SiEUGreen
Sino-European innovative green and smart cities

Sino-European Innovative Green and Smart Cities

Deliverable 5.1

Market Analysis I

Lead Partner: CREVIS
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The project has received funding from the European Union's Horizon 2020 Research, and Innovation programme, under grant Agreement N 774233 and from the Chinese Ministry of Science and Technology.

Throughout SiEUGreen's implementation, EU and China will share technologies and experiences, thus contributing to the future developments of urban agriculture and urban resilience in both continents.

The project SiEUGreen aspires to enhance the EU-China cooperation in promoting urban agriculture for food security, resource efficiency and smart, resilient cities.

The project contributes to the preparation, deployment and evaluation of showcases in 5 selected European and Chinese urban and peri-urban areas: a previous hospital site in Norway, community gardens in Denmark, previously unused municipal areas with dense refugee population in Turkey, big urban community farms in Beijing and new green urban development in Changsha Central China.

A sustainable business model allowing SiEUGreen to live beyond the project period is planned by joining forces of private investors, governmental policy makers, communities of citizens, academia and technology providers.

Technical References

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[1] **PU** = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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Executive Summary

The current Deliverable 5.1 – Market Analysis I, aims to provide an overview of the global market for Urban Agriculture (UA), analyse the competitive landscape and establish the positioning of the SiEUGreen solutions in the different markets (segments). To track relevant developments and reflect project progress, an updated version of the SiEUGreen market analysis deliverable D5.3 will be issued on M36.

The relevant Market Analysis deliverables serve as exercises to prepare results obtained from the SiEUGreen project to launch commercially onto the market; specifically aiming at identifying techniques, solutions, and characteristics of existing initiatives, examining the state of the art for the UA sector in both geographical territories. The market analysis will be the base for the development of business models (Task 5.2, Deliverables D5.4 Sustainability and Exploitation Plans; D5.5 Business Plan), contributing to the achievement of the Objective 5, i.e. to "*create new value chains and develop sustainable business models that can be replicable across regions and countries"*, ensuring the SiEUGreen' s self-sustainability beyond the project life-span.

The current analysis serves as the basis for establishing a macro-scale evaluation of the potential size of the market and the development of a sustainable business model for SiEUGreen. It presents an overview of the methodological approach and a thorough analysis of the status of the overall market for UA, considering the different typologies met at the market per technologies used, functions, characteristics, etc. It also provides an overview of the different market segments of technologies, approaches, techniques and solutions that would be considered competitive to the ones developed and used within the SiEUGreen project. Production and treatment methods and technologies delivering resource efficiency in UA applications, under the "Green" and "Blue" categories of the SiEUGreen project will be on the main focus of the market analysis deliverables.

As the project progresses and having assessed the market readiness level of SiEUGreen technologies, integrated concepts and/or other potentially exploitable outputs of the project, further analysis will be performed (D5.3 Market Analysis III – M36). It will focus on specifying the market segments within which SiEUGreen outputs (technologies and/or integrated concepts) will be positioned and serve as a basis for the overall marketing strategy of SiEUGreen, followed by SWOT (Strengths-Weaknesses-Opportunities-Threats) and PESTELI

(Political-Environmental-Social-Technical-Economic-Legal-Institutional) analysis per SiEUGreen showcase.

The current deliverable D5.1 Market Analysis I, is comprised of 5 Chapters. After a general introduction to the focus of the current deliverable in chapter 1, it continues with background information about the SiEUGreen project in the view of its innovation principle and showcases in Chapter 2. Chapter 3 provides the methodological approach for the deployment of the market analysis and continues to Chapter 4 which presents the UA/UF (Urban Farming) market insights. The document closes presenting the way forward in Chapter 5.

The development of the Market Analysis I has been a productive and on-going process lead by partner CREVIS (WP 5 Leader) in close collaboration with the coordinator NMBU and under continuous consultation and co-design with the rest of the partners, especially SEECON.

List of Acronyms

Acronym	Description
3R	Reduce, Reuse and Recycle
AI	Artificial Intelligence
APAC	Asia-Pacific
ASEAN	Association of South East Asian Nations
CAGR	Compound Annual Growth Rate
CEA	Controlled Environment Agriculture
CHP	Combined heat and power
CO_2	Carbon Dioxide
COST	European Cooperation in Science and Technology
CSA	Community Supported Agriculture
DB	Doing Business
DWC	Deep Water Culture
EC	European Commission
EP	European Parliament
ES	Energy Saving
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FLAG	Food Lab Accelerator at Google
GCC	Golf Cooperation Countries
GMO	Genetically Modified Organisms
GSHP	Ground Source Heatpumps
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
LED	Light-Emitting Diodes
LFP	Local Food Production
LFP*	Local Fodder Production
LWA	Light Weight Aggregate
MECE	Mutually Exclusive and Collectively Exhaustive
MUFPP	Milan Urban Food Policy Pact
NA	Nutrient Availability
NFT	Nutrient Film Technique
NGO	Non-Governmental Organization
OECD	Organisation for Economic Co-operation and Development
PESTELI	Political, Economic, Social, Technological, Environmental, Legal and Institutional

PPP	Public-Private Partnerships
PUA	Peri-urban Agriculture
R&D	Research and Development
RCEP	Regional Comprehensive Economic Partnership
RoW	Reuse of Water
RUAF	Resource Centres on Urban Agriculture and Food Security
SiEUGreen	Sino-European innovative green and smart cities
SMEs	Small & Medium Enterprises
SWOT	Strengths, Weaknesses, Opportunities, Threats
TFF	Thought For Food
TRL	Technology Readiness Level
UA	Urban Agriculture
UEA	Uncontrolled Environment Agriculture
UF	Urban Farming
UG	Urban Greening based on local resources
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
UWWTD	Urban Waste Water Treatment
VAT	Value-Added Tax
VUNA	Valorisation of Urine Nutrients in Africa
WB	World Bank
WHO	World Health Organisation
WP	Work Package
WR	Waste Recycling
WS	Water Saving
WWR	Waste Water Recycling

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1. Introduction

The current Deliverable 5.1 – Market Analysis I provides an overview of the current status of the global Urban Agriculture (UA) market aiming to analyse the competitive landscape and establish the positioning of the SiEUGreen solutions in the different markets (segments). As the basis to develop the modalities for the exploitation of project outputs and showcase results, the market analysis series of deliverables aims at providing an overview of the current UA market at a global level and in particular European Union (EU) and China. They serve as exercises to prepare SiEUGreen launch to the market, aiming at identifying techniques, solutions, and characteristics of existing technologies, initiatives, examining the state of the art for the UA sector in both geographical territories and also determining factors that affect the development of the UA market and potentially determine the adoption of SiEUGreen results.

Production and treatment methods and technologies delivering resource efficiency in UA applications, under the "Green" and "Blue" categories will be on the focus of the market analysis deliverables. As the project progresses, and after having assessed the market readiness level of SiEUGreen technologies, integrated concepts and/or other potentially exploitable outputs of the project, further analysis will be performed (D5.3 Market Analysis III – M36). It will focus on specifying the market segments within which SiEUGreen outputs (technologies and/or integrated concepts) will be positioned and serve as a basis for the overall marketing strategy of SiEUGreen. The market analysis will be the base for the development of business models and plans (Task 5.2, Deliverables D5.4 Sustainability and Exploitation Plan; D5.5 Business Plan), contributing to the achievement of the Objective 5, i.e. to "*create new value chains and develop sustainable business models that can be replicable across regions and countries"*, ensuring the SiEUGreen' s sustainability beyond the project life-span.

2. About SiEUGreen

The "Sino-European innovative green and smart cities", SiEUGreen project, aspires to enhance the EU-China cooperation in promoting Urban Agriculture for **food security, resource efficiency and smart, resilient cities** through the development of showcases in selected European and Chinese urban and peri-urban areas. Throughout the implementation of the SiEUGreen project, EU and China share technologies and experiences and generate ground-breaking multidisciplinary demonstration cases, built upon 4 main pillars relating to **Land Use, Food Security, Resource Efficiency and Societal Inclusion** (analysed in detail in deliverable D1.1 - *Maps of quantitative and qualitative data for each of the showcase locations - Synthesis reports*)**.** Building on the model of zero-waste and circular economy, SiEUGreen combines both technological and societal innovation providing innovative technological tools, novel methodologies for cultural and behavioural analysis and impact assessment tools.

2.1 The SiEUGreen Innovation Principle

With an overall objective to strengthen EU-China collaboration in food security and sustainable UA, developing **resilient**, **socially coherent** and **smart future cities**, SiEUGreen will assemble numerous existing and/or unexploited technologies, aiming at facilitating the development of the state-of-the-art UA models that can be implemented in China and Europe. Building upon the combination and implementation of different kinds of technologies, SiEUGreen aims to achieve the **3R**s - **R**educe, **R**euse and **R**ecycle: waste is harnessed to be productively utilized to generate bio-products, such as organic fertilizers, and provide a source of sustainable urban food supply with minimum transport, effective use of solar energy and carbon dioxide (CO_2). It will thus demonstrate UA and its environmental, economic and social benefits, contributing to a circular economy and improving social well-being and quality of life for residents.

Figure 1: The SiEUGreen Innovation Principle

Figure 1 above depicts the interconnectivity of innovative concepts involving techniques, existing and novel technologies that will be developed and used on the basis of the objectives of SiEUGreen. The distinct technologies with are grouped in Green, Blue and Yellow will be incorporated with elements of digital Social Innovation, aiming at enhancing resident participation and awareness-raising through digitized tools (e.g. gamification app; interactive platform). This will facilitate the collection of information linked to the social and cultural changes expected to be generated at each of the local communities and at an international level by the implementation of the SiEUGreen showcases.

The technologies building the SiEUGreen innovation principle are categorized as:

1. **Green technologies** (T1): concerning soil-based traditional plant growing, water-based hydroponic culture (soilless) and aquaponics (fish and plant), paper-based plant-growing technology, and greenhouse technology;
2. **Blue technologies** (T2): concerning water and waste management, production of fertilizer and soil amendments from waste streams, and resource recycling;
3. **Yellow technologies** (T3): concerning biogas production from suitable waste resources, seasonal solar storage, combined heat and power, and photovoltaic generation of electricity;

4. **IT software** (T4): mainly concerning the development of an application – gamification (COMMURBAN) to stimulate and enable active social engagement through an interactive platform for raising awareness and sharing best practices. IT (Information Technology) software will be used for water management purposes and for the monitoring of the plantation through sensors.

Through its implementation in the showcase sites of the SiEUGreen, the combined technologies and social innovation tools will be tested and verified (laboratory and open environments) examining how they **demonstrate circular economy in practice**, **minimizing energy footprint**, **increasing climate-resilient urban food security** and **health and happiness** of participating citizens.

The 5 SiEUGreen showcases have been designed to address technical and social elements, being implemented in different geographical, environmental, social and economic environments of urban areas, aiming at **engaging multi-stakeholder groups**.

2.2 The SiEUGreen Showcases

SiEUGreen is deployed in different settings and environments in two cities in China (Beijing and Changsha) two cities in Europe (Fredrikstad - Norway, Aarhus - Denmark) and one in Turkey (Hatay). These heterogeneous urban settings were deliberately chosen to allow SiEUGreen to obtain insights into different implementation conditions and their implications for target groups in diverse contexts – multi-stakeholder approach (public sector, private sector, researchers, residents). The showcases are conceived as the most vital part of SiEUGreen and are expected to function as **"lighthouses"** that inspire and lead the way forward for future environmentally friendly UA projects. Identified stakeholders (as presented in Table 1) are also approached as the potential clientele of the SiEUGreen outputs, that will be further considered and analysed in the development of relevant business models.

The showcases play a two-fold role within the SiEUGreen project, representing an "open laboratory" that will allow for testing of both **technical** and **social innovation**. Therefore, all SiEUGreen showcases combine these two elements, while some have a stronger focus on one of the two (see Table 1). These combinations are expected to create UA value chains providing both products and services, varying within the 5 showcases environments.

Table 1. Stakeholders to be engaged in the SiEUGreen showcases

Showcase site	Expected stakeholders	Focus	
		Technical	Social
Fredrikstad (Norway)	Researchers, architects, policy makers, municipality, communities, habitants	●●●	●
Changsha (China)	Residents, communities of retired people and the elderly	●●	●●
Hatay (Turkey)	Municipality, residents, refugees	●	●●●
Beijing (China)	Residents, communities of marginalized groups, (3rd age, school drop-outs)	●●	●●
Aarhus (Denmark)	Municipality, residents, immigrants	●	●●●

Key: ●●● … high; ●● … medium; ● … low

Additionally, in the cases of Aarhus, Beijing and Hatay the participating communities are already built while in Fredrikstad and Changsha, the establishment of communities will take place during the SiEUGreen project term, allowing comparisons in terms of awareness, participation, food literacy and acceptance.

Table 2 below, presents an overview of the different technologies developed and/or implemented within the 5 showcases of SiEUGreen. Certain technologies had been developed under other past and/or ongoing initiatives implemented by the SiEUGreen partners, while others are developed in the framework of the SiEUGreen project[1]. They are tested in controlled environments (small scale and laboratory demonstrations) and then successively demonstrated, qualified and/or proven in the different operational environments of the SiEUGreen showcases (WP3).

Input received from the case studies developed within Deliverable 1.1 - *Maps of quantitative and qualitative data for each of the showcase locations - Synthesis reports,* has also been incorporated in the table, showing the expected contribution of each technology in terms of resource efficiency. Due to the delay in commencing the activities of Chinese partners, the

[1] Work Package 2 – Development of Sustainable and circular urban farming systems - Deliverables 2.1; 2.2; 2.3; 2.4 all due M16.

case studies focused only on the European showcases in Fredrikstad and Aarhus and the one in Hatay. Therefore, relevant information about what is the expected contribution of the mentioned technologies at the Chinese sites is not available at present.

Based on the case mentioned above studies, SiEUGreen technologies are expected to contribute to Energy Saving (ES), Local Food Production (LFP), Waste Recycling (WR), Nutrient Availability (NA), Local Fodder Production (LFP*), Water Saving (WS), Waste Water Recycling (WWR), Urban Greening based on local resources (UG) and Reuse of Water (RoW). These concepts will be verified and evaluated within the showcase deployment, allowing the consortium to identify the dynamics of sustainable integrated UA models developed within the SiEUGreen showcases.

Table 2. Set of technologies, application at each showcase and expected contribution to resource efficiency

Technology	TRL[2]	Norway, Fredrikstad	Turkey, Hatay	China, Beijing	China, Changsha	Denmark, Aarhus
Green						
1.Innovative greenhouse technology using special insulation, solar heat storage, and biogas for light CO_2 and heat	5	ES				
2. Greenhouse technology, traditional	7		LFP	√	√	LFP
3. Polytunnels	7					LFP
4. Mobile gardens	7					LFP
5. Soil-based traditional plant growing	8	LFP	LFP	√	√	LFP
6. Water-based hydroponic culture	7	LFP	LFP	√	√	
7. Aquaponic cultures (plant fish fully recycling technology)	6		LFP	√	√	
8. Paper-based plant growing technology	6	LFP	LFP	√	√	LFP
9. Balcony gardens	6	LFP		√	√	LFP
Blue - Processing of waste for recycling						
1. Biogas production from Antec Biogas pilot scale reactor	7	ES, WR				
2. Treatment of Biogas digestate by biofiltration	3	NA				
3. Struvite precipitation from biofilter percolate	4-6	NA			√	

[2] The TRL level included in the table is relating to the current level of each of the technologies. For a full description of the TRLs refer to Annex G of the General Annexes of the Work Programme 2016/17.

4. Use of organic waste product for the production of insects in connection of aquaponic system	5	WR, LFP*	WR, LFP*			
5. Biofiltration of urine	6	NA				
6. Co-composting of organic house hold waste /green waste and solar dry toilet residue	6	WR, WS			√	WR, WS
Blue - Source separation of wastewater						
1. Vacuum- /low flush toilets	7	WS			√	
2. Urine diverting toilets	7	WS, WWR				
3. Solar dry toilet	5	WR,WS			√	WR,WS
4. Greywater treatment using a Biofilter/Filter bed treatment system	7	WWR			√	
5. Greywater treatment using a biomembrane system	5	WWR			√	
6. Green wall for greywater treatment	3	WWR, UG				
Blue - Stormwater handling						
1. Green roof lightweight aggregate (LWA) for water retention	4	RoW, UG			√	
2. Green wall for water retention	5	RoW, UG				
3. Wetland/pond system for stormwater disposal	7	RoW, UG			√	
4. Wetland/infiltration system for stormwater disposal	7	RoW, UG			√	
Yellow						
1.Borehole thermal energy storage (BTHS)	5	ES				
2. Ground source heat pumps (GSHP)	9	ES				
3. Photovoltaic panels (PV)	9	ES		√	√	
4. Solar collectors for heating water	9	ES			√	
5. Combined heat and power (CHP) from biogas	6	ES				
Social engagement IT tools						
Social engagement app - COMMURBAN						

Additional software solutions (regarding sensors and water management software) developed by Scanwater, NMBU and SAMPAS will be also used in the SiEUGreen showcases implementation. With specific reference to the Fredrikstad showcase, a sensor and IT-based monitoring system developed by SCANWATER (in collaboration with its mother company Malthe Winje Ltd.) will be also used.

At this early stage of the project findings from D1.1 can provide an overview of the showcase characteristics on the basis of the 4 pillars, representing how the SiEUGreen project approaches UA, namely **Land Use, Food Security, Resource Efficiency and Societal Inclusion.** Further information and findings are expected to be gathered within the further implementation of WP1- *Support to Institutional and Social structures for creating resilient cities with UA* (M1-M48), WP2 – *Development of sustainable and circular urban farming systems* (M1-48) and WP3 – *Showcases deployment*.

3. Methodological approach

This chapter provides an overview and describes the methodological approach upon which the market analysis for SiEUGreen is being performed within Task 5.1 – *Market research and benchmarking in the EU and China*. Deploying the below-described methodology, we aim to assess the market for SiEUGreen showcases, integrated concepts and SiEUGreen technologies, which will be the base for the development of robust business models (Task 5.2, Deliverables D5.4 *Sustainability and Exploitation Plan*; D5.5 *Business Plan*). It is the starting point for the elaboration of the pathway for SiEUGreen' s concepts self-sustainability beyond the project term (Figure 2).

Figure 2: The SiEUGreen Sustainability pathway

The SiEUGreen market analysis aims at identifying both enablers and market barriers that determine the market landscape within which SiEUGreen concepts will be positioned. The analysis proceeds in a top-down approach, commencing with research at macro-level aiming to depict the overall UA market at a global level and continues to a regional level in terms of the two main focused territorial areas EU and China, and then local level at the basis of showcases (and national concepts).

The overall methodology is founded on two main steps. The first step is desk research and a review of SiEUGreen deliverables that feed into the market analysis:

- Conduct a comprehensive literature review to gain a profound understanding of the state of the art, market situation, expected market trends, technology aspects, market segments, investments and investors, competition landscape etc.
- Draw outcomes from WP1 regarding the identification of main processes and structural elements that are key to understanding the status and future potential of UA;
- Draw from deliverables D2.1, D2.2, D2.3 and D2.4 (all due in month 16) for SiEUGreen technologies and innovations developed in the project;

The second step (to be performed within the upcoming D5.3 Market Analysis III M36):

- Provide short overviews on technologies selected for demonstration at SiEUGreen showcases;
- Conduct In-depth semi-structured interviews with key informants;
- Use PESTELI (Political, Economic, Social, Technological, Environmental, Legal and Institutional) analysis and SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis as analytical frameworks for external and internal factors;
- Update available information throughout the project term.

Drawing upon SiEUGreen typologies (D1.2) and technical characteristics (D2.1-2.3), will facilitate the definition of the relevant market for analysis as well as the target groups of end-users and stakeholders for further exploitation.

Within this concept, we will analyse the national and local-level conditions that will determine the development of SiEUGreen showcases (through PESTELI analysis will be developed in D5.3 Market Analysis III, M36). Findings from SiEUGreen project deliverables, desk research, available market information (e.g. surveys) as well as in-depth interviews will be used to collect necessary data and information allowing for qualitative and quantitative analysis.

3.1 Input from the SiEUGreen project deliverables

Active and dynamic interaction between the SiEUGreen WPs has been focused on planning and developing project activities since the proposal stage and early implementation. Thus, interlinks between WP1, WP2, WP3 and WP5[3] are necessary. It is expected that substantial synergy will be realized from this mutually-beneficial exchange during project implementation.

Deliverable 1.1 - *Maps of quantitative and qualitative data for each of the showcase locations - Synthesis reports*, already provides a solid basis about **how UA is perceived in SiEUGreen** on the basis of 4 main pillars: **Land Use, Food Security, Resource Efficiency and Societal Inclusion**. The findings provide an insight into the development of the market analysis and will be further elaborated in the course of Task 1.2 *Baseline study on land use in EU and China (M7-M36)*. This will lead to the development and definition of the SiEUGreen typologies through which we will be able to identify deterministic characteristics for the positioning of the SiEUGreen showcases in the market. It is also expected that the research will be extended and also cover the Chinese cases which were not covered in D1.1.

Selected technologies to be applied in the different concepts of the SiEUGreen showcases will be verified and tested within the scope of WP2 and documented within the Deliverables D2.1 – *Green Technology ready*, D2.2 *Evaluation of crop techniques*, D2.3 and D2.4 – *Blue technology ready I and II*, all completed by M16. At this stage of the project, a first questionnaire has been prepared and already sent to the partners involved in the implementation of WP2. The questionnaire will be adapted to cover functional systems of the integrated concepts and aligned to be focused on the technologies demonstrating a high market readiness level. The exercise will enable certain input needed for the PESTELI and SWOT analyses that will inform relevant market strategies and business plans.

Project partners responsible for the implementation of SiEUGreen showcases together with technology providers (WP2) will be also asked to describe how the various technologies deployed will be integrated into a functional system.

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[3] WP1 - Support to Institutional and Social structures for creating resilient cities with UA (M1-M48); WP2 - Development of sustainable and circular urban farming systems (M1-48); WP3 - 3 Showcase deployment (M10-M48); WP5 - Business Modelling and Sustainability.

3.2 Input and validation from experts

Experts from within the consortium and outside of it will be used as a valuable source of information to gain an understanding of the market-facing technological advancements and integrated concept innovations. The SiEUGreen is comprised of a mix of technological and research focused partners. For internal experts, in addition to the use of questionnaires, technological and showcase partners will be engaged directly through teleconferencing software (e.g. GoToMeeting) to expand upon the input provided through the questionnaires. The idea is to initiate a discussion with experts to draw on their expertise.

The means to engage internal and external experts will be to use in-depth semi-structured interviews. Internally, consortium members with direct relation to the technological developments and with strong market orientation will be engaged in interviews to provide input on relevant market aspects. In regards to the external experts, a number of stakeholders of the diverse and collectively exhaustive expertise will be reached to provide a comprehensive understanding of the market. See table 3 below for a preliminary list of the stakeholders identified in line with the needs of the PESTELI analysis.

At a later stage in the project, a Sustainability Working Group will be assembled consisting of relevant stakeholders from the UA or relevant sectors under Task 5.2 – *Development of Exploitation and Scaling Plans for each of the 5 showcases*. The goal of this group is to provide expertise and facilitate knowledge transfer across sectors and within and between countries and partners. We will draw upon this group of experts to support the market analysis, and the broader exploitation and replication activities.

3.3 PESTELI and SWOT analytical frameworks

PESTELI (Figure 3) is an analytical tool that will be applied to identify external factors which determine macro elements of the environments within which the SiEUGreen showcases will be positioned. To this end **P**olitical, **E**conomic, **S**ocial, **T**echnological, **E**nvironmental, **L**egal and **I**nstitutional (local to national) factors of relevance are identified and assessed as to how they impact SiEUGreen positioning in the market (Table 3). Adding institutional aspects for consideration, the PESTELI analysis is instrumental in this case as it allows for a "MECE approach", i.e. mutually exclusive and collectively exhaustive, to all relevant elements – thus ensuring a comprehensive understanding of key market factors (Oxford College of Marketing, 2018).

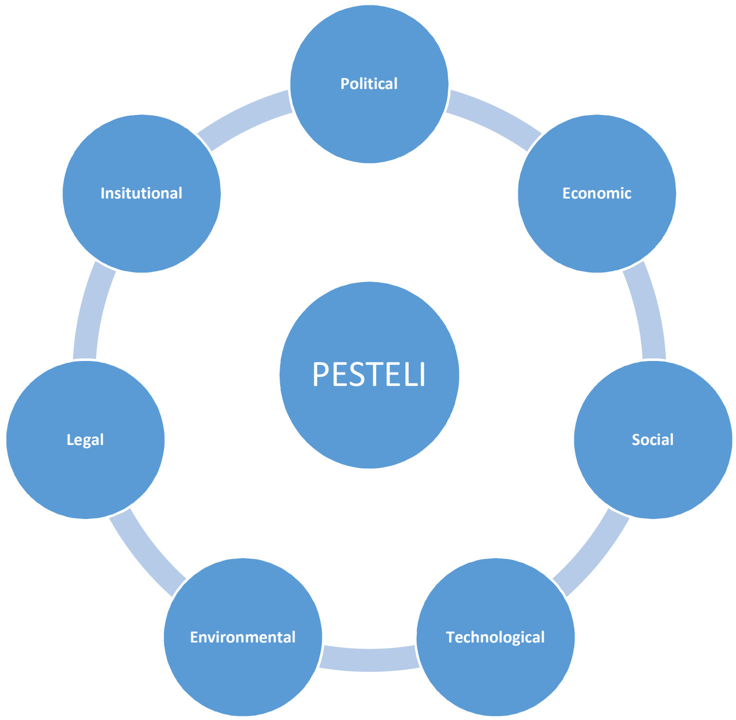

Figure 3: PESTELI analytical framework

Outcomes of the PESTELI analysis will be also used to define the opportunities and threats in the SWOT analysis (Oxford College of Marketing, 2018).

Table 3. PESTELI categories and factors

PESTELI Categories	**Relevant factors of focus for SiEUGreen**	**Expert input provided by**
Political	Government policies (local to national), zoning, urban development programs, greening initiatives, social inclusion politics	Municipal/ regional authorities, EU & China governmental bodies, civil society, policymakers
Economic	Marco-economic trends, demand trends, input/ operational/ capital costs,	Project partners, economists knowledgeable in the sector,

	available subsidies, tax schemes (e.g. property tax)	municipal/ regional authorities, urban planners
Social	Family demographics, education levels, cultural trends, attitude changes, changes in lifestyles, well-being, social consciousness, religious beliefs, social acceptance	Project partners, social scientists, civil society/ relevant NGOs
Technological	Efficiency, innovation, technical maturity level	Technology providers, civil society, urban planners, scientists
Environmental	Climate change, recycling procedures, carbon footprint, waste disposal, sustainability, pollution	civil society, urban planners, municipal/ regional authorities, scientists
Legal	National/regional legislation, consumer law, health and safety regulations	Urban planners, municipal/ regional/ national authorities, regulators
Institutional	Local, regional, national institutions having a stake in UA	Project partners, municipal/ regional/ national authorities, EU/EP representatives

In performing a SWOT analysis, we aim at analysing internal (**S**trengths and **W**eaknesses) and external (**O**pportunities and **T**hreats) factors that will be affecting the SiEUGreen positioning in the market. The SWOT analysis is a robust tool in this context given the novel nature of the integrated concepts and the fact that the concepts will deliver economic, scientific and social value.

Strengths refer to the distinguishably positive qualities of the integrated concepts and their exploitation by the consortium. Specifically, this can include tangible assets, key differentiators (from the current situation as well as from competitors), and internal resources of the integrated concept teams (knowledge, technology, sets of skills, experience, synergy in the consortium). In essence, the question will come down to "what is done well?", "what values are delivered?", "what gives us an advantage?".

Weaknesses refer to characteristics and conditions that limit or constrain the integrated concepts and their exploitation by the consortium. Specifically, this refers to resources that are not available yet are recognized important (e.g. unavailable resources), unclear business proposition, unfavourable positioning compared to competitors. In essence, weaknesses are the inverse of strengths, referring to "what is a point of concern?", "what do we lack?", "where is the concept missing?".

Opportunities are external factors that are recognized as favourable circumstances that can contribute to successful exploitation of the showcases. This can include various categories as defined in PESTELI that benefit the showcase positioning.

Threats are the opposite of opportunities, referring to negative external factors that limit or complicate exploitation of the showcases. Once again, as external factors, they are full covered by the PESTELI categories.

3.4 Definition and types of Urban Agriculture

3.4.1 Scope

A clear view of how UA is defined, its characteristics, as well as the types we meet, will help us map the relevant market landscape and key trends affecting the positioning of SiEUGreen. This section provides a preliminary literature review to describe the state of the art in UA.

3.4.2 How is UA defined?

Within the relevant literature, several authors have described local urban farming systems, based on localized definitions and descriptions, leading to a large variety of definitions and subdivisions of local farming systems, usually allowing comparisons between cities (FAO, 2007). Numerous definitions have been developed, defining UA using different concepts, as an engagement in food production or related activities within or nearby cities, practised by various stakeholders under different backgrounds, motivations and socio-economic conditions (Duzi et al., 2017).

As defined by Luc J.A. Mougeot (2005), *urban (and peri-urban) agriculture is an industry located within ('intra-urban') or on the fringe ('peri-urban') of a town, a city, or a metropolis, that grows and raises, processes and distributes a diversity of agricultural products from both* *plants and animals, using human, land and water resources, products, and services found in and around that urban area*".

In more recent definitions, UA is regarding *the growing, processing and distribution of food or livestock within and around urban centres with the goal of generating income,* or considering urban agriculture to encompass *the production of food and non-food plants, as well as husbandry, in urban and peri-urban areas*'. With reference to the concept of peri-urban agriculture (PUA), it's considered to be 'agriculture at the boundaries of cities, in the transition or ''buffer zone'' zones between rural and urban areas' (EPRS, 2017).

The most important distinguishing feature of UA, as derived from the above definitions is that UA is an **integral part of the urban economic, social and ecological system** (FAO, 2007; RUAF, 2018):

- Using urban resources such as **land, labour** (urban residents as labourers) and **urban organic wastes** (organic waste as compost; urban wastewater);
- Having **direct links with urban consumers**;
- Having **direct impacts on urban food security and poverty, urban ecology and health**. This can be seen from the point of view that UA is a part of the urban food system, competing for land with other urban functions, being influenced by urban policies and plans, etc.
- Being **located within a zone** directly influenced by urban activities and opportunities.

3.4.3 UA dimensions

Assuming a broader view, UA has been conceptualized by international institutions and researchers based on different **dimensions** i.e. **spatial, functional, origin, market-orientation, actor, motivation, stakeholder, and process** as presented in the following Table 4 (COST, 2018).

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Table 4. UA components within different international institutions

	Spatial	Origin	Functional	Actor	Stakeholder	Market	Motivation	Process
FAO	UA: small areas **within cities**. PUA: Farm units **close to town**		**Food production**. UA: crops, small livestock or milk cows. PUA: vegetables and other horticulture, livestock, milk and eggs	Farmers, unemployed labour	Urban population, especially **low-income** sectors	UA for **own-consumption** or sale in neighbourhood markets. PUA: intensive **semi- or fully commercial** farms	**Food security. Employment**: employs workers and produces high value-added products that can yield reasonable income and returns	**Compete** for resources - land, water, energy, labour. **Efficiency**, making productive use of **under-utilized** resources. **Adaptability** and mobility
UNDP	**Within** or at the **edge** of a **metropolitan** area	**Land unused**, vacant and unkempt lots and roadsides. **"edible buildings"** Permanent-non permanent	Food provision, environmental enhancement, disaster management	Household, community gardens	low-income urban groups. Small-scale entrepreneurs and larger enterprises Categories based on the complexity of the farming system	**Close-by urban markets** (mainly) ->perishable products. Capture important percent of the retail price	**Food security** and nutrition, save on food expenses, increase **incomes**, or for **pleasure**	**Intensive**, **efficient** use of space, water and other resources. Face restrictive land-use policies. Contributes to **close ecological loops**
RUAF	The growing of plants and the raising of animals **within** and **around** cities. Intra-urban and peri-urban		**Food production**. **Non-food products** (like aromatic and medicinal herbs, ornamental plants, tree products, etc. Also **inputs** (e.g. compost) and **services** delivery	Urban poor, women. Also lower and mid-level sectors, and richer people. Tend to be **more specialized** than rural enterprises. Includes micro-and small		Self-consumption, and market-oriented (urban)	Richer: good investment for their capital	Agricultural production, processing and marketing tend to be more closely interrelated
COST	Proximity to an urban area. "Transect" from rooftop production to open space in the urban fringe	Remnant areas embedded in the city or introduced areas (belt or other planned structures)	Production. Provision of services (residence, health, education, recreation, treatment of waste, storm water discharge...)	Conventional farmers (full time or part time), hobby farmers. Social groups without a farming background	Some services benefit the entire urban community. Food or job opportunities have direct impact only on some people	At least partly oriented to local residents. UA evolution towards global market	Healthy living conditions. Concern for nutrition. Socio-cultural roles	

Source: http://www.urban-agriculture-europe.org/mediawiki/index.php/UA_in_institutional_documents, 2018.

On the basis of the 4 main pillars – **Land Use, Food Security, Resource Efficiency and Societal Inclusion** – of UA in the SiEUGreen project, D1.1 – "*Mapping of quantitative and qualitative data for each of the showcase locations*" suggested that land for urban agriculture can be described through three dimensions: **Spatial, Functional and Institutional.** These dimensions describe where UA takes place (spatial – peri-urban, intra-urban areas) how UA is performed (functional – on plot, off plot) and by whom (institutional). Factors shaping the process of securing land for UA appear to be quite complex and diverse between the 3 European showcases[4]. They go beyond simple quantitative indicators such as land price or land availability and require further exploration in order to draw a better picture of the potential and hindrances for UA as well as to understand how UA can help create greener landscapes. Institutional aspects play a significant role in affecting what types of UA initiatives occur and what land can be efficiently utilized for UA.

Food security, within the scope of SiEUGreen, is considered in the context of the following broad goals:

a. **Increase food security** in line with the measures provided by the Food and Agriculture Organisation of the United Nations;
b. **Increase access to high-quality food** that is healthy, nutritious and contamination-free;
c. **Increase understanding** of the contribution of UA to the urban food system;

All SiEUGreen showcase countries experience **a good level of food security** when considered in a global context (methodology and indicators provided by the Food and Agriculture Organization FAO). The evidence available at this early stage of the project underlines that the role of UA in providing access to high-quality food is marginal in the showcase locations. In order to understand food security at an urban or regional level, a more qualitative approach is required – engaging with participants in SiEUGreen initiatives throughout the lifetime of the project. At showcase level, it will be of particular interest to study the way that UA may be useful in reconnecting urban dwellers with the food production process.

With regards to **resource efficiency**, considerable differences were found between the showcase locations (e.g. different use of fuels, different waste management systems, water

[4] Information on Chinese Showcases will be updated once available.

use and management, etc.). The SiEUGreen innovative technologies will be key to ensure resource efficiency through UA. With the integration of the SiEUGreen technologies in the showcases, we will be able to monitor their contribution to the showcases' performances with regards to environmental indicators, developing improved resource efficiency in UA.

The diverse and varied nature of the showcases offers a rich opportunity to study **societal inclusion** in the context of UA. Findings already show the value of UA as a tool to enhance social capital and provide opportunities for new forms of political ecology.

3.4.4 UA typology

The way UA is defined, on the basis of its components and characteristics, determines the **typology** that will be examined by the project, including within Task 5.1**.** In the relevant literature, UA typology is ranging from "**urban food gardening**" to "**urban farming (UF)**". The first is associated with small-scale food self-provisioning and met as subsistence oriented with low economic dependence on material outputs. Usually, the production of food is used to achieve mostly social goals, practised by individuals or small group of gardeners (extension to small-mid scale semi-commercial gardens). It is mainly characterized as non-profit oriented gardening, taking advantage of the proximity to the city, building strong connections and offering local products and services to urban residents. As a type has been broadly met, in a way dominating how UA is expressed in Global South especially in its self-provisioning and subsistence character.

The second is largely based on business principles (World Bank, 2013; Duzi et al., 2017; EPRS, 2017; EPRS, 2018; COST, 2018) for industrial and production purposes referring to conventionally managed farms, located within or nearby cities (mainly indoor and vertical farms), while production and supply chains are oriented mainly on national or international markets (Duzi et al., 2017).

Further, vertical differentiation between urban farms is usually made by farm types - as commercial, community, home gardens, corporate; by crop types - food and non-food crops; by growing medium - in soil and non-soil based as hydroponics, aquaponics, aeroponics; by hardware components - hydroponic components, irrigation component, lighting devices, sensors, containers, Light-emitting diodes (LEDs); as well as by structure - in indoor farming, outdoor farming.

Urban farms are also categorized as Controlled Environment Agriculture (CEA) where key environmental conditions for the cultivation of plants (such as light, temperature, humidity, radiation and nutrient cycling) are controlled to a high degree in conjunction with urban architecture or green infrastructure (greenhouses, vertical farming, etc.). This allows for intensive production systems which are required to justify the capital costs that are necessary to create such controlled cultivation conditions. Such types are met all over the globe but are considered dominating in the Global North.

Uncontrolled Environment Agriculture (UEA) or open space farms are met in urban agriculture including community gardens, vegetable garden, rooftop farm, etc. (UN, 2015). In UEA, key cultivation parameters are controlled to a limited degree, depending to a high degree on natural environmental conditions, and comparatively, require lesser capital expenditure.

Another type is defined as "**non-urban oriented farming**" which includes farms located in urban areas, but whose business models have not (yet) been deliberately adapted to the proximity of the city (COST, 2018).

Table 5. Different typologies of UA and UF

Main typology	**Urban food gardening**	**Urban farming**
Sub-categories	Family Gardens Allotment Gardens Educational Gardens Therapeutic Gardens Community Gardens Squatter Gardens	Local Food Farms Leisure Farms Educational Farms Social Farms Therapeutical Farms Agri-Environmental Farms Cultural heritage Farms Experimental Farms

A more specific differentiation of UA typologies based on the purpose of production is provided in the below Table 5.

Table 6. Typologies by production purpose (referring to vertical farming)
Source: https://vertical-farming.net/vertical-farming/integration-typology/

Typology	Purpose	Orientation
	Grow to Support	Community focused
	Grow to Teach	Education focused
	Grow to Prepare	Restaurants, cafeterias, home-use
	Grow to Retail	In/at super market production
	Grow to Wholesale	Commercial greenhouse or warehouse
	Grow to Clean	The primary purpose is to treat air/water
	Grow to Heal	Bio-pharma
	Grow to Develop	Mainly purpose is R&D (Research and Development)

4. Market insights

SiEUGreen develops a suite of innovative technological solutions and integrated concepts (within its showcases) relating to the broader UA/UF market. Production and treatment methods and technologies delivering resource efficiency in UA applications, under the "Green" and "Blue" categories[5] will be on the focus of the market analysis deliverables.

On the basis of the characteristics of the SiEUGreen technologies, stand-alone technologies are considered to be positioned in different market segments relating to UA/UF (i.e. technologies, treatment methods, growing mediums, productions methods, services, etc.), addressing a prominent market as well to be targeting to different potential end-users (included in Table 7. Further analysis of the customers' segments will be provided in the D5.4 Sustainability and Exploitation plans M30). In this market analysis, we provide an overview of the overall urban agriculture market aiming to identify the different market segments within which SiEUGreen technologies and integrated concepts would be aimed to be positioned.

Table 7. SiEUGreen end-user/customer segments

Category	Description
Public sector	This segment covers public institutions as municipal authorities, interested in or developing UA innovative and efficient concepts and practices. Additionally policy making stakeholders and authorities (considered at local and national level) are considered in this segment too.
Private sector	This segment includes: - Relevant industry, technology developers and services providers, SMEs, commercial urban

[5] Green technologies (T1): concerning soil-based traditional plant growing, water-based hydroponic culture (soilless) and aquaponics (fish and plant), paper-based plant growing technology, and greenhouse technology; Blue technologies (T2): concerning water and waste management, production of fertilizer and soil amendments from waste streams, and resource recycling.

	farms/farmers, building developing companies and professionals, etc. that are interested in using/developing resource-efficient UA innovative solutions and concepts aiming to commercially exploit innovative tools and services. - Grassroot organisations, NGOs, UA initiatives, interested in adopting UA innovative solutions to perform UA practices.
Residents	Residents and individuals that are interested in using turnkey UA solutions and innovative concepts applying or interested in applying UA.
Researchers	Research community and academia interested in using and further expanding research activities in the fields of resource-efficient UA techniques, socioeconomic research within UA concepts, etc.

To do so, chapter 4.1 provides a general market overview on UA on a global perspective. Insights into disruptive technological developments in hardware, software and data analytics for commercial UF and indoor farming is presented in chapter 0. and region-based information on technologies is included in chapter 4.3. Considering the increasing attention and substantial development of this particular segment, a more focused analysis for the vertical farming market is provided in chapter 4.4. Key economic information and indices for SiEUGreen inter-regional analysis and comparison are included in chapter 4.5 while chapters 4.6 and 4.7 focus on the developments in investments and potential (financial) instruments supporting UA/UF.

As the project progresses and having assessed the market readiness level of SiEUGreen technologies, integrated concepts and/or other potentially exploitable outputs of the project per potential target group (e.g. waste and wastewater treatment methods/installations; liquid fertilization; algae production; smart buildings concepts; integrated showcase concepts etc.), a further analysis will be performed. It will focus on specifying the market segments within which SiEUGreen outputs (products, technologies and/or integrated concepts) will be positioned and serve as a basis for the overall marketing strategy of SiEUGreen. This analysis will be included in the upcoming relevant deliverable D5.3 Market Analysis III, due M36.

4.1 Overview of the Global UA Market

The terminology used within relative market studies refers to Urban Farming (UF) than Urban Agriculture, considering the commercial activity and economic outcomes in the relevant market, mainly relating to commercial ventures.

The Global UF Market (covering both structures of indoor and outdoor farming and CEA; farm types, crop types, growing mediums; hardware) revenue was estimated on $210 billion in 2017 and forecasted to further grow (at a Compound Annual Growth Rate - CAGR of 3.6%)[6], reaching $288.71 billion by 2026 (Research & Markets, 2019).

Table 8. Global Urban Farming market segments

Segment per	Categories	Sub-Categories
Farm type	Commercial Community Home Gardens Corporate Others	Open Field Controlled environments
Growing medium	Hydroponics Aquaponics Aeroponics Soli based	
Structure	Indoor	Greenhouses Container Vertical Rooftop

[6] Compound annual growth rate (CAGR) is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

	Outdoor	Open field Rooftop
Crop type	Food	Vegetables Cereals & Grains Fruits Others
	Non-Food	Aromatic herbs Medicinal herbs Ornamental plants Others
Region	North America Europe Asia-Pacific Rest of the World	

Especially, in 2017 it was estimated that community gardening accounted for the highest share of the overall revenue estimated, reaching $136.1 billion, with also home gardens reaching $29.61 billion (IndustryARC, 2019). Such growth is propelled by the emerging need to meet the growing demand for food for an increasing global population, the 60% of which is expected to live in cities by 2030 (FAO, 2008) while by 2050, in the developed world the respective figure will reach 86%. Beyond the need to address disruptive drivers such as the increased food demand due to urbanisation and growing population, climate change, etc. UF market growth is driven by the development of technologies.

Box 1. Urban Agriculture global scale

In most of the research activities in UA-PUA, there is the use of disparate definitions of urban and peri-urban agriculture depending on the local context and study objectives. This coupled with scattered statistics on UA makes the quantification of the extent of these practices difficult to estimate at the global scale difficult.

With a particular focus on urban and peri-urban croplands, it has been estimated that the ***global area extends to a total of 68M ha****, considering both irrigated and rainfed croplands.*

Source: "Global assessment of urban and peri-urban agriculture: irrigated and rainfed croplands" Thebo et al 2014

Such ever-increasing demand for food has also been driving the development of the overall greenhouse market, which reached a value of $23.7 Billion in 2018 and projected to grow at $37.8 Billion by 2024, exhibiting a CAGR of around 8% for 2019-2024 (Research & Markets, 2019). Coupled with technological development, the greenhouse market development will potentially fuel the UF market growth. Greenhouse construction companies are scaling significantly and locate growing facilities within and near the urban sprawl, capitalizing on the rising trend of rooftop farming and the demand for short food supply chains.

Technologies used as such in performing UF activities or developing structures and growing mediums are examined in the following sections. Within the overall market major players have been identified into those applying UF for growing and providing produce in the market; those that develop and produce the technological parts or integrated systems and structures for UF and a mixed model that applies to both of the above (see Figure 6).

The Asia-Pacific (APAC) region has been constantly enhancing for the expansion of urban farming, driven by the need of feeding the increasing population in the emerging economies. It has been estimated that Asia will face an emerging increase in the middle class by 2030, representing around $^2/_3$ (66%) of the global middle-class population. At the same time predictions for the middle-class population show that a slight growth of 2% is excepted in Europe, while in the US the relevant figures will decline by 5%. This trend is also reflected in consumption forecasts, for Asia to account for 60% of global consumption, while the European and US is predicted to account 30% by 2030 (Pezzini, 2012).

The middle-class population increase is also affecting the global food supply accelerating the move towards regional supply chains, which also led by the demand to lower transportation costs and supply of fresh produce at competitive prices, is expected to further boost the UA market development. The high likelihood for new structures of UA is expected to be met in China if considering the relocation plans of the Chinese government bringing 250 million people from farmlands to the cities (Eiterstraum, 2017; Johnson, 2013).

Beyond the production of fresh food via UA, estimated to account for 20% of the world's food, health and nutrition, food security and transparency, education, urban sustainability and the growing demand for local food are the key factors raising the popularity of urban agriculture. China and India are predicted to guide the development of the market in the APAC region.

Box 2. Urban Agriculture's estimated ecosystem services value

*A recent study performed by Clinton et al. 2018, estimated the **potential economic value of ecosystems services** - food production, nitrogen fixation, energy savings, pollination, climate regulation, soil formation and biological control of pests - **delivered by UA between $80 to 160 billion annually** (in 2010 dollars). In an intensive UA applied scenario, the researchers estimated a potential annual food production of 100–180 million tonnes, energy savings ranging from 14 to 15 billion kilowatt-hours, nitrogen sequestration between 100,000 and 170,000 tonnes, and avoided stormwater runoff between 45 and 57 billion cubic meters annually.*

4.2 UA and indoor farming technologies

Technological developments in hardware (climate control systems, lighting, irrigation systems, etc.) software and data analytics (big data), Artificial Intelligence (AI), Internet of Things (IoT) and sensors are expected to contribute to an exponential growth of the UF market. Such developments are expected to cause disruption in the whole agri-food chain boosting production, and meeting the increased demands for quality foods with less environmental impact in the global food markets.

High Impact	Medium Impact	Low Impact
•IoT •Automation & Robotics •AI •Big Data •Traceability	•Blockchain •GNSS •Virtual reality	•Broadband •ICT •e-Business platforms

Figure 4: Technologies impacting the agri-food sector;
Source: Pesce et al. 2019

Indoor and CEA farming operations (widely used in urban environments) are characterized by widespread penetration of technologies. The most common type of technology integration in indoor and CEA structures is artificial lighting, used to supplement (or exclusively to cover) the daily integral requirement of food crops. Light-Emitting Diodes (LED) are mainly used as artificial lighting technology in indoor and CEA structures.

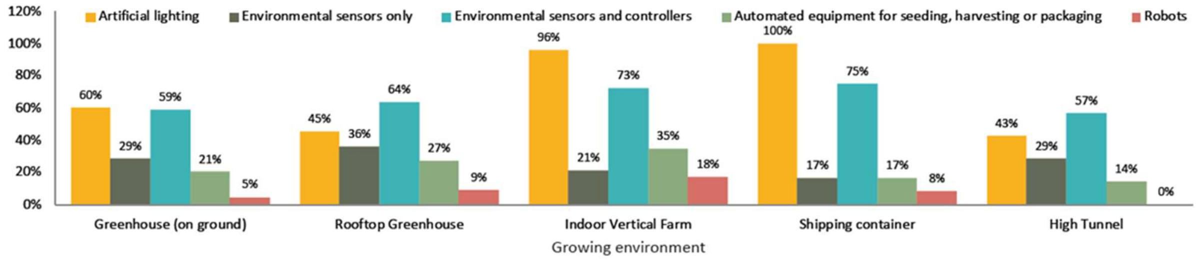

Figure 5: Technologies used in CEA by growing environment
Source: Global CEA Census report, 2019

Environmental control systems and sensors/controllers are also wildly used in indoor farming installations within which IoT, Big Data and analytics play a crucial role. Control systems are integrated with the information or computational platforms allowing remote and continuous monitoring of the structure and production system. Automated seeding, transplanting and harvesting processes incorporated with robotic technologies are less used in the current ecosystem, but it is considered that due to labour intensity demanded in operational environments of indoor farming, an increase in using such technologies will render more efficiency in the industry.

In 2017, the overall market for indoor farming technology was valued at $25.40 billion and is estimated to reach $40.25 billion by 2022, at a CAGR of 9.65%. It is projected that further growth of the indoor farming technologies market is estimated towards 2024 (forecast period from 2019 to 2024), at a CAGR of 15.23% (BIS Research, 2019).

Table 9. Indoor farming technologies market segments (per technology type)
Source: BIS Research, 2019

Segment per*	Categories	Sub-Categories
Technology	Hardware	Lighting Systems
		Climate Control Systems
		Sensors, Controllers, and Monitoring Systems
		Irrigation Systems
	Software & services	
	Integrated systems	

**other segments apply to the ones referred in the above Table 8.*

The hardware segment was dominant in the market in 2018, in terms of technology types and is expected to maintain its dominance within the period 2019-2024. It is envisioned to record a relatively higher CAGR of 9.88% in the overall global market by 2022 (Research & Markets, 2018). The increased focus on research and development activities within the indoor farming technology sector is expected to further escalate the development of the provision of the service (Software & Services), and this segment is projected to be the biggest revenue generator in the market (Market Future Research, 2019).

The below Figure 6 presents the most representative companies within the global indoor agriculture technology ecosystem. With the assessment of the market readiness level of SiEUGreen technologies, integrated concepts and/or other potentially exploitable outputs a further analysis will be performed (in D5.3 – Market Analysis III) specifying the market segments within which SiEUGreen outputs (technologies and/or integrated concepts) will be positioned, exploring the competitive landscape and serve as a basis for the overall marketing strategy of SiEUGreen.

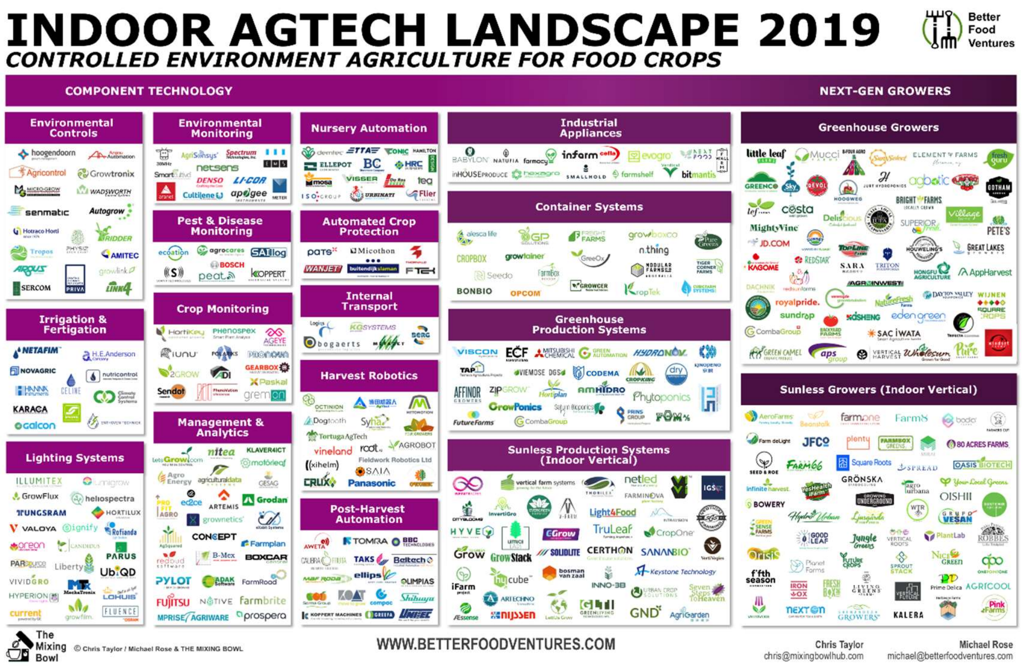

Figure 6: Major players in CEA indoor agricultural technologies
Source: AgFunder. 2019

Produce based, the indoor farming technology market is segmented into vegetables, fruits, microgreens and herbs, medicinal crops, and others. The segment of vegetables was dominant in the global indoor farming technology market in 2018 and is anticipated to maintain its dominance through the coming years.

On the basis of growing systems/growth (mediums) mechanisms indoor farming technology market is segmented into hydroponics[7], aquaponics[8], aeroponics[9], soil-based, and hybrid ones. In 2018, the segment of hydroponics was dominant in global indoor farming technology market and also as a type of CEA, and is anticipated to maintain its dominance. Together with aquaponics, the global market for systems and equipment used is expected to reach $1.98 billion by 2022, growing at a CAGR of 15.4% from 2017 (BIS Research, 2018).

The different basic hydroponics systems met in the market are categorized into the Wick system, the Water Culture system, the Ebb and Flow (Flood & Drain) system, the Drip system (recovery or non-recovery), the Nutrient Film Technique (NTF) and the Aeroponic one. However, there are hundreds of variations on these basic types of systems, but all hydroponic methods applied are a variation (or combination) of these six[10]. In Aquaponics, the basic different types of the system met in the market are the NTF, the Deep Water Culture (DWC) and the Media Bed[11].

As revealed by the Global CEA census performed in 2019 within the overall population of operators examined, the 56% of them use a single growing method while the remaining 44% use more than one growing methods. The high rate of operating in multiple systems is related with the realization of growers that crops have a better performance in one than another growing system, but also is also linked to the availability and development of new equipment and technologies in the CEA market. While soil-based systems used to be the only option, at present there is an abundance of hybrid systems available in the market and operators can mix in different systems. Available data show that within the 44% of operators that use more than one cultivation system, hydroponics is the most used/combined one (Figure 7).

[7] Soil-less plant growing method using mineral nutrient solution in a water solvent
[8] Symbiotic system that combines conventional aquaculture (raising aquatic animals) with hydroponics
[9] Soil-less plant growing method using a nutrient enriched spray mist to sustain plant growth
[10] https://www.simplyhydro.com/system/
[11] https://www.ecolifeconservation.org/updates/types-aquaponics-systems-design/

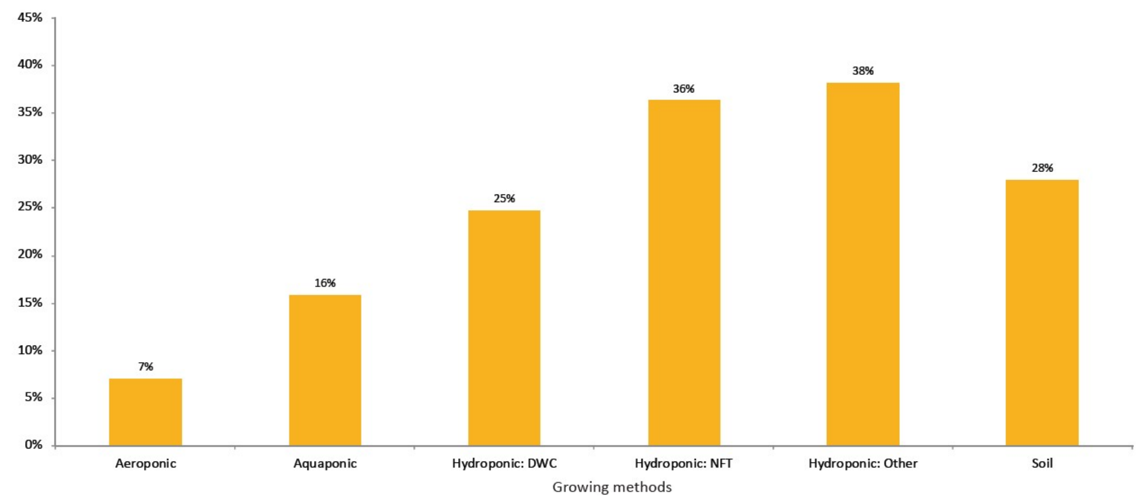

Figure 7: Main growing methods used in CEA
Source: Global CEA Census report, 2019

The following figure 8 shows again the dominance of hydroponics systems within the different growing systems among operations using more than one growing system.

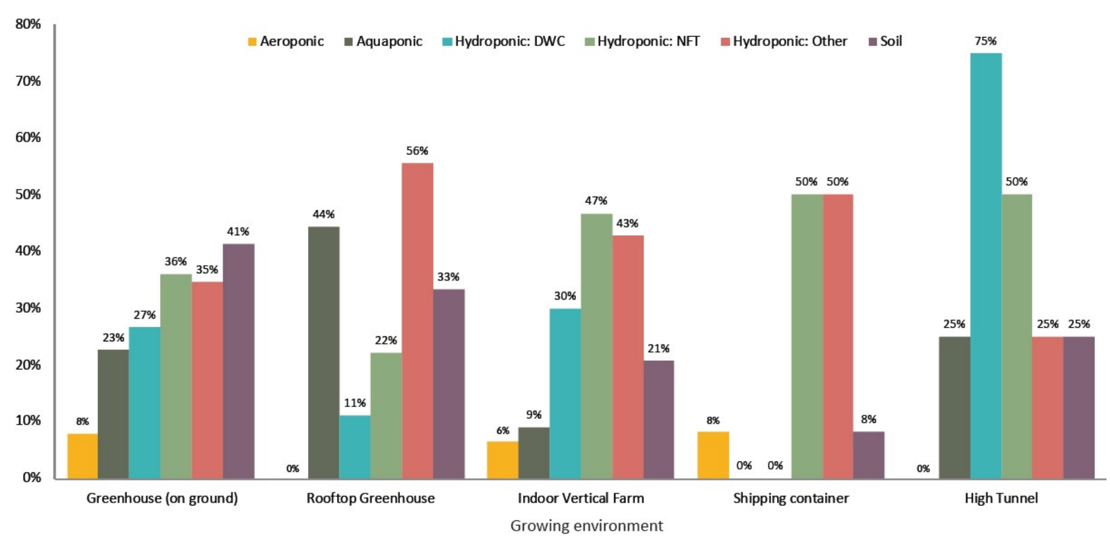

Figure 8: Growing systems used by operation
Source: Global CEA Census report, 2019

Waste and waste water treatment systems are often integrated in operational closed cycled growing environments. Both treatment systems have been largely used in different industries and at municipal level for various uses across the globe, with relevant markets largely developed and expected to record substantial steady growth in the coming years (Research and Markets, 2019). At a decentralised - smaller scale and within urban farming waste and water treatment systems are used to support circular concepts of input (as of natural fertilizer, irrigation water, nutritional supplements for animals, etc.). While market information has not been directly relating to UF applications, drivers of UF integrated systems and increasing interest of local authorities in achieving circular economy goals, are expected to provide lucrative market opportunities.

Waste is used as input for composting as well as in waste-to-energy solutions and anaerobic digestion. Less technologically elaborated systems are used broadly in urban gardening while more advanced systems (bio-reactors) are met in integrated systems for urban farming. Similarly, wastewater systems are becoming more and more applicable in small and medium-sized business units within UF. Rooftop urban gardens, farms and greenhouses are characteristic examples of structures that use wastewater that would otherwise discharge in into waterways enhancing sewage pollution. Commercial rooftop farms (but also construction developers – see info in "*The Swedish fully automated plantscraper"* Box 4. in 4.4.4) such as those developed by Brooklyn Grange[12] (in New York, USA) and Gotham Greens[13] (various farms in the US) in the US or Building Integrated Greenhouses (Belgium) in Europe, use integrated waste an water treatment systems and apart from covering their irrigation and/or composting needs, help urban structures reduce heat radiation but also reducing energy needs of the buildings.

As in the SiEUGreen "Blue" technologies, waste and water treatments are used to recover valuable nutrients from blackwater[14], digestate[15] or urine to be used as fertilizers or in fertigation (combined irrigation and fertilisation), composting or in algae production. Human excreta has been used historically by subsistence farmers but also in permaculture practices. Recently, higher-density pilot systems have been constructed to collect and apply urine to agricultural fields (Cardoso et al, 2017).

Livestock manure-based fertilisers are broadly used in agricultural practices especially in organic farming production. The relevant global market of organic fertilisers is estimated to reach $6.40 Billion by the end of 2025, considerably developed from its evaluated worth in

[12] https://www.brooklyngrangefarm.com
[13] http://gothamgreens.com/our-farms
[14] wastewater from flush toilets, that can contain feces, urine, water and toilet paper
[15] material remaining after the anaerobic digestion of biodegradable feedstock

2016 reaching $3.37 Billion (Transparency Market Research, 2017). However, market studies on organic fertilisers do not provide information regarding fertilisers produced by human excreta.

Beyond the users or buyers perceptions in the application of human waste-based fertilisers, regulatory frameworks regarding the implementation of systems for recycling of nutrients from sanitation systems are not well or at all developed in many countries. This, in turn, creates implications in the implementation and scale-up of innovative sanitation solutions, but also in the use and commercialization of human excreta based fertilizers (Richert et at. 2010; Berta et. al 2019).

The World Health Organisation (WHO) provides guidelines "*to encourage the safe use of wastewater and excreta in agriculture and aquaculture in a manner that protects the health of the workers involved and of the public at large*". In terms of health protection measures to be considered related to "*treatments to be applied to these wastes to remove pathogenic organisms, …. Other health protection measures are also considered, including crop restriction, waste application techniques and human exposure control*". As indicated these guidelines refer primarily to senior professionals within various sectors in which wastes reuse is applied, and aim to prevent transmission of communicable diseases while optimizing resource conservation and waste recycling (Mara et al. 1989).

Box 3. Swiss urine-based fertilizer - VUNA

VUNA stands for Valorisation of Urine Nutrients in Africa *a project implemented by Eawag developing a nutrient recovery system – from separate urine collection to fertilizer production. Beyond the system development (VUNA process) the product – liquid fertilizer is traded under the name "Aurin" as the world's first urine fertiliser with total approval and is available in Switzerland, Germany and France. VUNA liquid fertilizer is officially licensed by the Swiss Federal Office for Agriculture as a universal fertilizer for all plants. After an intensive test phase starting in 2015, it received a full license in 2018. The product is available on bottle 500ml at the price of CHF 12.80 (incl. VAT)*

Source: http://vuna.ch/index_en.html , 2019

At EU level existing legislation in wastewater treatment relates to the 91/271/EEC Directive for Urban Waste Water Treatment (UWWTD), within which treated wastewater shall be reused whenever appropriate. An earlier adopted one, the Sewage Sludge Directive 86/278/EEC aims to encourage the application of sewage sludge in agriculture and to regulate its use, so as to present harmful effects on soil, vegetation, animals and humans (EC, 2019). The directive *prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. Treated sludge is defined as having undergone "biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use*".

In the view of reducing the risk of shortages of water for irrigation, the EU has recently regulated measures to facilitate the use of treated urban wastewater for agricultural irrigation, but also for other uses such as industrial water reuse and for amenity-related and environmental purposes. The European Commission (EC) adopted the proposal for "a regulation on minimum requirements for water reuse" on 28 May 2018 as part of delivering on the circular economy action plan. With the adoption of position the European's Parliament, ad the agreement of the Council, the adoption of the new rules are expected in 2020 (European Council, 2019).

The EC sets strict requirements to be met for the quality of reclaimed water and its monitoring to ensure that human and animal health, as well as the environment, are protected. Within the adoption of expected regulation on minimum requirements for water reuse, general awareness-raising campaigns will take place in the member states that reclaimed water is used, to strengthen public information on savings of water resources as a result of water reuse in agriculture.

While there is established regulation on the larger scale urban and other sources wastewater treatment and the use of water or sludge in agriculture, "*sewage sludge is not currently included in the EU's 'end-of-waste' criteria, which define materials that cease being considered wastes and are eligible as inputs for other processes*"… "*creating a barrier to the production and commercialisation of composts derived from sewage sludge*", while the "*source-separated human excreta didn't fit into a specific category at the moment and perhaps could be included as an animal by-product"* (Berta et. al 2019).

4.3 UF technologies' regional markets development

4.3.1 Asia-Pacific

Within regions, the indoor farming technology market in the APAC region is foreseen to be the fastest-growing (within the period of 2017 to 2021), with North America, Europe and the rest of the world following. Structured governmental support for the development of the indoor farming industry, ranging from beneficial policies to subsidies is expected to further boost the growth of the market in the APAC region (Research & Markets, 2018).

China is positioned as first in the APAC region, recording the highest usage of aquaponic and hydroponic techniques (BIS Research, 2018). Further development in the overall agri-food related market is expected to occur due to the implementation of the Regional Comprehensive Economic Partnership (RCEP). The RCEP is a free-trade agreement between China, India and the Association of South-East Asian Nations (ASEAN), being the three largest consumer markets in the globe, of as well as Japan, South Korea, Australia and New Zealand, expected to enable more investment in agri-food technology in the region (AgFunder, 2019).

4.3.2 Europe

Europe was the largest regional indoor farming technology market in 2017. As a market has been traditionally characterized by high adoption of advanced techniques in hydroponics in smart greenhouse horticulture structures, which drive the development of the overall European hydroponics market. The Netherlands leads the European market, followed by Spain and France.

Hydroponics gain traction and expands also in Belgium, Germany, but also Turkey and Russia, contributing the region's market growth. The Netherlands is also the largest producer of hydroponic crops and is expected to maintain its lead for the next 10 years attributable to the vast expansion of hydroponics technology (BIS Research, 2018). In Turkey, there is an increasing interest in hydroponics. Since 1995 with the first attempts in commercial soilless growing (using hydroponics) in Antalya, nowadays there has been an expansion in a 100 million square feet area in total (iGrow, 2018). Such an expansion has been driven by a steadily increasing need for exports which attracted private investments but also led to the development of governmental subsidies for the establishment of soilless cultivation systems (Gül, 2018).

4.3.3 North America

North America's market (covering the USA, Canada and Mexico) is one of the most important ones, where leading companies of hydroponics and aquaponics equipment systems and products, generate their revenues. The region accounted for the largest share of the global market in 2017 and projected to reach $832.8 million by 2022, driven by increasing technological advancements, and increasing government investments pertaining to the agriculture industry (TechSi Research, 2019).

4.4 Vertical farming

Indoor urban farming is largely associated with vertical farming. Vertical is mainly performed in controlled environments and due to its structure (developed in vertical either in buildings - "farmscrapers or plantscrapers" or in containers) is a usual type of farming applied in urban and peri-urban environments with limited land for cultivations. Indoor vertical farms are the largest application segment accounting for more than 75% of the total vertical farming market size in 2018.

4.4.1 Global perspective

The overall global vertical farming market was valued at $2.3 billion in 2018 and is projected to reach a revenue of $12.77 billion by 2026, growing at a CAGR of 24.6% from 2019 to 2026 (Alied Market Research, 2019).

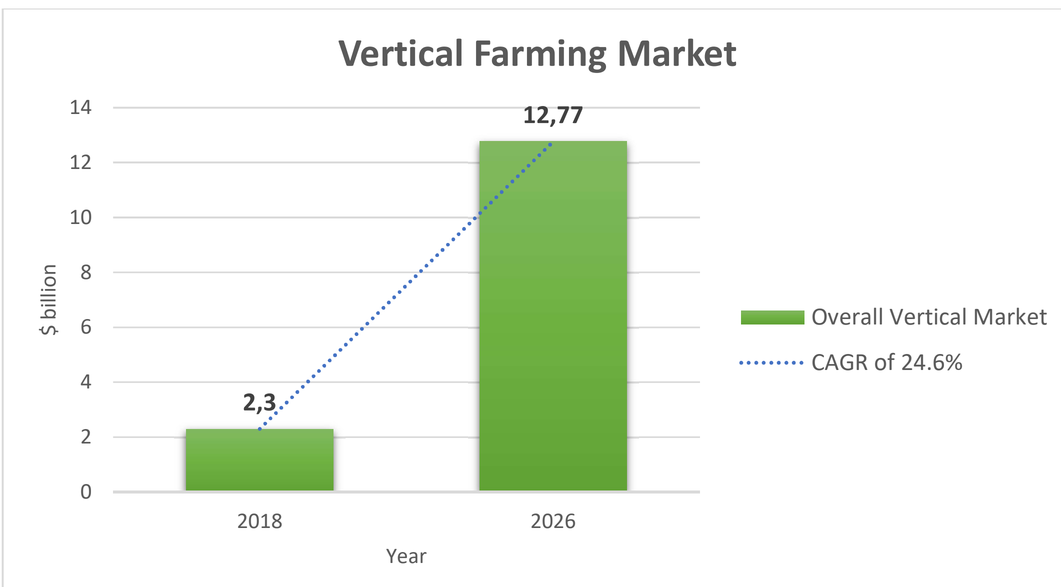

Figure 9: Vertical farming market value
Source: Allied Market Research 2019

Hydroponics as technology and growing medium is the one most commonly used in vertical farming, dominating in the relevant market, contributing for more than the 2/5 of the market. Other than hydroponics, aquaponics, aeroponics, as well as hybrid ones are also used in vertical farming.

4.4.2 Asia-Pacific

The APAC region had a dominant share in 2018, estimated to have contributed to almost half of the total share of the global vertical farming market, and is expected to maintain its dominance towards 2026. Asia is marked as a hotspot of "plant factories" (indoor mainly vertical farm megastructures) with Japan being a pioneer with nearly 200 plant factories in operation. Plant factories are spread widely in other countries of the region, with Taiwan hosting around a hundred farms installed and China, with 10 factories in service but 160 projects announced (Bidaud, 2019; Spread, 2018[16]). Singapore is characterized by the increasing number of tech-sophisticated urban farms but also governmental initiatives to boost further the development of the urban vertical farming sector.

4.4.3 North America

North American market is expected to record the second-highest share in the global vertical farming market within the period between 2019-2016, with the US dominating with a 64% share in the region in 2018, and expected to reach an overall value of $3 billion by 2024.

4.4.4 Europe

Among the regions, Europe is estimated to grow with the highest rate, approximately with a CAGR of 26.0% (Allied Market Research, 2019), and expected to reach $2.31 billion by 2023. France is leading in the European vertical farming market, followed by Germany, Spain, Italy and the United Kingdom.

Box 4. The Swedish fully automated plantscraper

*The World Food Building, is a 16 floor tower combining office spaces (2/3) and **indoor vertical hydroponic farming system** (1/3), **fully automated in operation**. Its construction started n Linköping, Sweden in 2012 and will be ready by early 2020. The tower is designed to be fully circular using heat and energy from a waste biogas incineration plant. In addition the waste that will be produced by the farm will sent to the biogas plant for composting.*

[16] https://worldagritechusa.com/wp-content/uploads/2018/03/J.J.-Price-Spread-Vertical-Farming.pdf

Plantagon (Sweden) behind the development of the tower is a developer and operator of urban farms, delivering innovative "agritecture" products and services falling under concepts of new buildings construction; retrofitting; buildings extension and integration of symbiotic systems.

Apart from the World Food Building, the company is in discussions with developers in Sweden, Singapore, the United States, Hong Kong, and Shanghai to build similar structures.

Source: http://www.plantagon.com/; Business Insider, 2017

*Another example from Sweden is **SweGreen**. An innovation and technology urban farming company based in Stockholm, providing circular solutions for controlled-environment urban farming. They integrate smart vertical farming solutions into real estate properties and provide circular energy-waste-water and carbon-absorbing systems, which enable locally grown, quality greens and help minimize the environmental footprint of facilities. Under the brand Stadsbondens, SweGreen's CityFarm in Stockholm produces herbs.*

Source: https://swegreen.com/

4.4.5 Impacting factors

Increased harvest cycles, higher yield compared to traditional agricultural practices, limited use of any kind of pesticides or fertilizers and ripening agents but also high-profit margins are further enhancing the growth of the overall vertical farming market. Coupled with the increasing consumer demand for organic produce, free of pesticides residues and genetically modified organisms (GMOs) products, are seen as major driving forces of the market. Additionally, production (supply related) in controlled environments using artificial lighting coupled with minimum dependency on weather conditions, drive the market from the producers' side.

It shall though be considered that there are major factors for which indoor vertical farms, as well as commercial greenhouses, are not more prevalent in the market. High costs for initial investment covering establishment and equipment (especially artificial lighting), high operational costs as well as high risks (iGrow, 2019), are quite restraining factors to the growth of the indoor farming market (Research & Markets, 2018; Market Future Research, 2019) also referring to the overall CEA applications, technologies and growing mediums for vertical farming. It has been estimated that the cost of production is about 3 to 5 times higher in a greenhouse or vertical farm compared to conventional farming. Conventionally grown vegetables can provide a much higher profit margin than the greenhouse of vertical farm-grown ones (AgFunder, 2019).

The high-level operational complexity of advanced technologies used in CEA demands high skilled labour, which is considerably high (almost 15% of the total operation cost in the case of hydroponics).

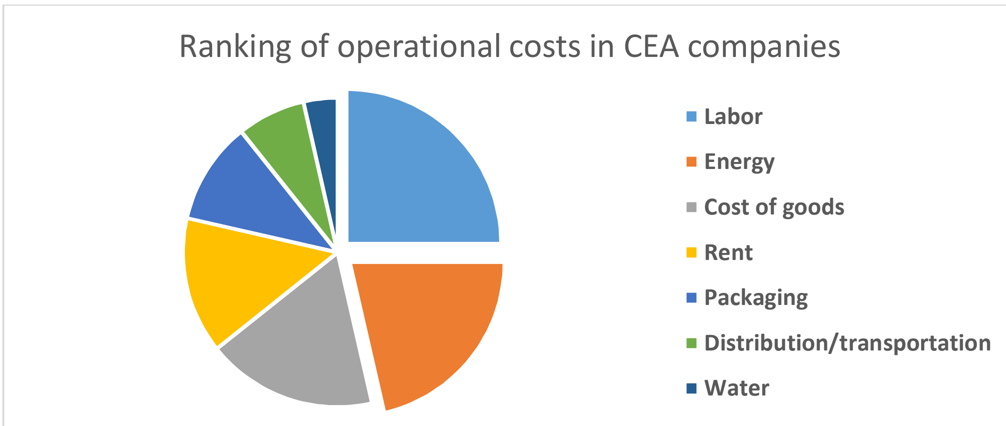

Figure 10: Ranking of operational costs in CEA companies
Source: Global CEA Census report, 2019

In vertical farming specifically, labour has been estimated to be one of the largest operational costs accounting around 25%, the following electricity at 26% (Agritecture, 2018). However, automation and use of robotics are expected to reduce labour costs leading to a reduction of product cost and increase margins in the sector.

Additionally, capital requirements for vertical farms limit the potential numbers for market investors. It is considered that is not the just the size of required investment as such that keeps investors away, given that there has been a growing number of investments in the sector (see section 4.6) but a combination of other factors. These mainly relate to the lack of technological certainty, the timing of returns which appears to be more lengthened, and also the size of the market which shall be considered beyond the desire of consumers but also to the potential margin of retailers to change their purchasing programs. However, as the technology develops and returns improve and get more consistent investments are expected to increase in a more comprehensive way (AgFunder, 2019).

4.5 Inter-SiEUGreen regions analysis

4.5.1 Enabling doing business in the SiEUGreen regions

The recently published report of the World Bank (WB) about doing business for 2020, identifies that worldwide, 115 economies have improved their structure to allow making easier to do business, depicted on the Doing Business (DB) index.

The DB is an aggregate figure based on 12 areas to measure the regulatory performance in economies (see Figure 11). The DB index scaled from 0-100, with 0 representing the lowest and 100 represents the best performance, allowing comparison for easiness of doing business across countries and over time (WB, 2019). Ten of these areas regarding starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency, are included in the ease of doing business score and ease of doing business ranking.

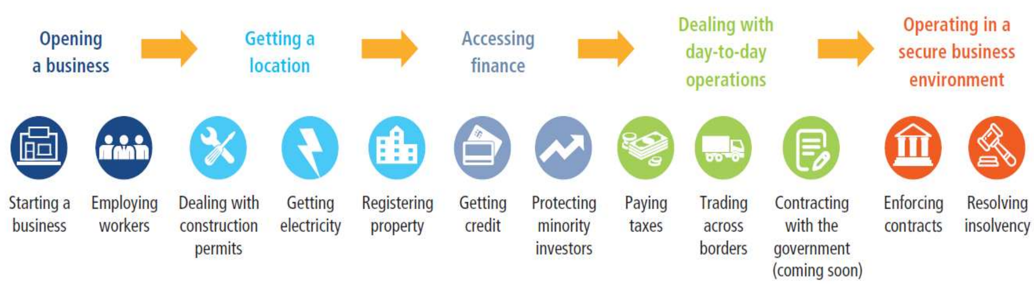

Figure 11: WB Doing Business indicators
Source: WB, 2020

The following Table 10 presents an overview of the SiEUGreen showcase countries on the basis of the business areas studied and DB indices. SiEUGreen EU showcase countries Denmark (4th position) and Norway (9th position) are ranked in quite high positions being among the 10 countries with the highest DB score. While China is listed on the 31st position, the WB report highlights that in the last year (2018-2019) has recorded a notable improvement in the regulatory frameworks of nine out of the ten areas of business (WB, 2020). Similarly, Turkey recorded developments in the regulations covering most of the studied categories, and is ranked as the 33rd country on the basis of the DB index. As stated in the WB report, changes that improve regulatory efficiency in countries have positive effects on entrepreneurship, firm formalization, access to credit, and Foreign Direct Investment (FDI) across sectors.

Table 10. Easiness of Doing Business scores across areas of business for SiEUGreen showcase countries
Source: World Bank Doing Business database 2020, data elaborated by the author

Country	Ranking (2020)	Score		Areas of business									
		DB 2020	DB 2019	Starting a Business	Dealing with Construction Permits	Getting Electricity	Registering Property	Getting Credit	Protecting Minority Investors	Paying Taxes	Trading across Borders	Enforcing Contracts	Resolving Insolvency
Denmark	4	85.3	85.2	92.7	87.9	90.2	89.9	70	72	91.1	100	73.9	85.1
Norway	9	82.6	82.9	94.3	80.6	84.3	87.3	55	76	85.1	97	81.3	85.4
China	31	77.9	74	94.1	77.3	95.4	81	60	72	70.1	86.5	80.9	62.1
Turkey	33	76.8	75.3	88.8	73.8	84.5	81.6	75	76	86.6	91.6	71.4	38.5

*Note: Values marked in green colour represent the increase in the score compared to the previous year, red those decreased, black those remained unchanged.

With a specific look into the agri-business sector, enabling business is highlighted as of strong relevance for promoting investment and developing agro-enterprises within the whole agritech and agrifood value chains. These sectors are subject to stringent public sector regulations, aiming to cover not only food safety and quality but also food security and political stability (FAO, 2013).

According to Christy *et al.* (2009) nine enablers of agribusiness and agri-industry are to be considered and provided by the governments:

- essential enablers, such as land tenure and property rights, trade policy and infrastructure, necessary to make possible the functioning of markets and enterprises;

- important enablers, as financial services, research and development, and standards and regulations;
- useful enablers, as business linkages and business development services being sufficient to enhance easiness of doing business.

Box 5. Policy and Regulatory frameworks

Other than grants or funding opportunities (see section 4.4.2) for UA/PUA projects and activities, governmental support is interlinked with ***political processes*** *as well as* ***regulatory frameworks*** *of countries/regions. A comprehensive analysis of the policy concepts of UA in different cultural contexts and spatial planning systems, is provided in Deliverable 1.2 Baseline study including key indicators and development of a typology.*

The analysis provides information about different policies, regulatory frameworks, planning systems and funding schemes in EU and China within which UA is addressed. Existing examples across the regions (EU & China) underlining the support by local authorities (municipal level) strengthening the development or maintenance of UA are also included.

Enabling business in the agri-business sector is depended on macro-level forces relevant to other sectors of economy, as *efficient land markets and tenure systems; access to appropriate rural and agricultural finance and risk management products; specific regulatory provisions, consistent trade policies and access to global markets; availability of skilled human resources, improved technologies and adequate infrastructural facilities and utilities (particularly rural roads and storage facilities); and capacity for complying with food quality and safety standards* (FAO, 2013).

4.5.2 Trade balances between the SiEUGreen regions

Developments in the easiness of doing business enhance the development of open and economic environments and provide access to economic opportunities supporting trade, thus enhancing the potential of development across sectors of the economy, including the agri-food tech. This is in a way addressed in the below Figures 12, and 13 that provides an overview of the evolution of trade within EU, China and Turkey respectively, per sector of the last decade

(2008-2018) but also in the Tables 11 and 12 regarding the imports and export of high tech between, EU, China and Turkey.

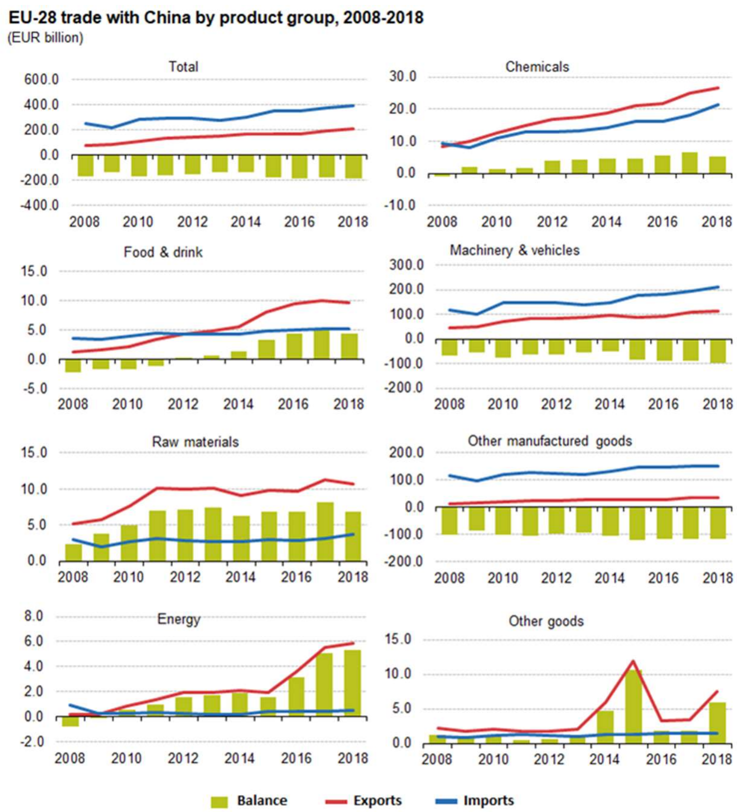

Figure 12: EU-China trade by product type
Source: Eurostat, 2019

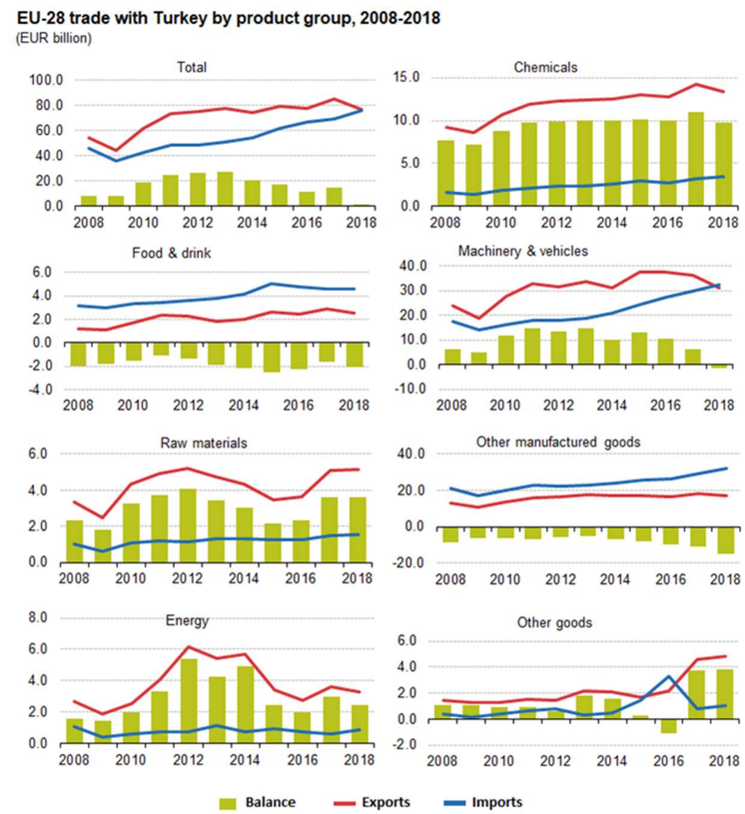

Figure 13: EU-Turkey trade by product type
Source: Eurostat, 2019

In 2018, an overall €373 billion value of high-tech products were imported by the EU with China being the main high tech import partner to the EU-28, with a total of €129 billion. Turkey has been placed within the 20 largest import to the EU partners, with about €1.2 billion. The six first countries represented in 2018 around 78 % of total imports of high-tech products, a ratio that since 2009 is increasing with China recording a significant growth (Eurostat, 2019).

Table 11: EU imports of high-tech products in € million 2008-2018
Source: Eurostat, 2019

Imports of high-tech products, top 20 trading partners, EU-28, 2008-18											
Country	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Extra-EU	238,693	218,392	271,414	268,120	279,407	270,954	276,721	327,915	336,001	362,620	372,934
China	**68,079**	**62,222**	**89,329**	**91,303**	**91,511**	**86,790**	**90,396**	**111,352**	**111,116**	**121,723**	**128,860**
USA	55,942	53,063	54,409	58,038	65,077	61,519	65,122	85,622	93,785	97,568	96,557
Switzerland	15,169	14,752	15,909	17,749	18,966	18,911	19,507	20,902	22,320	23,221	22,363
Vietnam	486	447	939	3,115	7,872	10,629	9,436	14,030	15,729	17,287	17,270
Malaysia	8,663	7,808	10,298	9,654	9,058	9,094	10,098	12,143	11,467	13,465	13,540
Taiwan	10,352	7,368	11,047	10,817	9,543	9,032	9,441	10,349	11,730	12,824	12,888
Japan	16,518	13,759	15,558	14,630	13,652	11,992	11,642	11,522	11,824	12,262	12,657
South Korea	11,841	10,366	12,001	9,513	9,006	8,806	8,450	8,686	7,946	11,785	11,255
Singapore	6,663	5,844	8,372	8,677	9,235	9,119	7,948	7,966	7,015	7,085	7,685
Thailand	4,583	3,753	4,505	3,861	4,013	4,201	4,845	5,309	5,838	6,880	7,373
Canada	4,490	4,434	4,328	4,791	4,677	4,044	4,488	5,068	5,911	5,383	5,280
Mexico	2,600	2,412	3,096	3,335	3,265	3,309	3,207	4,057	4,509	4,626	4,938
Hong Kong	4,281	3,965	4,095	3,661	3,553	3,855	4,069	5,963	3,015	2,868	3,955
Philippines	3,180	2,211	3,052	2,687	2,367	2,484	2,712	3,360	2,649	3,536	3,737
India	1,823	1,808	2,582	2,569	2,319	1,952	1,980	2,077	2,086	2,293	2,480
Russia	1,749	1,677	2,145	2,136	2,465	2,132	2,166	1,955	1,968	1,646	2,014
Brazil	814	1,456	2,176	2,093	2,145	1,419	1,309	1,411	1,922	1,213	1,379

Norway	1,797	1,731	1,716	1,480	1,722	1,707	1,793	1,866	1,523	1,445	1,321
Turkey	**616**	**470**	**584**	**659**	**673**	**690**	**895**	**1,165**	**1,107**	**1,120**	**1,180**
UAE	593	558	718	670	462	581	654	797	423	901	725

At the same time, in 2018 EU exports of high tech products did worth €349 billion, corresponding to 18% of all EU exports. Within the last decade, high tech product exports grew significantly and specifically for the case of China which is ranked as the second-largest importer of high tech products from the EU. Turkey follows in the 10th position recording a more variable development in the high tech product imports from the EU (Eurostat, 2019).

Table 12: EU exports of high-tech products in € million, 2008-2018
Source: Eurostat, 2019

Exports of high-tech products, top 20 trading partners, EU-28, 2008-2018											
Country	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Extra-EU	201,914	187,262	218,518	240,086	264,935	266,427	266,429	304,648	310,629	334,702	349,142
USA	43,898	43,956	47,604	52,060	58,259	57,653	61,513	78,895	81,238	84,985	91,797
China	**14,671**	**14,430**	**18,684**	**21,207**	**24,496**	**24,736**	**27,192**	**30,151**	**32,576**	**39,014**	**41,717**
Switzerland	13,421	12,629	14,309	15,950	16,542	16,603	16,473	18,442	19,157	21,015	21,430
Japan	6,395	6,128	7,425	8,288	10,331	10,154	9,911	9,786	10,734	11,843	13,445
Russia	13,181	9,382	11,492	13,672	15,586	14,340	12,535	9,262	9,857	12,278	11,798
Singapore	7,302	6,363	7,528	7,591	8,720	7,825	6,897	7,601	8,836	9,629	11,223
India	5,475	4,937	5,251	5,390	5,369	5,013	4,914	5,668	6,170	8,529	9,844
UAE	5,889	5,688	7,802	9,204	10,633	12,154	12,100	15,276	15,407	12,564	9,225
Hong Kong	4,840	4,592	6,549	6,961	8,998	6,830	5,809	6,260	7,349	8,437	8,788
Turkey	**5,817**	**5,157**	**7,148**	**7,983**	**7,681**	**7,797**	**7,662**	**9,583**	**9,154**	**8,638**	**7,930**
Canada	3,765	3,716	3,859	4,459	4,786	5,065	5,265	6,298	5,672	6,573	7,665
South Korea	3,751	3,561	4,330	5,409	5,449	6,533	6,770	6,809	6,923	7,552	6,857
Brazil	4,179	3,635	4,931	5,588	6,334	6,068	6,418	6,943	6,135	6,083	6,382

Norway	4,542	4,680	4,861	4,846	5,091	5,117	5,451	5,269	5,125	5,675	6,362
Mexico	2,746	1,943	2,722	3,002	3,479	3,486	3,672	5,185	5,630	5,028	5,902
Taiwan	2,252	2,064	2,439	3,057	3,081	3,176	3,659	4,106	4,845	5,719	5,383
Malaysia	5,687	4,359	4,836	4,667	6,067	5,427	5,580	4,659	4,474	4,960	4,905
Thailand	1,778	1,829	2,273	2,134	3,235	3,334	2,267	2,644	3,068	3,817	3,409
Vietnam	664	799	1,175	1,214	1,486	1,421	1,267	2,113	2,388	3,166	3,265
Philippines	1,593	1,013	1,346	1,379	1,823	2,573	3,068	2,157	1,937	1,757	2,949

The following Figure 14 provides the high tech trade balance, depicting the trade deficit between the EU and China and the trade surplus between the EU and Turkey.

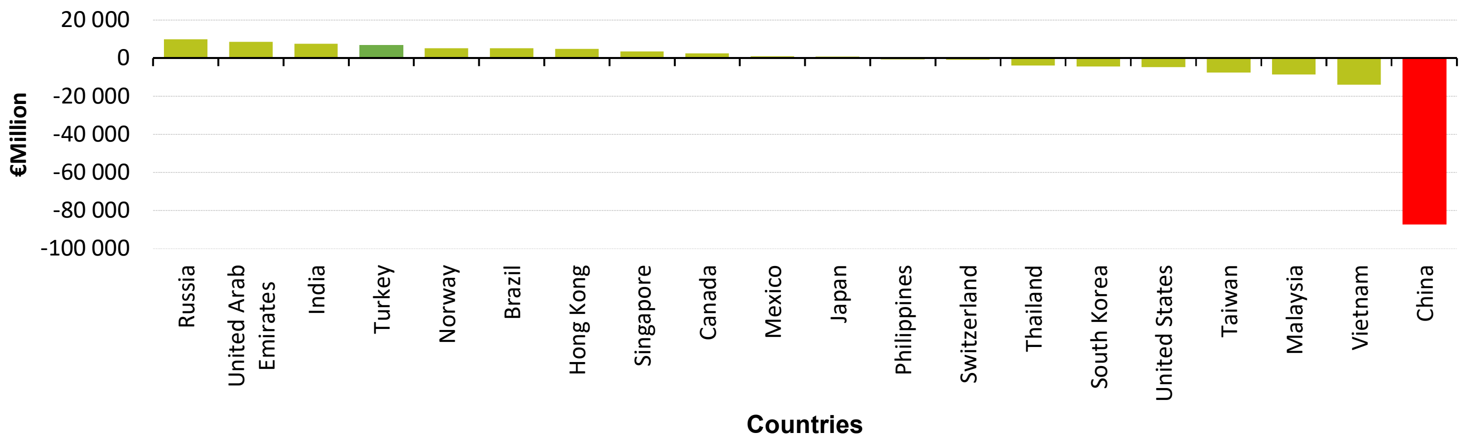

Figure 14: Balance of trade in high-tech products in € million, in 2018
Source: Eurostat 2019

4.6 Investments and support in UA/UF

4.6.1 Investments in ag-tech and UF relevant technologies

In the overall agri-food and technology sector, estimated to value $7.8 trillion in 2018, investments have been playing an important role in the sector's growth, having been increased from $500 million in 2012 to $4.4 billion in 2017. It is predicted that 2020 will be characterized by big investment deals relating to start-ups applying emerging technologies to traditional problems in agriculture such as sustainability, food safety, traceability, increased production and navigating climate change (Food & Ag Tech Investor Sentiment report, 2019).

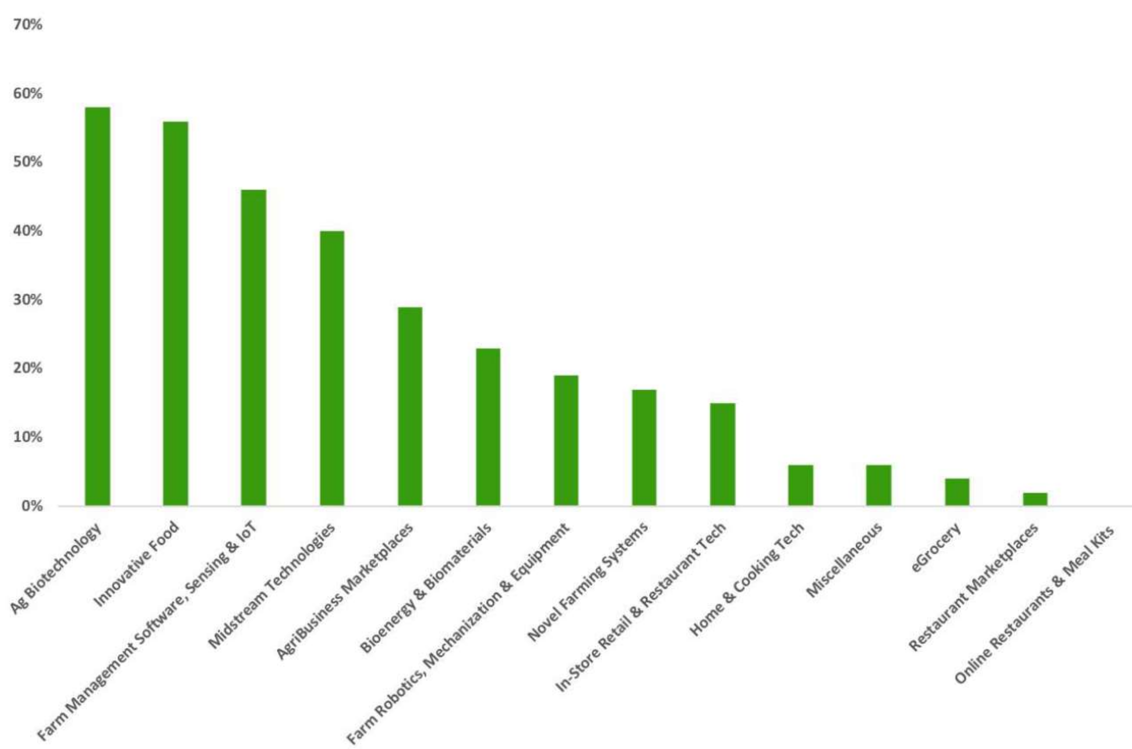

Figure 15: Top interest categories for investors in Food & Agri Tech for 2020
Source: Food & Ag Tech Investor Sentiment report 2019

Moreover investments, collaborations and joint ventures between large corporates and start-ups are increasing in numbers and volumes in the agri-tech sector. An evident example coming from the biotechnology and agri-food sector is that large corporates are reducing their R&D

development and instead they are sourcing for innovations and disruptive technologies within the agri-tech environment and start-ups.

The 6 biggest players in the field of biotechnology and inputs, Monsanto, Bayer, DuPont, Syngenta, DOW and BASF have launched Venture Capital funds. These corporates turn in to start-ups and Small and Medium-sized Enterprises (SMEs) for solutions and technologies allowing them to keep up on the rapid technological evolution (Pesce et al. 2019). Alongside with direct investments of large corporations scouting for technological advancements, an increasing number of Incubator and Accelerator programs emerge across the globe.

Box 6. TFF x FLAG Circular Economy on Food Challenge

The Thought For Food organization is partnering with the Food Lab Accelerator at Google (FLAG) to launch the ***TFF x FLAG Circular Economy of Food Challenge****. The initiative is inviting participants from around the world to incorporate Circular Economy principles into the technological innovations and social enterprises that they develop to address prevailing food and agricultural challenges across the value chain. Specifically, solutions should focus on reducing and reusing waste, using products and materials for as long as possible, and recycling end-of-life products back into the economy. Successful participants will have access in to a range of practical resources, including circular economy toolkits, mentorship, and special perks that will support participants on their entrepreneurial journeys.*

Source: https://thoughtforfood.org/content-hub/tff-partners-with-food-lab-accelerator-at-google-flag/

Agricultural Biotechnology, encompassing on-farm inputs for crop & animal production, including genetics, microbiome, breeding and animal health, is considered the most interesting vertical category for investors in 2020. The category of Farm Management Software, Sensing and IoT is the third most popular vertical, while Novel Farming Systems (covering indoor farms, aquaculture, insect and algae production), is the 8th most popular vertical for investor optimism.

North America and Europe have been the most popular markets for allocating funds in food and agricultural technology sectors in 2019, with 67% having exposure in North America and 65% in Europe. Asia has been the third popular market, but investors consider that has the highest potential for further development concerning the agricultural and food technology (Food & Ag Tech Investor Sentiment report, 2019). So far, the Asian market has seen a lack of investments mainly due to large size, complexity and diversity of the food and agricultural industry that create a challenging investment environment, being at the same time a significant opportunity for knowledgeable investors.

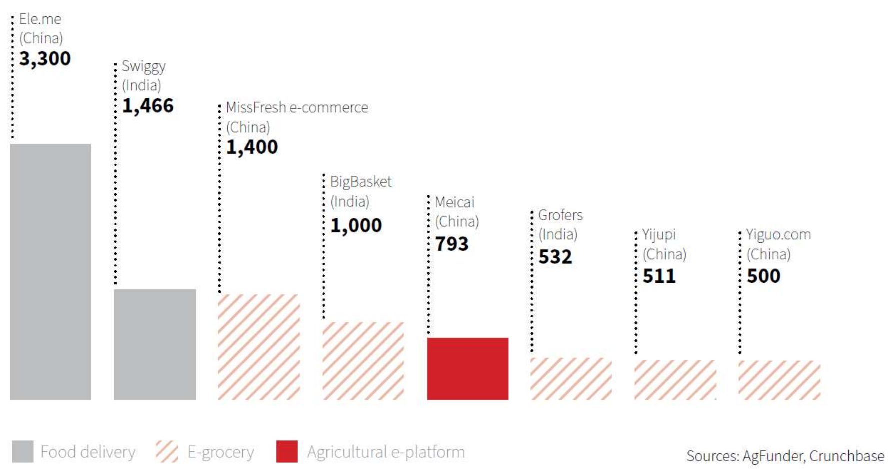

Figure 16: Most funded Asian agri-food tech companies, sum of deal investment 2012–19 (US$ million)
Source: Skinner et al. 2019

Apart from the immaturity and precommercial nature of many technologies that will result into longer timelines for investment returns, there is a range of specific challenges for the Asian region. These refer to the diversity of countries within the region, the different levels of economic development, the diverse regulatory systems, as well as currencies and dietary preferences that are keeping investments behind, across the agri-food and technology sectors. Experts consider that the urgency to meet the need for increased food productivity but at the same time ensure sustainability in Asia, will drive the investments in technological developments.

Box 7. GROW Asian Fund

*AgFunder, a global food tech and agtech venture capital (located in Silicon Valley and Singapore) launches the **GROW Asian Fund**, Asia's first dedicated agri-food technology accelerator. The fund is dedicated to invest in at least 50 start-ups around the globe that are developing technologies which will have a material positive impact on the Asian food system. AgFunder brings together more than 75.000 members and subscribers, key players in agriculture, food, technology, government and finance.*

Source: https://agfunder.com/invest/grow-fund/

A recent report published by PWC, Rabobank and Temasek (Skinner et al. 2019) estimates that above the existing investments, there will be a need of $800 billion for the Asian food and agricultural industry to grow to a sustainable size.

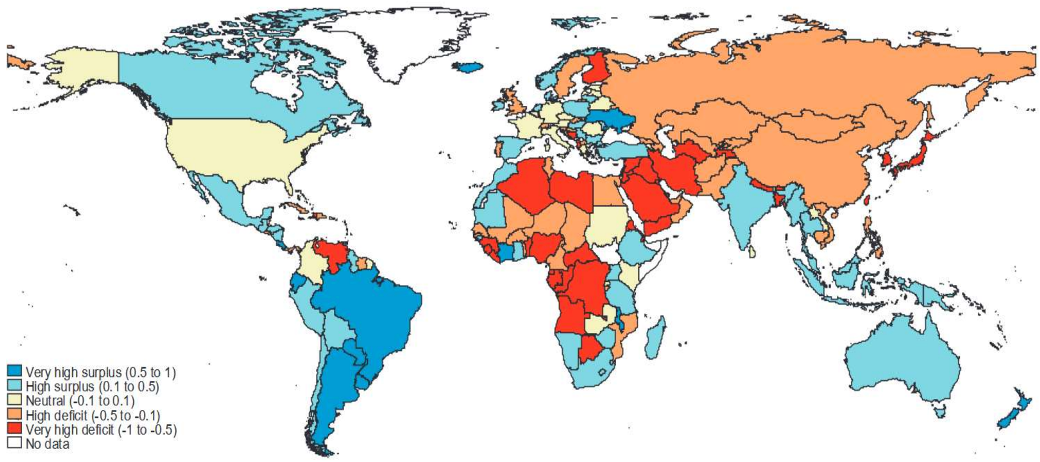

Figure 17: Food net index position in 2017
Source: UNCTAD, 2018

This is driven by the population growth and changing consumer requirements, coupled with the major challenges due to climate change and environmental degradation, and will thus stimulate investments that will enable the development and adoption of new technologies in agriculture and food production.

Box 8. Food net position index

Food net position *is computed as a country's exports of agricultural products minus its imports of agricultural products. This is then normalized by dividing it by its agricultural trade (imports plus exports). The index varies between -1 and 1, with positive values meaning that the country exports more agricultural products than it imports. Based on the Figure 17, most of the European countries are considered neutral (-0.1 to 0.1), Turkey with high surplus and China with high deficit (2017 values).*
Source: United Nations Conference on Trade and Development (UNCTAD), 2018

To unlock the investment potential, the report highlights the necessity for strengthening or developing structures to enable public-private collaborations; collaborations between corporates, investors and academia; establishment of corporate venture capital teams and incubators; legislation restructuring and supportive policies to foster technology development and support to investors. Furthermore, the creation of "*government-coordinated ecosystems* *and the development of regional agri-food tech hubs"* are expected to be critical catalysts for investment and innovation in the agri-food tech in the region.

4.6.2 Private investments

Indoor farming has attracted the attention and interest of big investors, given the fact that it involves the use of highly sophisticated technologies and the intense vertical use of space, achieving high yields compared to traditional methods. In 2013, vertical farming companies, mainly start-ups, received $4.5 million in venture funding, according to AgFunder. By 2017 the vertical farming market has experienced a significant increase in investments. Within 2016 to 2017, venture capital funding for vertical farming increased from $36 million to 271 million, recording an increase of 653%. Additionally, crowdfunding increased by 900% from $2.8 to $28 million on sites such as Kickstarter and Indiegogo (Agritecture, 2018).

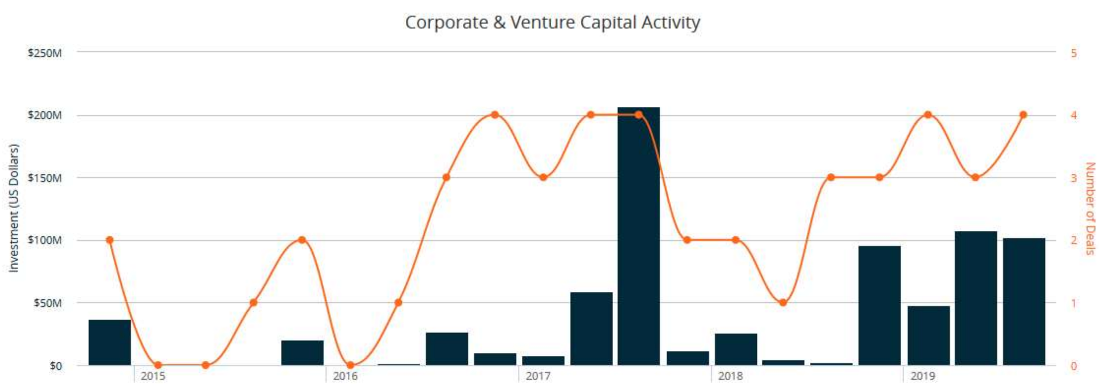

Figure 18: Investments in vertical farming
Source: i3connect, Investments in vertical farming, 2019

Not all of the vertical and indoor farming companies receive funding something that has been expressed in the number of investment deals for the last few years, focused on a few companies with strong tech initiatives.

Box 9. Technology and real estate companies investing in UF

*An **increasing number of companies with little connection with the agricultural sector have been investing in the development or expansion of indoor and vertical farming structures**. In Japan, major electronics and energy conglomerates, such as Hitachi, Mitsubishi or Toshiba, or real estate companies, such as Fudosan, are establishing subsidiaries for plant factory projects.*

Source: Bidaud Florent, 2019

In most of these investment cases, the companies receiving fund, primarily allocate it into substantial engineering and R&D to further develop new or existing operational growing systems and technologies. Secondly, they use the funding to expand their activity and operations into the market. So far even if few deals were made, trends show that interest and funding opportunities are expected to grow. While most of the recent indoor funding has been in the US, investments have significantly been expanded around the globe.

The potential that the sectors of vertical farming and CEA demonstrate, leads investment firms to dedicate funds specifically in these sectors, as already Equilibrium and Contain Inc. have done (Agritecture, 2018). Representative cases of UF companies having received high investments and also considered as major players in the UF market (and specified segments) are presented in section 4.3.3.

4.6.3 Governmental support for UA

Governmental support has been typically slower to act than private companies and investors. However, there has been an increasing trend for policies (for more info see SiEUGreen deliverable D1.2 - Baseline study including key indicators and development of a typology) as well as government grants and funding, but also the establishment of public-private partnerships favouring and supporting the development of UA/PUA as well as of relevant technologies applied in UF structures.

At the international level, already for decades, the Food and Agriculture Organization (FAO) has been providing assistance and funding to national and city governments in optimizing policies, develop institutional structures as well as support UA-PUA initiatives (FAO, 2019). Furthermore, at a global level, UA/PUA issues and food systems have become an important part of political processes, strategic documents as well as initiatives and networks (e.g. UN SDG; UN-HABITAT; ICLEI Declaration of Sustainable cities; MUFPP, etc).

Box 10. UNDP - Innovation for Sustainable Agriculture

UNDP launched on October 2019 the ***Cultiv@te initiative****, aiming to bring together a global coalition of innovators, investors, corporates and stakeholders willing to bring innovation and technology in addressing the most pressing challenges in agriculture; generating inclusive livelihoods across the agri-food value-chain; and adopting sustainable practices. Combining globally-leading innovation with local knowledge, expertise and market insights, Cultiv@te calls start-ups and R&D teams submit proposals in addressing the challenges within Urban Agriculture; Rainfed Agriculture and Livestock Farming & Aquaculture at 13 cities under focus. Beyond the money prizes, participants will be benefited by mentoring, investment, and partnership opportunities.*

Source: UNDP - Cultiv@te, https://www.agorize.com/en/challenges/undp-cultivate, 2019

An increasing number of city administrations and civil society has started including food policies in their municipal agenda envisioning to improve food security, health and social integration, and local economies (European Parliament, 2018). With urban agriculture being acknowledged as an important strategy for more sustainable cities, municipalities are becoming keen on encouraging its citizens to initiate urban agriculture projects around the city, both for producing more locally and to advocate sustainable agriculture in general (Eiterstraum, 2017). Since 2015 with the Milan Urban Food Policy Pact (MUFPP) mayors from all over the world commit (voluntarily) to developing sustainable and resilient food systems supporting the sustainable development of their cities. The MUFPP is the main framework for cities and international stakeholders to define innovative urban food policies for the management and governance of local food systems (EC, 2019).

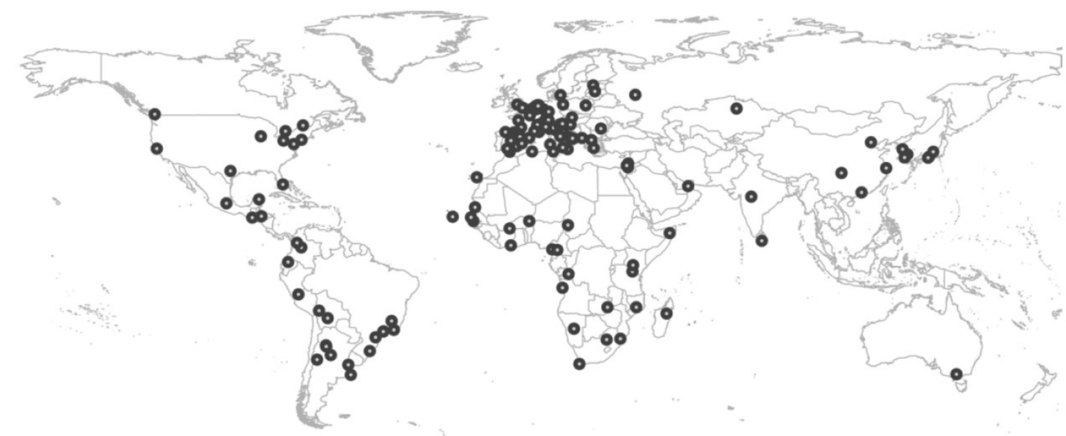

Figure 19 - MUFPP signatory cities
Source: EC report - European cities leading in urban food systems transformation, 2019

From SiEUGreen showcase cities, up to date, only Beijing is one of the 207[17] signatory cities of the MUFPP.

Box 11. Institutional support favoring UA in Oslo

The Oslo municipality in 2017 allocated a 2 million NOK fund to support initiatives for urban farming, including allotment gardens, beehives, and community farming projects. More than a few farms are now operating producing food but also being visitor farms for children (Eiterstraum, 2017).

At the European level, at the time the MUFPP was initiated, the EC launched the "Food 2030" a research and innovation policy framework on food. The initiative aims to achieve the transformation of the whole food system via a collaborative and multi-stakeholder approach, within a "*framework geared towards highlighting priorities and creating efficient investments*".

Furthermore, various EC research and innovation funding instruments, have been providing grants for projects relating to UA/PUA concepts. Specifically, under the priority of the societal challenges of the H2020 "Food security, sustainable agriculture, marine, maritime and inland

[17] For the full list of signatory cities visit: http://www.milanurbanfoodpolicypact.org/signatory-cities/

water research, and the bio-economy", numerous projects have focused on UA and PUA. Other past EC research funding instruments (FP5; FP6; FP7), as well as other funding strands such as INTERREG and COST Action, have also been providing funding for relevant projects realization (EP, 2018[18]).

In the US, support for UA has been recently embodied in the US funding agriculture policy[19]. The 2018 Farm Bill, has foreseen specific support to encourage and promote urban, indoor, and other emerging agricultural production. Further to the financial support, a dedicated body the Urban Agriculture and Innovative Production office has been created within U.S. Department of Agriculture (USDA) to provide financial and resource management support for the local and regional food production. In addition to the Office for Urban Agriculture, the Farm Bill also establishes the Urban, Indoor, and Other Emerging Agriculture Production Research, Education, and Extension Initiative. Further to the Farm Bill support, several cities have developed their support systems and structures (access to areas, funding, support and training programs, etc), aiming to strengthen the development of urban farming and gardening in the city. In New York city, the government provides information on a dedicated to urban agriculture website, connecting interested citizens with opportunities to become a part of the agricultural community in the city, serving as a one-stop-shop for resources, programs, and regulations that help grow agriculture in New York City[20].

4.6.4 Public – Private partnerships supporting UF

Different public-private partnerships (PPP) and initiatives arise across the world focusing at supporting the structures and development of UF. In the Netherlands, the Urban Farming Partners (UFP) a PPP of the Dutch government together with a group of experts in food, logistics and urban planning are working together in the development of UF. The UFP has

[18] Detailed list of EU funded projects in urban and peri-urban agriculture is provided in ANNEX 3 of: http://www.europarl.europa.eu/RegData/etudes/STUD/2018/617468/IPOL_STU(2018)617468_EN.pdf

[19] https://fas.org/sgp/crs/misc/IF11210.pdf

[20] https://www1.nyc.gov/site/agriculture/index.page

recently signed a collaboration with the Singaporean regional construction company HSL for the development of a 5-storey vertical farming building that will be expected to produce about 700 tonnes of organic vegetables for the Singapore market[21]. The UFP is also exploring to expand its activity in Hong-Kong.

The government of Singapore aiming to achieve its goals to produce 30% of its nutritional needs up to 2030 by increasing the local food supply. Recognizing the importance and potential benefits of the UF Singapore's Ministry of National Development created an interagency - the Urban Farming Taskforce - in order to analyse the potential impact of the technological innovation on domestic food production. This taskforce together with the Edible Garden City, a local organization working specialised in building urban gardens, set up a PPP to develop *the Citizen Farm project, navigate complex land use regulations, identify the obstructing factors to the development of gardens in the city, and develop solutions to such* (Bjorn, 2019). Furthermore, the taskforce persuading government agencies (such as the Singapore Land Authority) in order to enable the use of unused spaces in for community and commercial farming, but also to and to reform regulations and create a more accepting regulatory environment for urban farming.

[21] https://www.urbanfarmingpartners.sg/

4.6.5 Investments in UF companies and technologies across regions

This section provides an overview of the most significant investment deals on start-ups - major players within the urban farming ecosystem.

North America

Plenty (https://www.plenty.ag/) is a US (San Francisco) company (est. 2013) developing vertical farm installations integrated with AI, data analytics and IoT technologies creating high-yield, low space and water agricultural systems. In 2017 received $200 million, is the largest amount of funding for a vertical farming venture (Crunchbase Plenty profile, 2019). The investment was led by SoftBank Vision Fund and notable investment funds for Alphabet and Amazon. Already Plenty has a vertical farm in South San Francisco and a testing facility in Wyoming. With recent funds, they plan to expand to a 100,000 square foot farm in Washington, twice the size of their San Francisco farm, and globally (Agritecture, 2018). Plenty has previously raised in 2016 another $26million in two rounds (Crunchbase Plenty profile, 2019).

AeroFarms (https://aerofarms.com/), a US (New Jersey) based (est. 2004) urban cleantech company developing aeroponic growing systems. Since 2010 AeroFarms has raised an overall of $238 million in a total of 9 rounds of investments gathering a total of 13 investors (Crunchbase AeroFarms profile, 2019). In 2019, the company raised a $100 million investment by INGKA Group, the parent company of IKEA, which has been an existing investor for AeroFarms (AgFunder, 2019). The company has 4 commercial farms in the US, including its flagship 70,000 square foot facility is the company's headquarters, a 30,000 square foot farm in Newark, a research and development facility covering 5,500 square foot and a small 50 square foot school farm at Phillips Academy Charter School. Previous investment rounds in 2017 focused on the strategy of the company to increase its staff and expand the activity globally.

Bowery (https://boweryfarming.com/), is a US (New York) based (est. 2014) a global provider of produce grown in vertical farming facilities. With the last 5 years has recorded a substantial development. In 2018, the company raised $90 million funded by GV - formerly Google Ventures-, Temasek, Almanac Insights, and Uber. This year another $50 million was funded by the Singapore state investor Temasek, reaching an overall $167.5 million (Crunchbase Bowery profile, 2019). The company is currently operating two indoor farms in the US (Kearny and New Jersey) and with the last round of investment in 2019 is planning to expand to a third (3.5 times bigger) farm in the DC-Baltimore area in early 2020.

Bright Farms (https://www.brightfarms.com/), is a US (New York) based company (est. 2011) designing, constructing and operating hydroponic greenhouse farms and supplying big retailers and supermarkets like Kroger, Wegmans, Walmart, ShopRite, and Jet.com among others. Since 2011 the company has raised a total of $112.9 million, with $55 million (led by Cox Enterprises, Catalyst Investors, WP Global Partners and NGEN Partners) raised in 2018 aiming to expand its network nationally (Crunchbase Bright Farms profile, 2019; AgFunder, 2018).

CropOne (https://cropone.ag/), is a US (California, Silicon Valley) based company (est. 2012) developing modular vertical farming systems and supplying leafy greens produce through retailers in the US. Since 2015 the company raised $18.3 million and recently signed a $40 million joint venture agreement with Emirates Airlines to develop a vertical farming facility in Dubai (Crunchbase CropOne profile, 2019).

Gotham Greens (https://www.gothamgreens.com/), is US (New York - Brooklyn) based (est. 2009) is designing, building, and operating commercial-scale and technologically-advanced urban rooftop greenhouse facilities. The company has raised $30.1 million in three rounds since 2011 (Crunchbase Gotham Greens profile, 2019). Their flagship greenhouse, built-in 2011 was the first-ever commercial-scale urban greenhouse facility in the United States producing over 100,000 pounds of fresh leafy greens annually. The company currently owns and operates 4 production-scale facilities in NYC and Chicago and has under development of new facilities in 5 states.

Freights Farms (https://www.freightfarms.com/home/) US (Massachusetts) based (est. 2013) is upcycling shipping containers and incorporating them with CEA hydroponics, supports high volume crop production in a modular concept. The company so far has raised $11.4 million in funding so far, with the last one in 2017 reaching $6.5 million (Crunchbase Freight Farms profile, 2019). The container solution can produce over 500 types of lettuces, herbs, leafy greens, and small root vegetables at a commercial scale. At present their hydroponic container farms can be found in 38 U.S. states and also 15 countries. Their latest growing platform, The

Greenery, costs $104.000 offered with an overall remote production and structure control system.

Square Root Urban Growers (https://squarerootsgrow.com/) is a US (New York - Brooklyn) based (2016) farming accelerator providing training programs to indoor farmers. Although the company is a high-tech UF producing food into shipping containers, it has elements of socially driven business, empowering urban farmer entrepreneurs through its training programs. Participants do not pay tuition for the 12 months training program (they pay a refundable deposit) and the mainstream of revenue is from selling their produce to restaurants and through an office community-supported agriculture (CSA) subscription program (AgFunder, 2017). Following the first year training program, the company raised a total of $5.4 million funding in 2017 (Crunchbase Square Root Urban Growers profile, 2019), planning to expand its program activities to other US cities.

Seed & Roe, previously known as Edenworks, (https://seedandroe.com/) US (New York - Brooklyn) based (est. 2013) produces and sells leafy greens and fish in an indoor aquaponics system. The company operates in a 10.000 square foot warehouse in Brooklyn and the produce and fish is provided to local retailers (NYC Whole Foods Market and Foodtown). The company raised $5 million in one round of investments in 2018, planning to expand its operations building a new farm in New York City (Crunchbase Edenworks profile, 2019).

Lufa Farms (https://montreal.lufa.com/en/), is a Canadian (Montreal) company (est. 2009) agricultural and technology company constructing commercial rooftop urban greenhouse. The company's first greenhouse in Montreal was built in 2010 and began operations in early 2011. On 2013 the company built its second greenhouse in Montreal an since 2017 a third one is operating. A fourth rooftop construction has been announced and is expected to be delivered by the end of the first quarter of 2020 in the borough of Saint-Laurent (Montreal). The greenhouse is going to be the largest urban rooftop in the world covering 163,800 square feet. All rooftop greenhouse are using hydroponic installations integrated into energy-saving greenhouse structures consisting of double glazed glass construction for improved insulation; water-saving system - capturing rainwater to be used in the closed-loop irrigation system; and recycling waste with an on-site composting system (iGrow, 2019).

The company has received so far a total of $4million in two rounds of investment in 2013 and 2014 (Crunchbase Lufa Farms profile, 2019).

Europe

In Europe, **Infarm** (https://infarm.com/) a Germany (Berlin) based company (est. 2013) has raised a total of $134.1 million in 6 rounds of investments within the last few years. Infarm develops indoor vertical farming system to be used in a variety of customer-facing city locations, such as grocery stores, restaurants, shopping malls, and schools, enabling the end-customer actually to pick the produce themselves. The structure and system operation is cloud-based, which means that it can be monitored and controlled remotely from Infarm's central control centre. The company farming system operates in more than 50 locations across Berlin in supermarket aisles, restaurants kitchens, and distribution warehouses, including in-store farming into EDEKA and METRO locations, two of Germany's largest food retailers, but also food retailers in Switzerland, Austria and France (Agritecture, 2019).

In 2019 Infarm raised a $100 million fund led by Atomico with other existing previous investors of the company, Balderton Capital, Astanor Ventures, Cherry Ventures and TriplePoint Capital (Crunchbase Infarm profile, 2019).

Agrilution (https://agrilution.com/) another German (Munich) company (est. 2013) has developed the Plantcube, an intelligent indoor growing chamber allowing vertical farming in under 1m³. The system is equipped with LEDs highlighting provided by OSRAM, a controlled climate system and a hydroponic installation, which allow growing of lettuce, microgreens and herbs, for house or restaurants applications.


Figure 20: Plantcube chamber and seed mat
Source: https://agrilution.com/plantcube

The Plantcube is available in the market on 2.979,00€ (incl. Vat. and shipping). Agrilution provides non-soil based seed mats for the cultivation using Plantcube, that are produced from upcycled material remnants. High quality, non-GMO seeds are used and provided in seed mats for baby salad, herbs, and microgreens cultivation (3-5€ per seed mat).

In 2017 Agrilution raised $3.75million led by Fluxunit - Osram Ventures and TEV Ventures, reaching a total of $4.5 since 2015 (Crunchbase Agrilution profile, 2019).

Agricool (https://agricool.co/), is a French (Paris) startup (est. 2015) producing fruits and vegetables vertically inside shipping containers ("cooltainers" – using LED and powered by 100% renewable energy). The company has raised $38.9 million in funding so far in 4 investment rounds. In 2018 received $25 million aiming to scale up its technology and expand into five new containers in the Paris region in 2019, but also launch 100 in France and Dubai by 2021 (Crunchbase Agricool profile, 2019; EU start-ups, 2018).

Intelligence Growth Solutions (https://www.intelligentgrowthsolutions.com/) is a Scottish company (2013) developing indoor vertical farming systems. The company raised in 2019 an overall of £7 million in two investment rounds. The first round closing at £5.4 million will address the need of the company regarding its further software development, engineering, robotics and automation, but also to increase its product development, including continued innovation in AI, big data and the Internet of Things. Other than the technical capacity, the relevant investment focuses on the expansion of the company into the global marketing, sales and customer support teams in three continents. A second round of investment at £1.6 million, focuses at the expansion of the company's offering and market presence through global sales operations for lighting in both agritech and commercial uses (Crunchbase Intelligence Growth Solutions profile, 2019; AgFunder, 2019).

UrbanFarmers AG (http://www.urbanfarmers.com/ - new website under construction), is a Swiss (Zurich) company (est. 2011) founded as a spin-off of the Zurich University of Applied Sciences, commercializing niche technology in re-circulating aquaponics in structures of urban rooftop farms. The company has at the moment 3 urban farms in the EU and the current pipeline includes projects in the Benelux and Germany. Since 2015 has also expanded its presence in the US (New York City) and in Brazil. The UF001 LokDepot, pilot commercial rooftop farm of the company located in Basel, Switzerland, produces and sells fresh fish and vegetables directly to local restaurants and food retailers. The company has raised a total of $6 million in funding over 3 rounds (Crunchbase UrbanFarmers AG profile, 2019). The last funding of $2.5 million was received in 2015 and focused on the development of the UF002 De Schilde in The Hague. The investment was led by SVn, a Dutch municipal investment, and a private Swiss investor (Startup ticker, 2015).

BIGH - Building Integrated Greenhouses, farms (http://bigh.farm/) is a Belgian (Brussels) company (est. 2015), developing and operating aquaponic urban farms. The current farm of BIGH is the "Ferme Abbattoir" an urban rooftop farm in Brussels covering horticultural greenhouses of 2,000 meters squared that is connected with a fish farm, as well as 2,000 meters squared of outdoor vegetable gardens. The farm was partially funded by BIGH's equity financing, and partly in a debt facility from BNP Paribas Fortis bank.

Implementing a circular approach BIGH integrates farms with existing buildings, benefiting from waste energy and reducing their environmental impact. BIGH uses sustainable technologies in order to capture building energy loss, recycle rainwater from the site and use renewable solar energy.

In 2018 BIGH raised €4.3 million ($5.1 million) to expand its activity constructing a series of aquaponics farms in major European cities (Crunchbase BIGH profile, 2019; AgFunder, 2019). The funding has been provided by a range of investors including a group of individuals from the banking, construction and architecture sectors via the Lateral Thinking Factory (LTFD[22]) a consulting firm providing services for urban studies and strategies, a real estate company (Fidentia Green Buildings[23]), the public investment Brussels region office (Finance.Brussels[24]), and aquaponic farm construction and operation company from Germany (ECF[25]).

Urban Crop Solutions (https://urbancropsolutions.com/) is a Belgian (Brussels) company (est. 2014) providing services in development and installation of fully automated grow infrastructure, as well as after-sales service (including seeds, substrates, nutrients and licenses on plant grow recipes) for vertical farming, covering growth recipes of more than 200 crop varieties.

The solutions provided in the market are the PlantFactory, the FARMPRO container, and the FARMFLEX container. All the three systems are hydroponic based and are provided with a

[22] http://www.lateralthinkingfactory.com/
[23] http://www.fidentia.be/services/fund-management
[24] https://www.finance.brussels/
[25] http://www.ecf-farmsystems.com/

controlled climate environment, robotized and controlled procedures. PlantFactory is suitable for industrial-scale, covering up to 130K square meters of growing surface expanded up to 24 layers. The FARMPRO and FARMFEX containers are smaller-scale structures providing sully automated production systems covering 80 and 50 square meters of growing surface expanded to 4 and 6 layers respectively. The company has raised so far a total of 4.4 million within one round of investment in 2019 (Crunchbase Urban Crop Solutions profile, 2019).

GrowUp Urban Farms (https://www.growup.org.uk/) is a UK based (London) company (est. 2013), developing industrial-scale vertical CEA production systems. The company has built and operates the UK's first commercial aquaponic vertical farm – Unit 84 - in London, and is aiming to scale up their business. Furthermore, the company has developed and operates the GrowUp Box, a community aquaponic urban farm based on a shipping container structure.

Figure 21: The GrownUp Box structure
Source: https://www.growup.community/the-growup-box

To strengthen further community engagement the company has developed a dedicated educational program and training for growing via its sister company GrowUp Community Farms. Since 2015 GrowUp Urban Farms has raised a total of £1.1M in funding over three rounds (Crunchbase GrownUp Urban Farms profile, 2019).

Asia

Badia Farms (https://www.badiafarms.com/) is a United Arab Emirates (Dubai) based (est. 2016) commercial high tech vertical farm, producing and selling fresh vegetable sand fruits in across the Golf Cooperation Council (GCC) countries. The company raised already $4 million in one round of investment and recently has signed an agreement to extend its reach to restaurants and food industry across the GCC (Crunchbase Badia Farms profile, 2019; Arabian business 2019).

Red Sea Farms (https://www.redseafarms.com/) is a Saudi Arabia based company (est. 2017) developing a combined desalination and indoor hydroponics tomato growing system at a coastal desert climate. The technology and system the company has developed can replace up to 90% of the freshwater usually used in tomato production. Beyond the technology development and production, the company provides consultancy services to interested clients developing their own growing systems. The company raised an overall $1.9 million in 2019 (Crunchbase Red Sea Farms profile, 2019) to build a 2.000 square meter saltwater greenhouse in Saudi Arabia, led by the country's King Abdullah University of Science and Technology innovation fund and the Research Products Development Company (AgFunder, 2019).

Spread (http://spread.co.jp/en), is a Japanese (Kyoto) based (est. 2007) producing fresh vegetables in multistage hydroponics systems. The company is considered one of the older vertical farming companies. The financing the raised has been up to $1 million. Recently the company developed Techno Farm™ (http://technofarm.com/en), its next-generation vertical farming system allowing automated cultivation at big scale with 30,000 heads of lettuce produced daily. The produce is provided to 2,400 supermarkets nationwide. The company plans to expand TecnoFarm reaching 100 farms by 2025 around the globe, further increasing the number of those in Japan (20 new farms), but also establishing 40 in North America, 30 in Europe and 10 in Middle East (Spread, 2018[26])

Sky Greens (https://www.skygreens.com/) is a Singapore based company (est. 2011) having developed a fully automated, hydraulic driven vertical farming system. The crops are grown in rotating metal towers, housed in glass buildings, allowing all plants to get a uniform amount

[26] https://worldagritechusa.com/wp-content/uploads/2018/03/J.J.-Price-Spread-Vertical-Farming.pdf

of sunlight, therefore with no need to use LED lights. The metal towers are rotated by a water-pulley system that uses collected rainwater, with the same rainwater used to grow the crops. Since 2012, the company has raised over $28 million through public and private funds to increase its production capacity (AgFunder, 2019). The company sells its produce to the local supermarket chain NTUC FairPrice and also exports to China, Malaysia, Thailand and Vietnam. In June 2019, Sky Greens announced a partnership with Nespresso to make use of used coffee grounds from that will be recycled as compost for Sky Greens' vertical farm, added to its nutrient mix. An indoor prototype for vertical farming has been developed which can be used in households and offices (SGSME, 2019[27]).

[27]https://www.sgsme.sg/news/towkays/towkays-speak/big-plans-ahead-local-vertical-farm-sky-greens

5. Way forward

This document aimed to provide a first overview of the urban farming market and relevant technologies market and vertical segments across the globe and regions. This will serve as the basis for the further analysis of the market segments within which the SiEUGreen expected outputs to be commercialized will be placed and relevant market strategies will be developed. This is inherently a challenging task, and perhaps even more so given the novelty of the concepts and that their ”market”' is not only economic, but also social and scientific.

Task 5.1 upcoming (continuous) activities will focus on the vertical market analysis, specified for the most market-ready SIEUGreen outputs considered for commercialization. The analysis will aim to investigate the potential competition for the SiEUGreen under commercialization outputs, covering stand-alone technologies and/or integrated concepts, as well as any showcase concepts that will be aimed for commercialization. The approach to be followed will be based on specific desk research focusing on relevant market studies that will feed into the market analysis and competitive landscape. The research will be driven by the specified SiEUGreen outputs that will be aimed for commercialisation. This will be performed in close cooperation with research partners performed activities WP2, the innovation manager (ScanWater), technology-oriented partners in both regions (EU and China) as well as other partners aiming for commercial exploitation of the SiEUGreen solutions. Interviews with key informants and other stakeholders will also be used via semi-structured interviews.

The results of these activities will be presented in D5.2 – *Market Analysis III* and D5.3 – *Market Analysis III*. The understanding gained through the market analysis will directly feed into the marketing strategies and the relevant business plans, as to be presented in the D5.5 (M46).

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