by the local government but a long term leasing is possible. The building permission process will be discussed more specifically in chapter 4.1

3.2 Integrating a Vertical Farm into nonfunctioning premises

Cities could use vertical farms to rehabilitate urban spaces once companies have left the premises empty after leaving. There are several vertical farms in the United States of America, which are established into old industrial buildings. A vertical farm will rehabilitate an empty urban space by itself but it will most likely attract other industries around it, such as aquaponics (a specialized system to grow fish), bakeries to sell freshly made bread from ingredients from the vertical farm or even restaurants, which would also use produce from the vertical farm to make their dishes. This would create a whole new industry of it's own and any government will be pleased with this kind of economic development.

For this configuration, the planning process is the same as on the option to construct a vertical farm building excluding the matters regarding to the building process. Once a business plan, finance or funding and an organization has been put together, an operator needs to search for a suitable real estate for the vertical farm. A suitable building would preferably have a lot of glass surface, which allows the natural light to reach the plants. In case the real estate doesn't allow much light in, artificial lightings can be installed. Another suitable feature is high walls for maximizing the space with the growing systems. One must also make a decision about the energy resources and waste management, which would ideally be as sustainable and as renewable as possible. An operator needs to purchase needed growing systems and other technologies for plant and/or animal production. The technologies for vertical farm are discussed more specifically on chapter 2.2.

3.3 Integrating a vertical farm into an existing building

A Vertical farm can be integrated as a part of an existing building, which functions for another purpose, for example a school, a hospital, an office, a restaurant or a residential building. In this case, a vertical farm can be part of a school building or it can be integrated as its' own separate part of the building. Integrating growing systems and other needed technologies into such spaces is not a difficult process. This configuration option also requires a business plan, some level of finance or funding and an operator to run the farm. This option doesn't necessary require as much investment as the other vertical farm configurations and suits for a startup company and it is an excellent way to start a pilot vertical farm. This is a great way to test one's business idea without being in a risk of losing investments or revenues. An integrated vertical farm can be done on a small or on a large scale; an operator must have an

idea, which way they want to lean on in order to find the most suitable building to match their ideal farm.

An integrated vertical farm could also work for another purpose than commercial reasons. It could be built inside a hospital to support its nutrition supply or inside a school building to educate children about nutrition, biology and just simply how to grow your own food. There isn't one way to integrate a vertical farm since the variety of different technologies and growing systems is huge, and therefore a farm can be built into almost any space. The possibilities of integrating vertical farms as part of our lives are beyond imagination, it is a system that can be fixed according to one's wishes and needs.

4 Possibilities of vertical farming in Suurpelto

The vision of Suurpelto consists of five different parts; sustainable development, new innovative service concepts, family-orientation, life-long learning and internationality. These values have been determined in the planning process before any construction work has begun and they have defined what kind of living area Suurpelto will become. The impact of the vision can be seen in the infrastructure of the area. The infrastructure is new and it differentiates from the other living districts in City of Espoo with its parking solutions, pedestrian ways, alternative energy solutions and other innovative building solutions. Parking in the area takes place in underground premises, which will leave the land free for parks and for footpaths. The goal of the area is to minimize the usage of cars by offering excellent public transportation services and the final plan for the area is to have mainly esplanades where cars are not allowed. Alternative energy solutions are being used as energy sources for residential buildings, such as solar panels, geothermal heating and passive house solutions. Also innovative service solutions can be found in these buildings in forms of digital info screens where residents can find the latest news of the area, and e-lobbies that have been built into each building, which functions as delivery rooms for shopping.

The development project of Suurpelto started in 2009 and the area's construction is estimated to be completed by year 2025. Currently there are approximately 2500 people living in the area and the estimation for future is 10 000 residents. The development of the area is still in the early stage and only $1/5^{th}$ of the infrastructure has been built, so far several residential and a few educational buildings have been built. Suurpelto has a new educational building called "A learning Hill Campus", which opens its doors for the public in autumn 2015. The campus will have new innovations integrated into its construction such as; new functioning models, new teaching methods and a versatile selection of leisure time opportunities. Suurpelto has had a temporary community garden for its residents for a few years now but it will

have to be relocated inside the area within the next three years because of the starting construction work in the spot.

When a construction project of a living area is still in a process, the changes for original plans are easier to make. Especially in Suurpelto, since the construction of business- and service premises haven't been started yet. Some of the original plans for the business- and service premises have changed and a lot of available space can be found. There are different rules and processes that must be taken into consideration if one was to build a vertical farm in Suurpelto. These rules and processes will be discussed more specifically in the following chapter 4.1. A thorough research of the infrastructure is necessary in order to learn about the possible challenges and figure out solutions on how to outcome them. In order to receive funding or other business cooperation, it would be a smart move to map out possible partners of the area. Partners who are familiar with the area and possibly have other activities in there would be an excellent addition in the process of making a vertical farm in Suurpelto.

Sustainable solutions are important in Suurpelto and they are one factor that defines the image of the area. Therefore new innovations, new buildings and anything that finds its way to Suurpelto, should support or promote sustainability. Vertical farming fits under each of the visions of Suurpelto and therefore would promote all of these values in the area (Vikkula, 2015). Also Salonen and Junkkari agree that the vertical farm concept fits well into the ideology of the area. "Suurpelto is called a living lab where testing new innovations and ideas has been made easy and this would completely support the idea" (Heimonen, 2015).

4.1 Constructing a new vertical farm

The infrastructure of Suurpelto is a city planned area and there are certain rules and procedures to follow if one wishes to build a vertical farm in there. In order to construct a vertical farm building, an exact spot from the infrastructure must be mapped out and find out it's originally planned purpose from the city planning department (In Espoo the infrastructure is planned for residential-, business-, educational-, or for green area purposes and the purpose defines what can be built on each plan of an area. If a wished spot was planned for residential purposes then it is most unlikely to be able to build business premises in this area.) Other factors that must be specified from the plan are the allowed square meters for construction and the allowed height for the building. These are determined in the plan and they have been decided at the city council. The height and square meters are determined to match with the scenery of an area, for example the city council would not accept a skyscraper building to be constructed in an area of row houses. Once this has been done, a plan proposal must be sent to the city planning department for an assessment, which will proceed according to the planning process of the city (see figure 1)

If one wishes to build on an area, which is not a city planned area but privately owned, permission is firstly required from the owner of the land. This will be followed by the owner of the land applying for permission to build from the city planning department. To get a building permission for a privately owned land also follows the planning process of the city (see figure 1) (Vikkula, 2015). The only differences between constructing on a privately owned land and on a city planned area are the terms of contract. A building permission proposal will have to be requested from to the city planning department, where the city planning board will make the decision about the building permission. If the permission is granted the property unit of the city will negotiate the details of the land usage contract with the company. Commonly, especially in Finland, the land is leased for a long period of time (3 to 30 years) and the payment will be a negotiated percentage of the value of the land that the operator will pay annually. If the contract was to be made with a private land owner, terms of a contract will be negotiated between the owner of the land and the party who wishes to build on the land within legal terms.

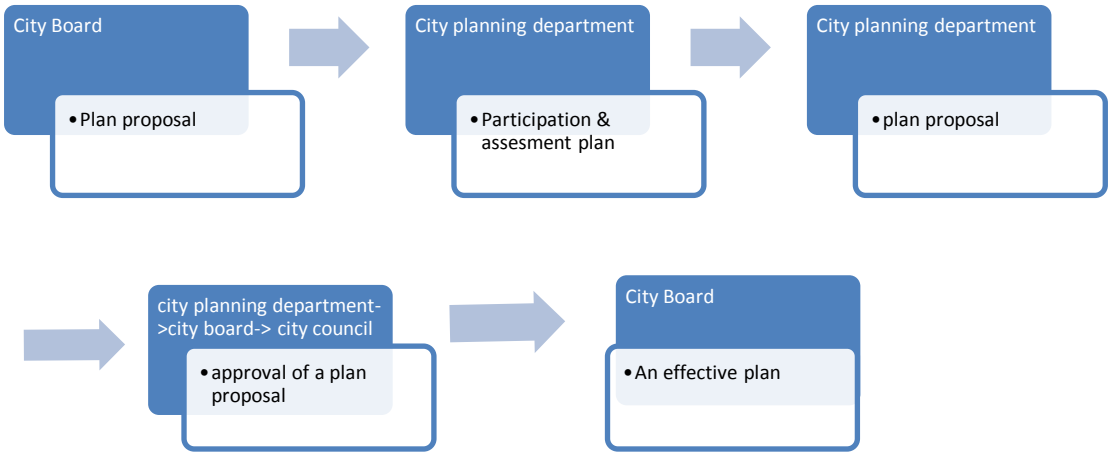

Figure 1: Processing stages of a plan and influencing decisions in the City of Espoo

In Espoo the city planning is a five steps process, which can be started from the action of the city or a private land owner. Researches are conducted at the designing stage of a draft of plans in order to gather relevant information needed to help the decision for plans to get approved at later stage. City board determines the starting points and goals of plans. This will be followed by a participation and assessment plan where the public have a chance to review and give feedback about the plan. An announcement about the public review of plans are done through the official newspapers of the city, the website of the city, personal announcements to local residence associations and private land owners. Also comments from the public authorities will be requested at this point of the process. Paper versions of plans can be seen at the customer service section of the city planning department as well as at citizen service points of Espoo. The plans are on a public review for 30 days. The 3rd step is a proposal where plans will be specified into their final versions at the city planning department. The

feedback from the previous part of the process will be handled at this part and possibly taking into consideration with the final work of the plans. At the 4th step the city planning board will handle the reminders of a city plan and then send it to the city board where it will be resend to the city council for an approval. At the 5th stage the approval of a plan will be made official by a public announcement through the official newspapers of the city (The City Planning Board, 2013).

The part of Suurpelto's infrastructure reserved for service and business purposes still has available land left. According to Vikkula, at least in theory Suurpelto has infrastructural possibilities to construct a vertical farm building. If a private company wished to build it, they would have to follow the planning process described above. If the City of Espoo was to establish a vertical farm, the process would have to start with a pilot project (Vikkula, 2015). A pilot project is a good way to test new technologies in a real environment, to learn more about the concept and its further development opportunities. In order to establish a pilot project, one must find relevant authorities to join the project and find a funding for it (Tekes). VTT (Finland's high tech R&D institute) and Finland's largest innovation University Aalto could be the perfect partners for Suurpelto to develop a vertical farming concept (Salonen, 2015). After a successful pilot project, a vertical farm could be located at the future service area of Suurpelto. Vikkula points out that if the City of Espoo was to be involved in the project, the construction process of a vertical farm building would most likely take a longer time than a construction project of private companies not including the public sector. Small steps towards the bigger picture are needed in order to reduce risks and be financially clever (Vikkula, 2015).

4.2 Integrating a vertical farm into nonfunctioning premises

Since Suurpelto is a new area in its early construction stage, there are no nonfunctioning premises yet and this configuration of vertical farm is therefore not possible. In case the situation changes in the future, it is possible to execute this configuration as discussed in the chapter 3.2. Pekka Vikkula mentioned in his interview that it would be possible to integrate a vertical farm into empty premises in other parts of Espoo, for example in the area called Kera.

4.3 Integrating a vertical farm with into existing premises

Junkkari believes that this configuration of vertical farm could have been possible in the day-care center of Suurpelto or in the Learning Hill Campus if the idea had been included at the planning stages of the buildings. Pekka Vikkula confirms this; it is not possible to integrate a vertical farm into these premises anymore since all the spaces have been reserved. He also

mentions that there are no suitable buildings to integrate a vertical farm at the moment. Vikkula believes it could be possible to integrate a vertical farm into the future service buildings of the area, such as a parking garage or a self-storage building. It would be possible to integrate a vertical farm into the outskirts of the buildings by using storage racks and protective shells. This would also be a great factor in making the buildings more aesthetic (Vikkula, 2015).

Junkkari also believes that the future buildings of the area could offer possibilities for this kind of vertical farm. "An entrepreneur or a cooperative society could establish a vertical farm as part of the future buildings of the area, for example office buildings where one could integrate the required technologies according to the premises. This option would be financially possible for an entrepreneur or a cooperative society" (Junkkari, 2015). Junkkari is correct that this configuration of vertical farming has a lower obstacle for even a smaller company or group of people to start a vertical farm. It could also be an excellent addition to functions of a company to stand out at the market by practicing farming inside of their office building. Junkkari predicts that a vertical farm ran by any authority could bring jobs into Suurpelto and boost the image of the area, as well as bring something completely new for the entire Espoo.

4.4 Other possibilities

Vertical gardening was discussed in each interview and it gained a lot of interests from the interviewees, so it should be considered as a possible option in Suurpelto. Urban gardening is very popular in Espoo at the moment in forms of community gardens and small gardens in the kitchens and balconies of residential apartments (Junkkari, 2015). As mentioned earlier in this chapter, Suurpelto has a small community garden but it can only provide certain amount of spots for the residents. The future of the community garden is uncertain because of the construction work that will take place in the area where the garden is located. Vertical gardening gained interest from the residence association as well as from Jaana Junkkari and Kaarina Salonen and it turned out to be a possible solution for the problem with the community garden of the area.

Gardening and sustainable living have been the core matters connecting the residents of the area and these values have determined the activities of the residence association. "Vertical gardening sounds like an ideal future activity for our association since we could move the community garden inside and do gardening together all year round" (Järvisalo, 2015). Heimonen continues speaking for behalf of the residence association; a tight community improves the safety of a living area and it also improves the satisfaction to the area, which is why activities such as community gardening are vital to create these factors. New activities that bring people together and allow them to experience things together are very important for

the residents and for the communality of Suurpelto. Salonen also believes that people should have more places to meet each other and experience things together. A vertical garden premise could possibly offer other activities alongside gardening, to attain the interest of a larger group of people to do things together. These kinds of activities could be cooking, baking, handcrafts, cooking courses, etc. The residents could also form food groups (Junkkari, 2015). These groups could make profit from the gardening by selling their produce as the organic and local production of Suurpelto (Salonen, 2015). This kind of activity would have a positive effect on the image of the area and it would provide value for it with such activities. A vertical garden established for a community could possibly work as the core factor for the communality of the whole living area.

Heimonen suggested that an additional building for the vertical garden purpose would be ideal and it would be something that the residence could take care of together. Heimonen also points out that there should be both outdoor gardening and indoor gardening to start the transition process from traditional gardening to vertical gardening. In case the residence would want to build a temporary small sized house across the yard for vertical gardening, this would require a building permission for an extra wing from the city (Junkkari, 2015). This is information that the residence association of Suurpelto may use in the future when the current community garden will have to be destroyed.

Vertical gardening could easily take place at people's homes because of the easiness to arrange the required equipment and fix it according to one's premises. Suurpelto could also also integrate rooftop gardens on the roofs of residential buildings. This would require permission from the owner of the building and a set of practical rules to for the garden. The establishment of the rooftop gardens would have to be executed by the residents. This urban gardening option would offer another solution for the community garden and a chance for each individual to enjoy growing their own food locally. This may be a small step towards the bigger picture of vertical farming in the area that could be done immediately.

5 Funding

"Countries like Sweden, Norway, Finland and Iceland will most likely take a more active role in establishing vertical farms" (Despommier, 226). This quote of Dr.Despommier is very accurate in at least in theory; Finland has economic power and will to participate in such a project. Finland has an excellent innovation culture, organizations that fund and support good inventions. Finland has various funding possibilities for a new concept to take place either in a research- or a testing project. Funding can be found from the public sector, a private sector or other agreements. Also funding for the agriculture of Finland will be discussed in this chapter to show the reasoning why Finland should establish vertical farms. Based on the financial

reports of the vertical farms around the world, the estimated cost to construct a vertical farm building would be somewhere between 1,5 million to 10 million €, depending on the size and location of the building. “Finland is economically empowered to fund such long-term projects. Research could be funded by contracts and grants” (Salonen, 2015). Junkkari is at the same line with Salonen but she points out that a private sector could also take the charge of the project and then coordinate the practical everyday tasks for entrepreneurs or social co-operation. If a public sector was to take part in a vertical farm project, a pilot project would be necessary. In order to get a funding for a pilot project, a large interest group is required. According to Vikkula, the interest groups could be easily found for a vertical farm project from agriculture-, water- and electronic industries.

5.1 Agriculture in Finland

Agriculture plays an important role in Finland’s economy; in 2014 food industry was the third largest industry when measured by gross value of productivity and increment value. The biggest export items were dairy products, eggs and grains, which formed 3 % of Finland’s exported items (Agrifood Research Finland’s economic research 2014 publishment by MTT, 45). A large part of the imported items are produce that cannot be product in Finland such as coffee, cacao, tea and produce that cannot be produce enough in Finland such as sugar, vegetables and fruits (MTT, 6-7). These products form 20% of the imported items annually. There were 87 900 people working in the agriculture industry in Finland in year 2012, and the average age of a farmer was 51, 7 years. In 2013 there were only 57 600 farms seized over one hectare, and during Finland’s membership time in the European Union, the amount of farms has reduced approximately by 40%, and are reducing each year. The structure of Finland’s farms is 25% animal production, and 69% vegetable production farms, and the rest 6% were other farms such as country side tourism (MTT, 12-16).

“Consumers pay for value added tax (VAT) and excise tax when purchasing groceries, the VAT has been rising since year 2010 by 2 % (MTT, 7). Food products require a lot of handling, so the price of products includes approximately 60% of these “middle men costs”. “The price of food rose by 6, 2% in 2013 making the consumer price index change 1, 5%” (MTT, 39). With vertical farms, the price of food would become more stable with lower costs because it doesn’t require transportation or as much handling as food does today. Finnish grocery stores are able to tender domestic food industry among each other, as well as with foreign companies, which are increasing their popularity in the country because of the lower prices they can offer.

The challenge of Finnish agriculture is the short field plant production because of the weather conditions; “the harvest time in 2013 was approximately 180 days in South Finland and only

130 days in North Finland" (MTT, 22). With outdoor farming the crops are in danger for diseases and dryness, which will cause the loss of yields and farmers, will make loss. The global markets have been unstable because of the shifty economic situations around the world. Also weather changes have affected the produce and prices of agriculture and the reason for the drop in prices have been good foresights for the crop seasons. The profitability of farming has reduced for these various reasons as well as for the increased prices of energy, fertilizers, and animal feed (MTT, 58). In 2013, the profitability calculations of vegetables showed that greenhouse production (190 million €) was more profitable than open field production (136, 7 million €) (MTT, 31).

Finland received 1322 million € from the European Union agriculture support system, which 369 million € was targeted for environmental support and 423 million € for the damages of nature of inconvenient agriculture areas. European Union covers a quarter of these two costs and the rest is paid by the national funds. In addition to the support money from the EU, Finnish farms receive 499 million euros of support money from national funds, which 119 million € of this money is targeted for the damages of nature's inconvenience. In 2014, the total amount of national funds given to Finnish agriculture was 566 million €.There is also a benefit money to cover the environmental damages called "LFA", which is meant to secure the continuation of country side's livelihood and habitat in the areas that have been categorized as unsuitable country side areas. The environment support covers the profit loss caused by the reduction of production and increased expenses for a farmer, who commits to actions minimizing the environmental damages of agriculture (MTT, 49-52). The level of pesticide usage has increased during Finland's membership year in the EU and the environmental effects of agriculture have impact on the soil, water system and atmosphere (MTT, 60-70).

5.2 Public funding

Sitra is an independent fund that reports directly to the Finnish Parliament and its tasks are defined by law. The operations of Sitra include developing new operational models and testing them in practice. "Sitra's strategic goals for 2012-2017 focus on sustainable development themes, which are empowering society, resource-wise and carbon-neutral society, practices for sustainable well-being and employment" (Sitra, 2015). Sitra's condition for funding is that the concept can be replicated, scaled and exported after the pilot stage.

Tekes is the Finnish Funding Agency for Innovation. "Tekes is the most important publicly funded expert organisation for financing research, development and innovation in Finland" (Tekes, 2015). When we look at the national strategy for Tekes:

“Tekes promotes the development of industry and services by means of technology, innovations and growth funding. This helps to renew industries, increase the value added and productivity, improve the quality of working life, as well as boost exports and generate employment and wellbeing. Disruptive and pioneering business projects that originate from customers' own initiatives. The main focus areas of substance based funding are the common services offered together with strategic partners, joint programs, comprehensive service packages that support innovation, growth and internationalization as a whole, Impact-boosting funding services for developing businesses' competences and capabilities and support their growth into international markets, Investments in venture capital funds through Tekes Venture Capital Ltd (Tekes, 2015).”

We can see why Tekes is such a compatible partner for a vertical farming project. Naturally, they require a partner or partners to be involved in such projects, either from the private sector – and that partner will have to bring some financial power to the project, but in this case, that is the preferred result, as a private company who would like to explore research and development (a company such as Fortum for example), is the kind of driving force that this project requires.

Tekes could be interested in a vertical farm project from enhanced urban gardening perspective and this could fall into their currently ongoing “smart city”- project. The other perspective that could get Tekes into funding is a project “a clever usage of water”, where Kemira, a Finnish company specialized in water, could be one possible partner for the project. Also the Central Union of Agricultural producers and forest owners might be a possible candidate to join this kind of project (Vikkula, 2015).

5.3 Private funding

The vertical farm project in Sweden was funded by a group of private investors from abroad and a Swedish corporate on the initiative by a group of innovative entrepreneurs (Plantagon, 2015). This kind of a funding model could be also a possibility in Finland if interested investors were found to join the project. In this case, a risk could be that the vertical farm would be concentrating only on profitability. A vertical farm has potential to improve its immediate location, educate people, improve sustainable solutions and so much more, and therefore it would be pity to put these important factors aside and only concentrate on profitability. Money cannot be the only motivation for innovation especially when a vertical farm is also a solution for the greater good.

5.4 Other possibilities

There have been a lot of agreements between a private and public sector in the funding of the other vertical farm projects around the world. The public sector has seen the long-term benefits that these kinds of project will provide for them and private investors have seen the business opportunities in the projects. Also such cooperation agreements have been done where, for example a public sector gives a fund for the vertical farm project and in return the owner of the farm will donate clean plants for a hospital's research program or another purpose that will benefit the public sector. This kind of cooperative agreements could be relatively easy to arrange also in the City of Espoo. One example for this kind of cooperation with the City of Espoo could be a promise to create more jobs with a vertical farm and in return the city would donate money for the project (Vikkula, 2015).

Salonen sees that the City of Espoo could also be interested in an agreement that would create educational possibilities. The city could give an annual fund for a vertical farm project in return of teaching children about sustainable living and biology at the vertical farm (Salonen, 2015). If one wanted to include education in a vertical farm project in another way, students could do internships and other training periods at the vertical farm. It would be possible to include education from the early age to adulthood, and why not retirement, with different kinds of assignments and tasks. So a vertical farm would truly support lifelong learning.

6 Conclusions

The requirements for different configurations of vertical farming listed at Figure 2, are the very basic requirements needed in order to have a functioning vertical farm. There may be certain changes or additions to the lists depending on the rules, laws and policies of different countries. The selection of equipment for vertical farming is vast and it must be chosen for the farm according to what an operator wishes to grow in there. In order to grow crops, one must purchase either a hydroponic- or aeroponic growing system and a proper lighting solution. There are plenty of different kinds of configurations of these systems and they can be built into a space according to the need of an operator and the space. In order to grow fish, the equipment called "aquaponics" must be purchased

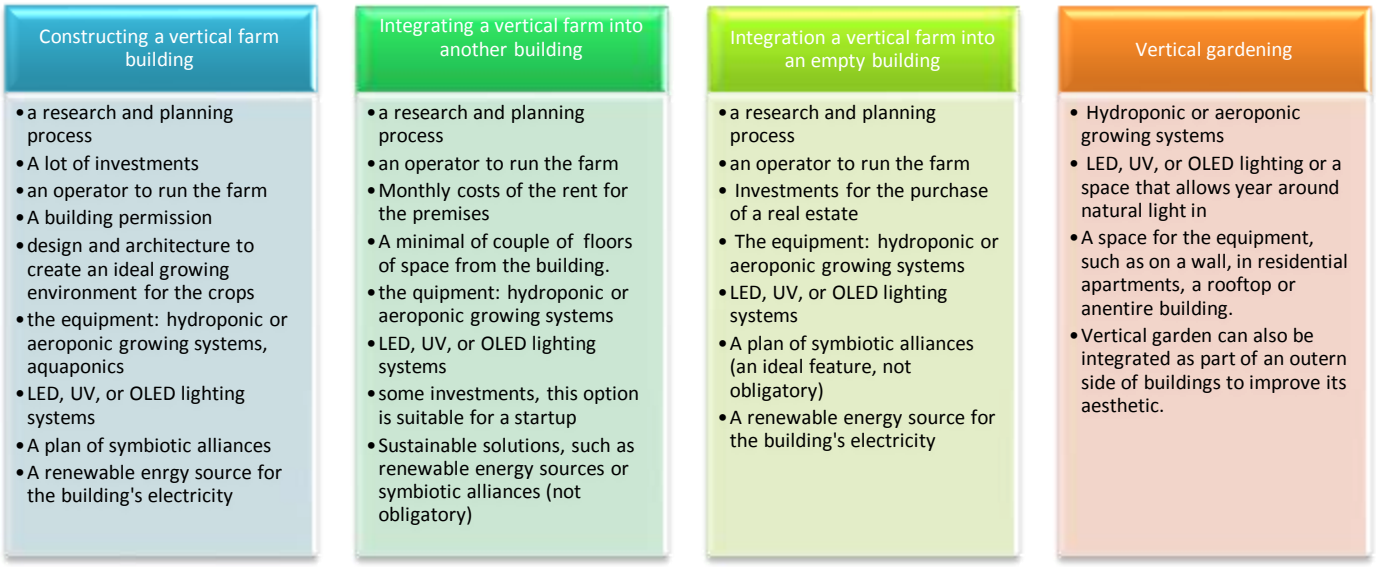

Figure 1: The requirements of different configurations of vertical farming.

From an infrastructural point of view, it is possible to build a vertical farm in Suurpelto. The executor of a vertical farm construction project can be the City of Espoo itself or an independent operator. The specific details and demands of a land, such as the allowed square meters and height of a building determined by the City of Espoo, must be investigated before making plans for a vertical farm project. A requirement for constructing a vertical farm is to make a building proposal of the land that is reserved for service- and business purposes, for the city planning department. A building proposal will follow a procedure called “the plan and influencing process” of the City of Espoo and once the building permission is granted, the terms and conditions of a contract will be negotiated between the property unit of the City and the operator of a vertical farm. In case, the City of Espoo was to state this configuration of vertical farming, it would have to begin from a pilot project to test the technologies, recognize the risks, understand the financial requirements, find partnerships and make operational decisions (Vikkula, 2015).

The configuration of integrating a vertical farm into nonfunctioning premises is not possible in Suurpelto. Integrating a vertical farm as part of the future service buildings of the area will be possible and the operational model of it shall be decided then (Vikkula, 2015). Vertical gardening could play a role as a community garden of the area in the future. This configuration will be beneficiary for the current residents as well as for attracting new residents into the area. Smaller configurations of vertical gardening that may be put into action immediately are rooftop gardens on top of the residential buildings and gardening at home with vertical garden equipment.

Public funding agencies Sitra and Tekes could be possible financiers of a vertical farm project. The project could fit into their ongoing programs or an application for its own funding

could be applied. A group of private investors, which can consists of companies, entrepreneurs, and foreign organizations could be an option to fund the project but it is not the most likely option in the case of Suurpelto at the moment. A mixture of funding between the public sector and private investors could also be an option in Suurpelto (Vikkula, 2015).

The Finnish agriculture industry is facing several challenges because of the rough weather and tough competition within EU, and it is not profitable for a farmer to practice agriculture in Finland. Finland receives annually a lot of money from the European Union and uses national funds to support the agriculture system. A large amount of this money is used to cover the damages of nature of inconvenient agriculture areas and for the damages of nature's inconvenience. (MTT, 2014)

7 Discussion

Based on the Agrifood Research Finland's economic research from year 2014, agriculture has certain challenges in Finland and the profitability of the industry is not good. A vertical farm would improve the agriculture industry in several ways. A vertical farm could produce the items that Finland currently imports by itself and save a lot of money by doing this. A vertical farm would create employment opportunities. A vertical farm in Finland would support the domestic food industry over foreign companies, which would improve employment and boost the economy. A vertical farm produces crops 365 days a year and therefore would increase the profitability of farming rapidly compared to today's existing harvest days in Finland. According to the agrifood research Finland's economic research, a significant amount of money is directed to cover the damages agriculture causes for the environment. If some of this money was directed in a vertical farm construction project, the damages for the nature would slowly reduce and eventually it could have a complete recovery from the damages agriculture has caused it. Even though we are not running out of farming land, global warming is affecting everyone. Finland should change its farming operations into more sustainable for long-term solutions and goals. Based on the research, a lot of money could be saved if this change would happen.

Since a vertical farm fits into Suurpelto's values and visions, it would most likely boost the image of the area, attract media and business interests to the area, and most importantly it would make the area a more desirable place to live. Suurpelto is already using renewable energy solutions and with the already existing knowledge and experience it would be easy to choose the energy source for a vertical farm, perhaps geothermal sources or solar panels. An interest group should be gathered soon to start the negotiations about establishing a vertical farm in the future. The City of Espoo and the project manager of the area are necessary authorities to include in the project group. According to the project manager of Suurpelto, an

interest group would be easy to gather, so he should be in a key position in gathering the members of the group. The interest group has to give a proposal for a funding agency to begin to evaluate the possibilities of a vertical farm project. With an interest group that consists of authorities from the government and other official parties, will be add the credibility when seeking for a funding.

Tekes might be an ideal funding agency for the project since they fund for innovation developments and a vertical farm is a world class innovation that hasn't been introduced to Finland yet. According to Dr.Despommier, the design and architecture of a vertical farm must be done according to the needs of the crops. We have world-leading designing and architecture in Finland and a Finnish "know-how" would be a valuable addition for the first vertical farm. Otaniemi is the innovation village of the City of Espoo that could offer possible partners for the project. These partners could be VTT, which is the leading high tech R&D institutes and the leading University in Finland, Aalto University with design and architecture.

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Figures

Illustrations

Appendices

Appendix 1: The presentation for the interviews.


Agriculture today
Requirements
• Fertilizers, pesticides,herbicides
• 70% of available fresh water
• Fossil fuel
• 80% of available land on Earth
Produces
• Food
• Agricultural run off that will end up in oceans creating deadzones.
Challenges
• Crop failure
• More severe weather
• Decreasing food supplies
• Less agricultural land
• pollution


The Vertical Farm
• High-tech futuristic building that produces food inside the city
• A large tower with multiple levels
• To deliver fresh produce with lower costs by marketing directly to consumers
• Many different forms
• To maxime the footprint usage ratio of the helix
• To minimize the demand for artificial lighting
• To gain as homogeneous light level as possible
• More efficient and profitable than freen land farming; → Year-round crop production; 1 indoor acre is equivalent to 4-6 outdoor acres or more


The benefits of Vertical Farm
No weather related crop failures
No agricultural runoff by recycling black water
Allowance for ecosystem restoration
No use of pesticides, herbicides, or fertilizers
Use of 70-95% less water
Reduces fossil fuel use→greatly reduced food miles, no tractors or plows.
More control of food safety and security
New employment opportunities
Converts black and grey water into potable water
Adds energy back to the grid
Converts abandoned urban properties into food production centers
May prove to be useful for integrating into refugee camps


Indoor urban agriculture is the solution
Indoor growing systems:
Hydroponic growing system
Aeroponic growing system
Lighting solutions


Vertical Farms around the world
New York, USA
2 x Chicago, USA
Ohio, USA
Indiana, USA
Singapore
Kyoto, Japan
Seoul, South Korea
Linköping, Sweden
Several others at the planning stage
Several companies around the world are specialized in these cultivation systems, design, consulting, etc. to create vertical farms.


A Prototype Vertical Farm in Suurpelto?
Clean local food
City activism
Communality
Sustainable lifestyle
Education for children, adults and universities.
Citizens caring about the environment and living area → security & safety
Vertical Farming supports the Espoo Story & administrative development programs

Appendix 2: Interview questions for the project manager of Suurpelto, Pekka Vikkula

1. Could you see a vertical farm in the future Suurpelto?
2. What would the capacities of the new innovative living area be to hold a vertical farm?
3. Would it be possible to integrate a vertical farm into the existing premises of the area at the moment? What about in the future?
4. What would be required in order to construct a vertical farm building in the area?
5. Do you think the City of Espoo would be interested to start such a project?
6. What could be the funding options from the City of Espoo's perspective?

Appendix 3: The interview questions for the residence association of Suurpelto, Anita Järvisalo and Leila Heimonen.

1. How would you see as residents a vertical farm in Suurpelto? Would the concept fit into the values and image of the area on your mind?
2. Does the thought of a commercial vertical farm in the area raise any critical/negative thoughts?
3. Do you think you could use vertical farming or vertical gardening as part of the activities of your association?
4. The future of the community garden of the area is unclear. What would you think if the future community garden took a vertical form instead of the traditional gardening?
5. How could it this enriches the lives of the residents in the area?
6. Does this bring you any other thoughts?

Appendix 4: The interview questions for the development manager from the Mayor's office of the City of Espoo, Kaarina Salonen and for a specialist from the technical- and environment department of the City of Espoo, Jaana Junkkari.

1. What ways do you think a vertical farm could benefit the City of Espoo? Could it help the City to stand out?
2. You two are part of the cross administrative development program "a participatory Espoo". Do you see a vertical farm in Suurpelto bringing new perspectives or values for the program?
3. Jaana, what is the gardening situation with the citizens of Espoo like? What is the future of community gardens and what are the future plans to participate citizens into gardening?
4. What kind of configurations of vertical farming would you see being possible in Suurpelto?
5. How could vertical farming be combined with education?
6. What kind of issues should be taken into consideration when constructing a vertical farm building from the technical- and environmental department point of view?