SiEUGreen
Sino-European innovative green and smart cities

Sino-European Innovative Green and Smart Cities

Deliverable 5.3

Market Analysis III

Lead Partner: DRAXIS
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Disclaimer

SiEUGreen

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)

Document History			
Version	**Date**	**Author - Beneficiary**	**Summary of Changes**
1.0	28-02-2021	DRAXIS	Initial Submission
2.0	13-05-2021	DRAXIS	Review comments incorporated in sections 2.1.1, 4.1.1, 4.1.3 & 4.1.5.
3.0	27-01-2022	DRAXIS	Revision (see detailed Table below)

REVISION CHANGES Periodic Report 2		
	COMMENTS	Revision (page)
5.3	It is unclear where raw data for some of the provided figures (e.g. Fig. 3) are collected	See the note under **Figure 3** in p30
5.3	The SWOT analysis seem highly optimistic and not fully substantiated by numbers (e.g. on App Use).	4.1.5- SWOT analysis was adjusted to reflect the realistic limitations of the app (COMMURBAN) highlighting its weaknesses p65-68.
5.3	The analysis on the Asia Pacific (APAC) region (section 4.1.1, 2nd paragraph) is not clearly developed.	4.1.1 Global Market Insights (APAC) and specifically, market insights concerning the Asia-Pacific market (2nd paragraph) were revised and developed more clearly p31.
5.1 & 5.3	However, there is not any mention to nonsuccessful experiences or those which have experienced bankrupcy (e.g. UF002 De Schilde). The case of UrbanFarmers AG (on page 72) is described, and the UF002 De Schilde in The Hague too, but nothing about the problems or difficulties. Since these experiences may also be relevant for understanding reasons for success or failure, they should be adequately detailed too. This should be revised and expanded in D5.3.	In 4.1.3 we present and analyze the case of Case Study: UF002 De Schilde a non-successful experiment (and lessons learnt) p45-47.
5.3	Please also update references to the showcase in Norway.	In the entire document references are updated with respect to Showcase in Norway (Campus Ås) p12,13,14,21,43,97.
5.3	Finally please make clear that in this deliverable you are discussing marketable exploitable outputs/ results of the project as outputs/results can be exploited in different ways (for research policy and which should be covered under deliverables of WP6).	2.2 SiEUGreen Market Exploitable Outputs It is made clear that the focus of the market analysis is on marketable (with commercialization potential) outputs/results rather than those with non-commercial exploitation p21.
5.3	Please also correct the typos (e,g. Error! Reference source not found, lack of verbs, empty pages).	p.4, 34
5.3	Blank pages removed	

Executive Summary

The current *Deliverable 5.3-Market Analysis III (M38)* is produced as part of *Task 5.1 - Market research and benchmarking in EU and China* – and builds upon the previous *Deliverable 5.1-Market Analysis I (M8)* that provided a general overview of the global Urban Agriculture (UA) market. The present deliverable focuses on the market aspects around SiEUGreen technologies that partners have considered for exploitation in *Deliverable 5.4-Sustainability & Exploitation Plan (M30)*. More specifically, it aims to establish the positioning of SiEUGreen commercially exploitable outputs within the landscape of competitors and to provide a detailed examination of each potential market. The results of the current market analysis will feed directly into *Task 5.2- Development of exploitation and scaling plans for each of the 6 showcases* and will serve as a solid base for the *D5.5-Business Plan*.

In the present deliverable, we describe the current state of each market on the European, Chinese but also Global level. We analyze current and future market trends and barriers and provide an estimated projection for market growth over the next years. Moreover, we identify the main end-users/customers in each market and provide an estimate for the Total Addressable Market. Furthermore, we conduct a thorough and extensive competitor analysis in Europe, China but also Globally to assess the level of competition and determine the key competitors in each market examined. Furthermore, we employ an analytical tool to determine the external macro factors that can affect the market deployment of the SiEUGreen commercially exploitable outputs. Finally, we analyze the internal advantages and disadvantages of every marketable output/result and the external opportunities and threats that they might be facing in the market that they have been positioned.

The rest of this document is structured as follows: Section 1 provides an introduction to the focus of the current deliverable. Section 2 shortly describes the SiEUGreen project and briefly presents the showcases which have been developed to demonstrate the concepts and technologies of the SiEUGreen project. Section 3, describes the methodology used to conduct the market analysis in this document. In Section 4 we analyze the markets for the SiEUGreen commercially exploitable outputs. Section 5 provides a discussion of what is the next step for the SiEUGreen technologies and the way forward for the *D5.5-Business Plan*.

List of Acronyms

Acronym	Description
AAKS	Aarhus Kommune (SiEUGreen partner)
AD	Anaerobic Digestion
AI	Artificial Intelligence
APAC	Asia Pacific
BAIESU	Beijing Eco-Creative Agricultural Service Alliance (SiEUGreen partner)
BCC	Beijing Capital Company Limited (company name).
BEWG	Beijing Enterprises Water Group (company name)
BF(s)	Bio-Fertilizer(s)
BGVS	Beijing Green Valley Sprouts Co Ltd. (SiEUGreen partner)
B2B	Business-to-Business
B2C	Business-to-Consumer
CAAS	Chinese Academy of Agricultural Sciences (SiEUGreen partner)
CAGR	Compound Annual Growth Rate
CAP	Common Agricultural Policy
CEA	Controlled Environment Agriculture
CHP	Combined Heat and Power
CH_4	Methane
CO_2	Carbon Dioxide
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FYP	Five Year Plan
HATAY	Hatay Metropolitan Municipality
HHEPSTI	Hunan Hengkai Environmental Protection Science & Technology Investment Co Ltd. (SiEUGreen partner)
IGS	Intelligent Growth Solutions (company name)
IGZ	Leibniz Institute of Vegetable and Ornamental Crops (SiEUGreen partner)
IoT	Internet of Things
IT	Information Technology
IVF	Institute of Vegetables and Flowers at CAAS
LA	Latin America

LED	Light-Emitting Diode
m^2	Square metres
ML	Machine Learning
NA	North America
NFT	Nutrient Film Technique
NGO	Non-Governmental Organization
NIBIO	Norwegian Institute of Bioeconomy Research (SiEUGreen partner)
NMBU	Norwegian University of Life Sciences (SiEUGreen partner)
NPK	Nitrogen (N), Phosphorus (P) and Potassium (K)
OF(s)	Organic Fertilizer(s)
PESTELI	Political, Economic, Social, Technological, Environmental, Legal, Institutional
R&D	Research and Development
R&D&I	Research, Development and Innovation
RO	Reverse Osmosis
SAMPAS	Sampas Bilisim Ve Iletisim Sistemleri Sanayi Ve Ticaret A.S. (SiEUGreen partner)
SCANWATER	Scandinavian Water Technology AS (SiEUGreen partner)
SCE	Selective Chemical Extraction
SiEUGreen	Sino-European innovative green and smart cities
SMEs	Small and Medium Enterprises
SWOT	Strengths, Weaknesses, Opportunities and Threats
UA	Urban Agriculture
UAE	United Arab Emirates
UF	Ultrafiltration
UK	United Kingdom
US	United States of America
UV	Ultraviolet
VF	Vertical Farming
WHO	World Health Organization
WM	Waste Management (company name)
W&WWT	Water and Waste Water Treatment
ZLD	Zero Liquid Discharge

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1. Introduction

The *D5.3-Market Analysis III* builds upon the *D5.1-Market Analysis I* that provided a general overview of the Global Urban Agriculture (UA) market and the *D5.4-Sustainability & Exploitation Plan* where the SiEUGreen partners identified the exploitable outputs of the project. The focus of this deliverable is to provide a thorough market analysis for the marketable SiEUGreen outputs/results that range from UA systems focusing on social integration to high-tech indoor solutions for vegetable production. Hence, the aim here is to analyze the markets for the SiEUGreen exploitable outputs and establish their positioning within the landscape of competitors.

To this end, we conduct an in-depth analysis of each particular market and provide a comprehensive market analysis on the European, Chinese but also Global level. This analysis includes an overview of the markets within which we position the market exploitable outputs/results of the SiEUGreen project. More specifically, we describe in detail the state of the market, the main market challenges and opportunities but also where the market seems to be heading. This helps us to understand if there's going to be more demand in the future and how competitive the markets are likely to be. Moreover, we identify the target customers and provide an estimate for the total addressable market. Furthermore, specific focus is placed on understanding competition and assessing the level of the competitiveness in the market as well as determining who are the main competitors in each market. Finally, we thoroughly analyze the internal strengths and weaknesses of the exploitable outputs and gain a better understanding of external opportunities and threats by examining how external macro factors can affect the market deployment of the SiEUGreen exploitable outputs.

The current market analysis is a significant step towards further exploitation of the marketable SiEUGreen outputs/results. D5.3 completes Task 5.1 - Market research and benchmarking in EU and China and provides a solid base for Task 5.2 and D5.5-Business Plan. Other outputs/results of the project can be exploited in different ways (i.e., research, policy recommendations, etc.) that are expected to be covered by the deliverables of WP6.

2. SiEUGreen in a nutshell

The Sino-European innovative green and smart cities (SiEUGreen) project aspires to enhance the EU-China cooperation in promoting UA for food security, resource efficiency, smart and resilient cities. SiEUGreen aims to assemble numerous existing and/ or unexploited technologies for the first time to facilitate the development of the state of the art UA model that can be implemented in China, Europe and elsewhere beyond the project period. Thus, in the general context of zero-waste circular economy, the SiEUGreen project uses existing technological tools and develops innovative resource-efficient agricultural techniques and integrated concepts to demonstrate how technological and societal innovation in UA can have a positive effect on economy, society and environment.

2.1. SiEUGreen Showcases

The development of novel methodologies for social engagement (UA typologies, IT software application), application of innovative technologies for UA (vertical farming, aquaponics and hydroponics) and waste and wastewater treatments (production of organic and bio-fertilizers) are taking place through the deployment and demonstration of 5 carefully selected showcases (see Table 1) in European and Chinese urban and peri-urban locations. These showcases include:

- **Hatay showcase:** UA for social empowerment of unemployed women and refugees, promoting job opportunities and local food production;
- **Aarhus showcase:** UA for social bonding, environmental and health awareness of citizens, promoting the usage of unused city spaces, local food consumption and production;
- **Beijing showcase:** UA for recreation and educational purposes to promote a healthy and happy life style;
- Campus Ås **and Changsha showcases:** Green housing development projects based on the principles of circular economy, using waste recycling and wastewater management for UA.

A wide set of innovative agricultural technologies are implemented at showcases within SiEUGreen, which are expected to be resource efficient and environmentally friendly. The technologies deployed in this project are summarized in Figure 1.

Figure 1: SiEUGreen Technologies

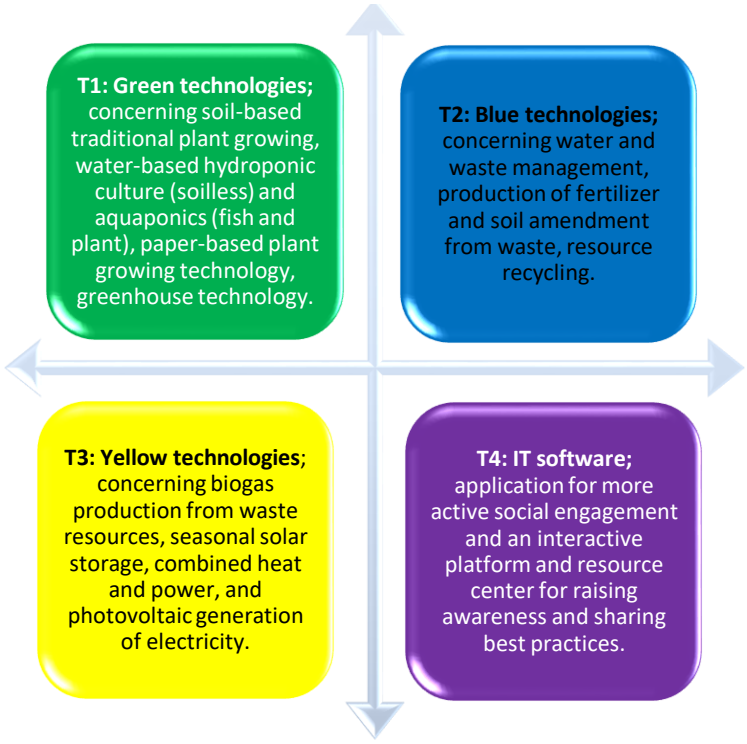


Table 1: Technologies and purpose per showcases

Showcase	Technologies	Purpose
Campus Ås	T1, T2, T3	local food production; solid waste recycling; wastewater treatment; production of organic & bio-fertilizers; energy and water saving.
Beijing	T2	recycle organic waste
Aarhus and Hatay	T1, T2, T4	local food production; waste recycling; IT software for social engagement

Changsha	T2	wastewater treatment; production of organic fertilizers.

2.1.1 Campus Ås showcase[1]

This showcase is planned as a high-tech ecosystem within a circular economy and UA. The idea is to combine societal and technological innovation to create a zero-waste, zero-emissions neighborhood. The technological innovation will be achieved by implementing the GREENergy concept: recycle of all waste and wastewater for reuse and to produce energy and organic fertilizers (henceforth, OFs) for the area's many gardens, green balconies and rooftop farms. The societal innovation is to involve local families in urban farming (i.e., balcony gardening) and the production of vegetables and fruits in greenhouses with high-tech recycling systems (see Figure 2).

Based on the principle of circular economy, the GREENergy concept is a smart integrated solution for water, sanitation, storm water, energy supply and nutrient management in cities and urban areas. Incorporated in building infrastructures it aims to increase resilience of cities and make of urban development more climate, environment and human-friendly with near zero emissions and low ecological footprints. More specifically, GREENergy will reduce water consumption, by using water saving fixtures such as vacuum toilets, and reuse greywater sources, facilitating recycling of nutrients to urban and peri-urban agriculture and thus, almost eliminate pollution of surface water. Integration of a biogas reactor, will allow biogas production from toilet waste (blackwater) and organic household waste, delivering heat and power, but also nutrient retention to support greenhouse food production.

The GREENergy concept builds upon the development and demonstration of the integrated organic waste and wastewater treatment system applied within the Norwegian showcase at Campus Ås. This showcase is led by the Norwegian University of Life Sciences (NMBU) that aims to:

a. Demonstrate smart systems for converting:

[1] This Fredrikstad showcase deployment that was planned initially is being cancelled at the moment this deliverable is produced and replaced by the deployment of technologies at NMBU's Campus in Ås. To the best of our knowledge, outside the location the showcase will not be otherwise affected.

- domestic organic waste into energy, burning off biogas to generate heat and electricity;
- wastewater into bath-quality water;
- organic waste (from biogas reactor) into UA fertilizers.

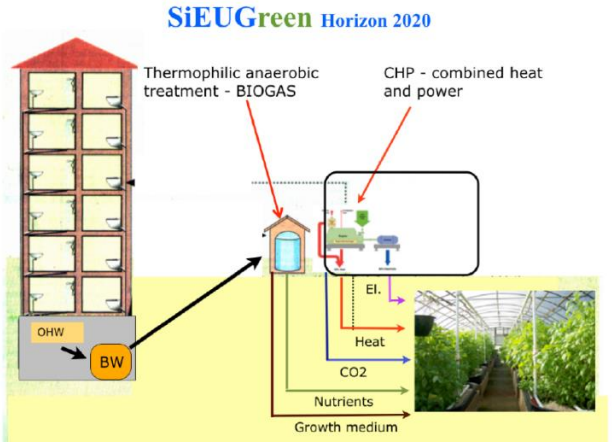
b. Reduce carbon footprint, water usage (by 20-30%) and reuse greenhouse gas emissions and waste-based nutrients in a local greenhouse.

c. Promote solutions for UA and sustainable urban lifestyle to local people and municipality.

The environmental, economic and health benefits arising from the implementation of the GREENergy concept in the Norwegian showcase can be used as a living example to inform the general public, draw political attention and raise the awareness of expected stakeholders for circular and sustainable smart city solutions. The expected stakeholders among other are residents, urban planners, architects, academics, municipalities and policymakers.

The set of innovative technologies and novel integrated concepts demonstrated in this showcase can generate significant public and private investments by third parties interested in the GREENergy concept.

Figure 2: Biogas reactor



Note: *The figure shows the collection of toilet sewage and organic household waste via vacuum system. This should go directly to the biogas reactor. The gas must be burned and heat and electricity generated are utilized in a greenhouse. The nutrient-rich effluent from the reactor will be treated and become fertilizer and growth medium. Source: Petter D. Jenssen/NMBU in Lothe (2019), <https://www.nmbu.no/aktuelt/node/37122>.*

2.1.2 Aarhus showcase

In 2015 the municipality of Aarhus (AAKS, Denmark) initiated a program called “Taste of Aarhus”. This initiative aims to re-connect citizens to nature and activate the unused city areas. As such it was chosen as one of the SiEUGreen showcases with the aim to demonstrate

how social empowerment through community based activities (urban farming) can scale-up and change the city. With food production relying heavily on the modern supply chain systems there has been a certain disconnection between people in the cities and their food sources. The key mission of the Taste Aarhus initiative is to underline the importance to consume locally and engage people in the practice of growing their food.

The city of Aarhus has supported more than 300 bottom-up agriculture initiatives with the greatest example of the largest in Denmark community garden of Ø-haven, a temporary project in Aarhus' harbor area that connected more than 300 local urban farmers. Citizens are invited to initiate UA projects and obtain support from their municipality. Moreover, the city provides information and signage of where to find edibles (apple trees, mushrooms, berries) and encourages people to use them.

These initiatives attract the local community to the site, which popularizes the area and demonstrates UA's potential to turn otherwise unattractive sites into venues for social interaction. The Aarhus initiative has already changed the city and the public awareness for community-based activities (i.e., urban gardening), as well as reconnection with the nature. Citizens are now using parks and public green spaces in a whole new way (Nordegio, 2019). Education, proper guidance and the development of community networks are the main drivers behind this behavioral shift. Beyond its social impact on bounding and increased community based activities, the local authority also plays an active role and uses UA as a mean of promoting healthier eating habits, encouraging physical exercise and further social interaction.

The long-run goal for the Taste Aarhus initiative is to have positive spill-over effects and inspire people from other parts of the city, other municipalities and regions to activate the unused spaces of their cities for urban farming and encourage the community-based initiatives. In addition, the municipality in two of its demonstration sites (the World Garden and Brabrand Common Garden) has presented polytunnels and mobile gardens, in order to encourage the practitioners to consider alternative crop production systems and hopefully diffuse them throughout the city. It is expected that the spread around the city of these systems would be possible, given the ease of the construction of polytunnels and mobile gardens (ability to move

it) and the associated benefits such as the fact that crops grow quicker, earlier and they are possibly larger with higher protection from rain, snow, frost, hail and all year round.[2]

The overall strategy of the municipality is to raise the awareness and engagement of citizens and gain the local support e.g., by inviting local businesses or associations into the collaboration and future investments. Moreover, the strategy is to go beyond the use of unutilized land and start setting aside urban land for UA activities.

To achieve these goals, the Taste Aarhus initiative will be using:

- the SiEUGreen integrated multiscale analysis frameworks to evaluate the benefits and drawbacks of UA (as defined in D5.4 Sustainability and exploitation plan);
- the systematic approach of the SiEUGreen typologies and engagement strategies to demonstrate the value created from the urban farming activities;
- COMMURBAN gamification app to enhance knowledge/guidance exchange and enable the dynamic interaction among urban farming practitioners.

2.1.3 Hatay showcase

The Hatay (Turkey) Community Garden showcase is a project that is directed towards social empowerment of unemployed women and refugees. Hatay is the 7th most populated region in the southern part of the country. Due to its proximity to the Syrian border, it has been challenged by a large influx of refugees in the recent years. The economic activity in this province is traditionally based on agriculture. The SiEUGreen project supports Hatay community to access UA-related technology and knowledge, with the aim of creating job opportunities, increasing food production and resource efficiency. More specifically, SiEUGreen was planned to support two projects, the “Women’s Cooperative” (Ureten Eller) initiative and the construction of greenhouse on the Kisecik Expo Zone in Antakya. Finally, it was decided that the Hatay showcase will move to Turunçlu, which is actually closer to the city center of Hatay making the transportation of the Syrian refugees and students easier.

[2]Polytunnels benefits: <https://www.allotment-garden.org/polytunnel-growing/polytunnels-for-productivity/>.

Currently, in the context of Women's Cooperative the urban farming has been used as a means to empower women with low-income to start their own businesses. The mild climate and fair weather conditions has set perfect environment for agriculture activities in an urban setting. The municipality has established local cooperative, and provides advice and materials to support and encourage the women in building small greenhouses in their backyards. This allows them to grow flowers and vegetables, some of which are then bought and used by the municipality. Great number of women have been already involved in this initiative and will be the driving force behind the greenhouse in Antakya. The aim will be to showcase the potential of aquaponics to increase the productivity of UA in the area.

The main objective of showcase exploitation is to widen the usage of UA technologies, maintain the potential and encourage the replicability of this project around Turkey. Moreover, it aims at raising the awareness of municipalities and local communities in the social engagement to UA of economically disadvantaged citizens and refugees.

2.1.4 Beijing showcase

The Beijing (China) Citizen Farm showcase involves the state-owned Sanyuan farm in the outskirts of the city that offers the opportunity to the residents of Beijing to rent small plots of land for practicing UA. Living in the megacity of such a magnitude habitants find it difficult to connect to the nature. At Sanyuan, they can grow their own vegetables in their free time, allowing them a break from the feverish city life. Sanyuan farm's vision is to demonstrate resource-efficient UA and a healthy-happy life style. The public farms cover a total area of 105 hectares, with a total of more than 1,400 small plots. Currently, more than 1,300 households are engaged in urban farming in the Sanyuan farm. Furthermore, the farm's staff organizes workshops and exhibitions for the city's elementary schools and kindergartens.

This showcase is led by SiEUGreen partners Institute of Vegetables and Flowers (IVF) at the Chinese Academy of Agricultural Sciences (CAAS) and the Beijing Eco-Creative Agricultural Service Alliance (BAIESU). At present, they key aim is to continue the research and investigations on the aquaponics methods and developed systems to incorporate the hydroponic and aquaponic crop cultivation techniques. Besides illustrating and providing consultancy to other companies on the potentialities of a soilless and hydroponic technology the greenhouse hosts school children, who learn about growing food. Chinese schools and parents want to ensure that their children don't lose touch with the traditional knowledge of agriculture. Urban farming is a great way to get familiar with the different farming methods and crops that can be grown in the soil. Finally, BAEISU aims to exploit this showcase of

aquaponics system as an attraction sight for visitors as the system is quite new for most people in China. The farm already offers the opportunity for tourists to “pick” the food cultivated in the site.

Furthermore, in November 2020, the Beijing showcase expanded from Sanyuan farm also to Pinggu. Pinggu showcase was created to demonstrate the new efficient Aquaponics system for mass production of fish and vegetables.

2.1.5 Changsha showcase

The second SiEUGreen showcase in China takes place in the capital city Changsha of one of the most densely populated provinces, called Hunan. This showcase is a housing development project that aims to establish green neighborhoods and create circular systems where waste recycling and wastewater management go hand in hand with urban farming. The real estate project Futiancangjun in the Green Controlling Area of the city was chosen to demonstrate the SiEUGreen technologies. The total construction site covers an area of 700 hectares, including mountain park, commercial buildings, schools and apartments. This area will become home to 3,500 families.

The Changsha showcase is led by partner Hunan Hengkai Environmental Protection Science & Technology Investment (HHEPSTI) Co Ltd. The main SiEUGreen technologies demonstrated at this showcase include:

- recycling of urban sewage and wastewater into fertilizers for UA (GREENergy concept);
- water-saving toilets;
- grey-water treatment;
- balcony gardens with soilless cultivation technology, automatic detection of greenhouse temperature and light environment and remote intelligent control technology.

The circular building structure and the functionality of the integrated system will be used by researchers for further research and development (R&D) or circular systems to recycle resources and reduce pollution.

The wastewater treatment in rural China is uncommon, but the latest regulations (*Action Plan for prevention and control of the water pollution* described in Liu et al., 2019) demand any wastewater to be treated before disposal. SiEUGreen partner, HHEPSTI, sees this as opportunity to market and replicate the integrated wastewater treatment system that is

based partially on the GREENergy concept. The infrastructure developed in the site aims to attract possible clients to the company's commercial activity and support the recognition and use of innovative decentralized wastewater treatment systems by the relevant public institutions. The GREENergy concept (integrated organic waste and waste water treatment system) builds upon the development and demonstration of the integrated waste and waste water treatment system (W&WWT) applied partially in the Changsha showcase.[3]

2.2 SiEUGreen Market Exploitable Outputs

This sub-section aims to present and summarize (see Table 2) the main exploitable outputs/results from the SiEUGreen showcases indicated in the *D5.4-Exploitation and Sustainability Plan* as commercially exploitable or with potentially commercial exploitation. However, as it is indicated in the D5.4 other exploitable outputs of the SiEUGreen project can be exploited in a non-commercial way (research, policy recommendations, other scientific exploitation).

Table 2: SiEUGreen Commercially Exploitable Outputs

SiEUGreen Outputs	Key Features	Potential Market(s)
GREENergy Consulting Concept	Services for the development of an integrated waste and waste water decentralized systems.	Water and Wastewater Treatment/wastewater consulting services
GREENergy Concept **(Production of Bio-Fertilizers & Organic Fertilizers)**	Recycle and reuse of waste and wastewater resources for the development of BFs and OFs.	Bio-fertilizers and organic fertilizers.
Multiscale analysis framework on UA typologies	Offers an alternative on how UA can be acknowledged as a strategy for long-term urban planning that connects people and nature for better urban life.	UA

[3] The main wastewater from the showcase building is from domestic sewage, which is recycled and reused in different ways. The greywater will be treated by using a Bio filter/Filter bed treatment system or a biomembrane system. The storm water will be treated by using a wetland/pond system or wetland/infiltration system. The nitrogen and phosphorus will be treated by struvite precipitation.

Urban Composting Hub	Production of OFs from Anaerobic Digestion (AD) of organic household waste streams.	Organic fertilizers Food waste management
High Efficiency Aquaponic System	Integrated ecological fish-vegetable production with zero pollution and zero emissions in water shortage area or around the large cities.	UA/Vertical Farming (Aquaponics)
Paper-based Microgreen Technique	Paper-based plant growing technique for residents to grow vegetables through balcony gardening at home and sell the production to process it into soap, nutritious food and other products and sells them to the market.	UA/Vertical Farming
Garbage Processor	Microbial fermentation, waste gas deodorization and drying technology to produce OFs from household kitchen organic waste.	Organic fertilizers, Food waste management
Vegetable and Fruit Planter	Equipment that allows urban residents to grow and eat their own organic vegetables and fruits.	UA/Vertical Farming
COMMURBAN App	Software to facilitate residents' and community engagement and raise awareness about UA.	UA
UA systems to empower disadvantaged communities (Hatay Showcase)	Support deprived populations with production of high quality organic local food by using innovative UA systems and renewable energy sources.	UA

Note: SiEUGreen results mentioned in the table were indicated as commercial or potentially commercial in the *D5.4-Exploitation and Sustainability Plan*.

GREENergy Concept

The GREENergy concept has been identified (in D5.4 - Exploitation and Sustainability Plan) by the partners involved (Scandinavian Water Technology AS - SCANWATER, Norwegian Institute of Bioeconomy Research - NIBIO, NMBU, HHEPSTI) as a commercially exploitable output from Campus Ås. The commercial exploitation has a focus on the concept rather than a single technology developed in the showcase. In D5.4 partners have indicated two business models based on the GREENergy concept:

- **Consulting services:** The provision of services for the development of fully operated waste and waste water decentralized systems for green and sustainable cities.
- **Nitrification of liquid streams:** The reuse of waste and wastewater resources for the development of Bio-Fertilizers (BFs) and Organic Fertilizers (OFs).

GREENergy Consulting Concept

The long-term experience and extensive expertise in the field of waste and wastewater management gives a comparative advantage in providing high quality consulting services based on the GREENergy concept. The GREENergy concept is a smart integrated solution for waste and wastewater management in cities and districts with climate resilient, environmentally friendly development that optimizes well-being and minimizes the ecological footprint.

The list of potential end-users of these consulting services includes municipalities, city planners, real estate developers, R&D project consortiums. Conferences, workshops, websites, social-media, press and exhibitions can serve as main dissemination channels for the consulting services. The main costs include communication, personnel and R&D outlays, while the revenue streams can be drawn from charging consulting and project fees. Lastly, the GREENergy consulting concept can be positioned within the water and wastewater consulting services market.

GREENergy Concept (Production of Bio-Fertilizers & Organic Fertilizers)

Another part of the GREENergy concept demonstrates the value of bio-based circular economy, created from household organic waste and resulted in bio-based products. More specifically, this concept has to do with converting and processing organic (human, food, etc.) waste into liquid or solid bio-fertilizer (sellable) using biogas reactors and post treatment facility. These fertilizers can be used for a sustainable and high-quality organic food production saving costs on chemical fertilizers and the wastewater discharge and treatment. This solution actively contributes to improve the environment and reduce waste accumulation and disposal.

Small food producer (i.e., home and urban community gardeners), local food producers as well as large non-food producers such as municipalities, flower companies, rural/local farmers and gardeners can be the end users of the GREENergy concept. The dissemination of this concept can be done through SiEUGreen partners, showcase sites, social-media, press, education, research and training centers. This solution can derive revenues from selling the

produced biofertilizers (solid/liquid) or from charging fees on provided technology and services. The main fixed costs include the construction, and R&D, and the operational costs consist of operational (i.e., quality control, packaging) and management, marketing & promotion costs. This part of the GREENergy concept can be potentially placed in water and wastewater treatment, bio and OFs markets.

Integrated Multiscale Analysis Framework on UA Typologies

The involved partner (NORDREGIO) has identified the integrated multiscale analysis framework on UA typologies as a potentially commercial output from the Aarhus showcase.

More specifically, NORDREGIO has developed a typology based on the variety of UA initiatives implemented in Aarhus that can help to address the lack of instruments to assess the benefits and drawbacks of UA for the development of cities. Through the mapping and classification into six types of UA initiatives the typology analysis framework offers an alternative on how UA can be acknowledged as a strategy for long-term urban planning that connects people and nature for better urban life. Typologies provide a means to unpack the different dimensions of UA, reducing the complexity and diversity of cases into a smaller number of more intelligible types. More specifically, the typology enables planners and policymakers to understand the different types of UA in terms of location (intra-urban and peri-urban); governance (the different actors that manage the UA initiatives); land ownership (private or public) and the technology that is employed to grow food (e.g., pallets, greenhouses).

This typology is evaluated and tested in the context of the Aarhus showcase. The value of this typology is to mediate the dialogue between different municipal departments and UA initiatives to enhance the role of UA in the city. Moreover, to provide instrument for the urban planners to assess the impact of UA in urban planning. Finally, this UA typology aims to change the perception about the unutilized land for UA. The dissemination of the UA typology can be done mainly through tours (to Aarhus showcase), training for practitioners, conferences and publically initiated campaigns.

There is a wide range of end-users for the UA typology that includes municipalities, UA practitioners and associations, private sector developers, researchers and the general public. The main costs involve the advertisement of UA for public, equipment and materials for UA and the main revenue streams can come in a form of consumption of local products, lower cost of public health (physical and mental), maintenance of public spaces, etc. The UA typology can be placed in the UA market (Section 4.1).

UA systems to empower disadvantaged communities (Hatay Showcase)

Main partners of the showcase (the Hatay Metropolitan Municipality – HATAY - and Sampas Bilisim Ve Iletisim Sistemleri Sanayi Ve Ticaret A.S. - SAMPAS) identified a potential business model for empowering disadvantaged communities towards continuous production of fresh, local, pesticide free, organic food by using innovative UA systems and renewable energy sources.

The main activities include: the training of refugees to operate greenhouses**;** the inclusion of women in the workforce (vegetable and flower production)**;** access and enrichment of innovative UA technologies**,** internship opportunities for students**;** provide, local, fresh and organic food; provide new technologies of aquaponics and hydroponics (offer profitable investments opportunities for private investors).

Main challenges are the high initial cost of the new technology, lack of experts, lack of manufacturers to deliver the complete systems, lack of intermediate staff, high renewable energy investment cost. Main benefits come from using less land and water, from producing and offering high quality (pesticide free) food for low price, using renewable energy, inclusion of women and refugees in the labor force.

The list of the end users includes refugees, women's association, universities (students and academics), local community, farmers and business investors. All the solutions, technologies and consulting services of this showcase can all be placed in the UA market (Section 4.1).

High Efficiency Aquaponic System

In the D5.4-Sustainability and Exploitation Plan, the partners (BAEISU and CAAS) have identified that the outputs of Beijing showcase are not commercially exploitable. The aim is to promote a high efficiency aquaponic system for the integrated ecological fish-vegetable production with zero pollution and zero emissions in water shortage area or around megacities. The potential end-users are researchers, students, citizens, SMEs and local restaurants. This aquaponics system can be placed in UA/Aquaponics market (Section 4.1).

Urban Composting Hub

The partner Leibniz Institute of Vegetable and Ornamental Crops (IGZ) identified urban composting hub as potentially commercially exploitable output. The business model values households' organic wastes to promote the production of OFs from Anaerobic Digestion (AD)

of organic household waste streams.[4] It aims to engage local communities (urban community gardening) and residents (home/balcony and allotment gardening) in recycling their organic household waste (and urban green waste) to produce fertilizers/compost for their own or commercial use. This business idea can be disseminated via internet (project websites, newsletters) or community gardens, as well as through the COMMURBAN App.[5] Revenues can be drawn from the selling surplus compost, receiving subsidies for recycling organic waste and producing compost that can be shared within the local community or even sold/given to municipalities. Fixed costs include the infrastructure of the hub, safety equipment, machinery. The operational costs include maintenance of the system, replacement of containers, input materials, space rentals, etc. The potential market for the urban composting hub is the market of OFs (Section 4.3) and food waste management market (Section 4.5).

Paper-based Microgreen Technique

This production method is used to cultivate edible sprouts on paper as an alternative to sowing seeds into the soil. This paper-based technique is developed by the SiEUGreen partner Beijing Green Valley Sprouts Co Ltd (BGVS), which has identified this technique as a commercially exploitable output.[6] BGVS aims to expand its presence in the Chinese market and access the European market for its cultivation devices and paper-based sprouting micro greens and vegetables.

The business idea is to engage residents to cultivate vegetables and microgreens using the paper based technique at home (balcony gardening). Then buy these vegetables from residents, in order to process them into soap and nutritious food and later sell them to the market. The potential customers or end-users of this cultivation method could be balcony gardeners, SMEs and the general public. Lastly, the potential market for this technique could be the UA/vertical farming market (Section 4.1).

[4] Anaerobic digestion is the breakdown of organic matter in the absence of oxygen by micro-organisms called methanogens. The process of anaerobic digestion provides a source of renewable energy, as the waste breaks down into biogas (a mixture of CH_4 and CO_2).
[5] COMMURBAN App can be useful in providing the information on how to set-up a composting hub as well as serving a platform to exchange knowledge on gardening among the users.
[6] BGVS supplies with knowledge and material the research activities in Chinese showcases.

COMMURBAN App

It is a mobile application aiming to promote urban eco-friendly farming techniques. It is an effective tool to engage residents, community and raise awareness about urban farming, food security and resource efficiency. COMMURBAN has been in several various SiEUGreen showcases, especially in Aarhus and Hatay getting positive feedback from the project's partners (SAMPAS, HATAY, AAKS).

The list of end-users includes public authorities that can engage citizens in diverse urban farming projects creating a sense of local community and promoting sustainable urban lifestyle. Moreover, COMMURBAN can serve as a tool to health organizations that can use the app to engage citizens/patients and other stakeholders in care farming activities to improve their mental health or provide social, or educational care services through the app to socially excluded people. What is more, COMMURBAN can help users to create their own food and income by granting the users with access to a number of urban farming techniques, resources, tools, training material and consultancy on urban cultivation methods. The main market for COMMURBAN app is the UA market (Section 4.1).

Garbage Processor

Garbage Processor is developed by the SiEUGreen partner Beijing Photon Science & Technology (PHOTON) Co. Ltd., which supports and provides the Chinese showcases. It is a device that produces OFs from household kitchen waste that can be used by residents in order to grow organic vegetables and flowers at home or in their balconies. More specifically, this device utilizes microbial fermentation, waste gas deodorization as well as drying technologies, so as to reduce the amount of waste and reuse it as OFs. Potential markets are the market of OFs (Section 4.3) and the food waste management market (Section 4.5). Potential end-users or customers include private sector SMEs interested in the appliance, researchers interested in the method used to process kitchen waste and residents that can use the OFs to cultivate their own organic vegetables.

Vegetable & Fruit Planter

Vegetable and Fruit Planter is developed by the SiEUGreen partner PHOTON which supports and provides the Chinese showcases. Vegetable and Fruit Planter is a home growing device that allows urban residents to produce balcony vegetables and succulent plants and consume their own organic food. This device automatically adjusts humidity and brightness, and

automatically replenishes water. The potential market for this device is UA/vertical farming (Section 4.1) market and potential end users are urban residents, balcony/home growers.

3. Methodological Approach for Market Analysis

This section describes the methodological approach employed for the market analysis for SiEUGreen project within the context of the Task 5.1 – Market research and benchmarking in the EU and China. The overall methodology is rested on three steps Desk Research, PESTELI (Political, Economic, Social, Technological, Environmental, Legal, Institutional) and SWOT (Strengths, Weaknesses, Opportunities and Trends) analysis.

3.1 Desk Research

Firstly, we reviewed the SiEUGreen deliverables that feed into the market analysis and provide short overviews on marketable technologies selected for demonstration at the SiEUGreen showcases. Secondly, we identified and analyzed the potential markets where the marketable outputs/results can be placed. Thirdly, we identified the competitors and assessed the level of competition in each market by briefly analyzing the competing companies. Finally, we described the main characteristics and defined potential customers in each competing market.

3.2 PESTELI Analysis

The second step was to conduct the PESTELI (Political, Economic, Social, Technological, Environmental, Legal and Institutional) analysis, which is an analytical tool that is applied to identify external factors which determine macro elements of the environments within which the SiEUGreen products/technologies from the showcases are positioned (Oxford College of Marketing, 2016). To this PESTELI factors (see Table 3) of relevance are identified and assessed as to how they impact SiEUGreen's positioning in the market. Outcomes of the PESTELI analysis was also used to define the external opportunities and threats in the SWOT analysis.

Table 3: PESTELI Analysis

Factors	Description
Political	Government policies, initiatives, political stability

Economic	General economy and its performance, economic trends
Social	Social environment and emerging trends
Technological	Technological innovation, R&D and scientific breakthrough
Environmental	Ecological aspects and recent environmental trends
Legal	Legal context, recent changes to legislation and regulations
Institutional	Specific institutional framework and the main institutions involved in overseeing or controlling markets/industries

3.3 SWOT Analysis

The third step is to employ the analytical framework of SWOT (Strengths, Weaknesses, Opportunities and Threats) that is used to identify internal strengths and weaknesses of a commercially exploitable output and its external opportunities and threats:

- Strengths: *internal* characteristics of the exploitable output that give it an advantage over competitors.
- Weaknesses: *internal* characteristics of the exploitable output that constitute relative disadvantage compared to competitors.
- Opportunities: *external* elements in the environment that the exploitable output could use to its advantage.
- Threats: *external* elements in the environment that could cause trouble for the exploitable output.

However, the new SWOT analysis suggests that threats and opportunities can be both external and internal and can be shaped by internal and external strengths and weaknesses (Brandenburger, 2019).

4. Market Analysis

In this section we conduct a thorough market analysis for the main marketable SiEUGreen outputs/results as they have been identified in the D5.4-Sustainability and Exploitation Plan and in Section 2.2.

4.1 Urban Agriculture (UA)

Deliverable *D1.2-Baseline study* provides an introduction to UA and includes key indicators and the development of a typology. *D5.1-Market Analysis I* defined and analyzed UA based on its typology and various dimensions (spatial, functional, origin, market-orientation, etc.). Moreover, *D5.1* provides general analysis of UA market and overview of its technologies. Here the aim is to conduct a market analysis for UA solutions, technologies and concepts (e.g., integrated multiscale analysis framework on UA typologies) that are developed under the SiEUGreen project.

By 2050, nearly 10 billion people will rely on agriculture and technology to feed them (Ranganathan et al., 2018). According to Food and Agricultural Organization (FAO) of the United Nations (UN), the current food system is already struggling, yet it is estimated that we will have to find a way to increase food production levels by 70% (FAO, 2009). What is more, it is estimated that by 2050, 68% of the world's population will be living in urban areas aggravating urban poverty and urban food insecurity (United Nations, 2018). Also, on an average, produce travels 2,400km to markets, losing 45% of its nutrition, increasing food waste, degrading topsoil and depleting aquifers.[7] Furthermore, on top of all this, the rapidly changing climate threatens not just food supply but also quality, access, tenuous transportation links and food security. However, UA owing to lower transportation cost and supply of fresh nutritious products at competitive prices can help us to meet future food demands while overcoming the aforementioned challenges in our current system.

UA is multifunctional (e.g., social, ecological) indoor and outdoor multi-purpose (e.g., recreation, self-supply, profit) plant cultivation practice that serves local inhabitants and distributes food in urban and peri-urban areas (McEldowney, 2017). Overall, UA has numerous advantages: promotes sustainable development by sequestering carbon, reduces the poverty

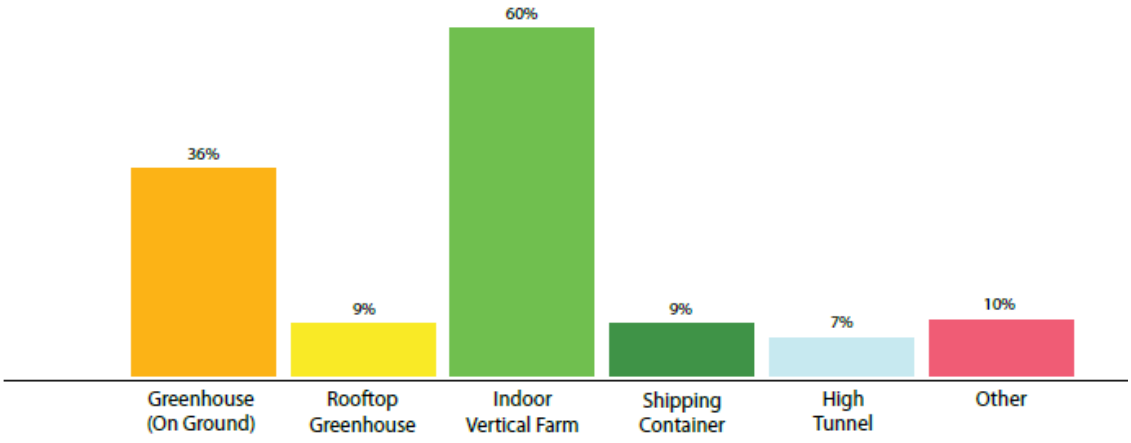
[7] Source: Urban Health Farms website, available at <https://urbanhealthfarms.com/>.

and food insecurity resulting from urbanization by producing fresh and local produce, improves the local economy and the health of city residents while also preserving the environment, creates social ties, enhances the value of empty spaces, enriches the city's biodiversity, and more.

UA produces 20% of the world's food keeping engaged everyone in urban farming globally (Research and Markets, 2020a). According to the Food and Agriculture Organization (FAO), more than 800 million people are engaged in UA and peri-urban agriculture worldwide. The main types of UA farms are: home gardens, corporate, community and other farm types. These farm types are divided into indoor and outdoor farming. The former includes structures such as greenhouses, containers, rooftops and vertical farms. The latter consists of open field and controlled environment structures. The main growing methods are aeroponics, aquaponics and hydroponics. These methods are used in growing food (vegetables, fruits, cereals and grains, etc.) or non-food (aromatic and medicinal herbs, ornamental plants etc.) crops for commercial or agriculture exploitation.

As it is mentioned in *D5.1* UA typology ranges from urban gardening to urban farming. The former refers to self-supply (subsistence) of food through small scale production that is oriented for local markets. The aim of urban gardening is to enhance social bonding among local residents and sync their lifestyle with nature and environment in urban areas. While urban farming refers to commercial side of agriculture production (mainly indoor through vertical farming) that takes place within or nearby urban areas and it is oriented for national or international markets.

Figure 3: *Type of controlled environment agriculture (CEA) facility used for cultivation*



Note: *Operators might be utilizing more than one facility type, that is why total % exceeds 100%.* **Source:** *Global Controlled Environment Agriculture (CEA) Census Report (2020). The raw data for this report were collected during a period of 8 weeks (8 July to 4 September 2020) including 371 respondents from 58 countries that participated in the*

Census, with the largest percentage of respondents being from the United States, India and the United Kingdom. There was a clear bias towards small to medium growers which is unsurprising given the large percentage of farms worldwide are small operations. Respondents ranged from small businesses with revenue under USD$10,000 to large with more than 100 employees with an annual revenue exceeding USD$3,000,000.

4.1.1 Global Market Insights

The global urban farming market accounted for $210 billion in 2017 (and $233.5 billion in 2020)[8] and it is expected to reach about $289 billion by 2026 growing at a Compound Annual Growth Rate (CAGR) of 3.6% during the forecast period.[9] In 2017 community gardening and home gardens generated revenue worth $136.1 billion and $29.61 billion, respectively. The home gardening market is expected to rise substantially in the forecast period (Research and Markets, 2019). The main factor propelling the market growth is the increasing demand for high quality agriculture food (vegetables and fruits) that can be produced in a narrow space without the use of pesticides or herbicides. However, the existing limits on the variety of crops grown using UA techniques can hinder the growth dynamic of this market.

By geography, the Asia Pacific (APAC) region accounted for the largest revenue share (≈$95 billion) in 2020, representing also the most promising region in terms of growth (4.8%) for the forecast period from 2021 to 2026 (Urban Farming Market, 2021).[10] The expansion of urban farming is urged by certain demographic and geographic features, and more specifically, narrow land accessibility, rapidly increasing urbanization and expanding population feeding requirements are among the main factors that predict the quick development of urban farming in the APAC region. . This expansion has been accelerated by the post-pandemic consumer preference related to reduced carbon footprint and shorter supply chains that are preferred also due to major supply chains disruptions that took place in the region. Moreover, as a post-pandemic trend, community urban farms have been suggested as a solution in Singapore for loneliness among the elderly. Finally, with respect to Asia, its extant history of agricultural technology innovation and prevalence of population density (China, India) makes urban farming both promising and practical for the region.

[8] The estimated value for 2020 is our own calculation based on CAGR of 3.6%.
[9] Compound annual growth rate 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. Source: Investopedia, <https://www.investopedia.com/terms/c/cagr.asp>.
[10] APAC was estimated including (China, Japan, India, South Korea, Australia & New Zealand, and Rest of Asia Pacific).

By structure indoor farming has the largest share of urban farming. More specifically, the global indoor farming market was estimated to worth around $113 billion in 2019, and it is projected to reach $131.22 billion by 2025, registering a CAGR of 2.5% during the forecast period (Research and Markets, 2020b). North America (NA) accounted for the largest market share in 2019. The United States of America (US) is a major contributor to the share in the region, followed by Canada and Mexico. Drylands in Mexico occupy large part of its territory, thereby thrusting the need for indoor farming practices.

As it has been noted in *D5.1*, the indoor urban farming is largely associated with vertical farming. According to the Global Controlled Environment Agriculture (CEA) Census Report (2020) the most popular type of CEA used for cultivation among the responders of the report is the indoor vertical farming, which accounts for 60% of CEA (see Figure 3).

Vertical Farming Market

Vertical farming is a revolutionary practice that facilitates the production of huge quantities of food and medicinal plants without relying on high quality soil, high water consumption and fair weather conditions.[11] This method of growing crops allows to have nutritious and high-quality fresh food (without the use of pesticides or herbicides) as well as consistent crop production throughout the year. The scarcity of arable land coupled with environmental concerns and increasing demand for food due to the growing population makes vertical farming one of the best sustainable solutions for years to come.

The potential of the global vertical farming market is apparent from its growing size. In 2019, it was valued at $2.90 billion and it is forecasted to reach $11.71 billion by 2027 at a CAGR of 20.1% (Emergen Research, 2020). The main drivers of the market come both from supply and demand sides. On the demand side, the rapidly growing population has increased the overall demand for food and the need to cultivate crops throughout the year. This in turn, has encouraged the adoption of vertical farming. Moreover, the rising number of chronic diseases

[11] An official definition of vertical farming comes from its founding father Prof. Dickson Despommier, "it is a method of growing crops usually without soil or light, in beds stacked vertically in a controlled-environment building." (Despommier, 2020). As suggested by Despommier (2020) vertical farming has a great potential to: a) supply year-round food production in a sustainable manner; b) discharge large tracts of land in many areas and restore the natural functioning of the ecosystem; c) use organic human and agricultural waste in a safe and efficient way in order to produce energy via CH_4 generation; d) make use of abandoned urban spaces; e) reduce the large-scale usage of pesticides and herbicides, improving the quality of food; f) create an eco-friendly and sustainable urban lifestyle, promoting healthiness and lower ecological footprint.

has raised the awareness regarding the adverse effects of pesticides in food production and has shifted the preferences of consumers towards a high-quality organic food that is safer, healthier and more nutritious. On the supply side, technological advancement in LED lighting has substantially boosted the production efficiency of vertical farming. However, the large fixed cost to install vertical farming systems still constitutes a significant market barrier and keeps many producers off the market.

The vertical farming market is divided in various segments, such as growth mechanism, component or farm structures. In terms of farm structures there is a division between building-based and shipping container-based farms. Most vertical farms are greenhouses in a building or container-based structures such as skyscraper, used warehouses or shipping container in urban or peri-urban areas (Allied Market Research, 2020). The current market is dominated by shipping container-based farms - with its market share reaching approximately 64% in 2019 - chiefly because of its low transportation cost and water usage, cost-effectiveness and cultivation under extremely harsh weather conditions (Emergen Research, 2020).

With respect to regional segmentation APAC dominates the vertical farming market with a share of nearly 40% in 2020. The scarcity of arable lands in densely populated countries such as India and China has resulted in the increasing adoption of the vertical farming method. However, Europe is expected to be the fastest growing region during the forecasted period (up to 2027) due to the increasing government initiatives to limit water consumption, ensure food security and satisfy the growing demand for organic food.

Based on growth mechanisms, the market is divided among aquaponics, hydroponics and aeroponics, with the lion's share of the CEA market belonging to hydroponics and the second largest share to aeroponics (Global Controlled Environment Agriculture Census Report, 2019). Overall, the growth of hydroponics and aeroponics systems is further driving the overall indoor farming market, majorly due to the increasing focus on adopting innovative and efficient technologies to improve the yields.

Hydroponics

Hydroponics is a method of growing plants without using soil. Hydroponic flowers, herbs, and vegetables are planted in inert growing media and supplied with nutrient-rich solutions, oxygen, and water. This method removes the risk of diseases that are caused by soil organisms. This system fosters rapid growth, stronger yields, and superior quality because of proper control over the nutrients.

The global hydroponics market size was valued at $1.33 billion in 2018 (Grand View Research, 2020a). Owing to its low fixed cost, ease of operation and efficiency of production hydroponics is widely used by commercial growers and it is forecasted to grow at 22.52% CAGR from 2019 to 2025. Moreover, hydroponics provides superior quality organic produce of vegetables with no use of pesticides or other chemicals. This is expected to boost its adoption in the near future given the growing global demand for high quality organic food.

The APAC region held the largest market share in 2018 owing to the substantial adoption of hydroponics mainly in China, Australia, South Korea. The market in China and India is expected to rise significantly over the forecast period owing to fast adoption of urban hydroponic farms due to the increased demand for food, given limited space, fertile soil and water scarcity. The second largest share of the market belongs to Europe due to the high adoption of hydroponics because of land scarcity and European Union (EU) initiatives. Already since 2010 the European Environment Agency has incentivized producers to build vertical farms in order to reduce the environmental impact and increase year-round yield in a sustainable manner.

NA holds a high potential of growth on account of numerous companies located in the region (see section 4.1.3) as well as owing to the growing popularity of alternative farming techniques in urban areas. However, the lack of government initiatives and the unavailability of essential infrastructure to set up large hydroponic farms is expected to hinder the growth in developing countries from the Middle East, Africa, and Latin America (LA).

Aeroponics

Aeroponics system offers the possibility to boost crop production in a cost-effective way when compared to traditional farming methods. Aeroponics system is pesticides free and zero harmful waste production. The controlled environment of aeroponics has the capability to produce approximately 70% more yield compared to traditional agriculture.

The global aeroponics market was valued at $580 million in 2018, and is projected to reach $3.53 billion by 2026 (Allied Market Research, 2019). Aeroponics, is estimated to have a substantial growth - increasing at a CAGR of 25.60% from 2019 to 2026 - owing to its method of rising plants by using less space, water and nutrients. The main market drivers include rising demand for organic foods, limited arable land for traditional agriculture, and growing popularity of disease-less environment in agriculture. Moreover, growing with aeroponics is rather simple and have benefits that outset any potential disadvantages (Barth, 2018). However, setting-up an aeroponics facility requires high amount of initial investment (even compared to hydroponics facility of the same size) hampering its market growth globally.

Aquaponics

Aquaponics is a combination of aquaculture, which is growing fish and other aquatic animals, and hydroponics, which is growing plants without soil. Aquaponics uses these two in a symbiotic combination in which plants are fed the aquatic animals' discharge or waste (North, 2016).

The global aquaponics market size was worth about $570 million in 2018. The NA market account for about the half (47%) of the global and almost the half belongs to the NA market (Research and Markets, 2020d). Aquaponics market is expected to grow by 15% CAGR from 2020 to 2025 and reach $2 billion. The main market driver has to do with aquaponics utilizing least aquatic space for husbandry of vegetables, which is of extreme importance in the view of limited and shrinking tillable land. What is more, organic produce acquired from aquaponics culture is free from any pesticides or fertilizers and hence suitable to satisfy the growing demand for organic food. As the global market is still undergoing expansion it is highly fragmented and the main strategies of emerging players are product launches and capacity expansion in order to secure a substantial share in the growing market.

In 2018 Europe was the regional market leader for aquaponics market due to the increasing demand for biological food. However, NA occupied the largest share in the aquaponics market, globally, in 2019. The US contributed the largest share in the region, followed by Canada. Currently, aquaponics is a small but rapidly growing industry in the region. In recent years, several educational and research institutions have created partnership with private companies and public authorities in order to raise the awareness about aquaponic farms. However, mass-scale production of aquaponic crops is yet to take form in the region.

UA Consulting Services

UA consulting services include assistance in designing and building farm infrastructures, developing integrated composting systems, training, software applications, design for edible landscaping and research support in local food systems analysis, etc. All these UA services are aimed for farmers, urban farming communities, organizations, SMEs, local authorities and individuals that are committed to sustainable urban development and to healthy lifestyle.

The UA consulting services can be used to empower impact-driven organizations to develop feasible urban farming solutions, turning their business ideas into sustainable business models. Companies involved in the UA consulting market offer wide range of services to their business customers such as:

- design and engineering of the urban farm project,
- economic analysis to find a viable economic model for the farm and thorough market analysis.
- business plan to assess project's readiness for investment and connection to investors,
- research and analysis on crops and growth,
- operational support and tools to run and manage the farm (software applications for control and management of production, data analysis and insights to improve efficiency),
- urban farming training, workshops and seminars.

UA consulting services can be also used by local authorities to support them in designing and running urban community farms that aim to achieve social goals and engagement of less privileged members of a society in urban farming activities. UA consulting companies can support the design and functioning of such farms as well as providing training and educational workshops to participants. Moreover, UA consulting services can be employed by health organizations and design care farming activities to engage elderly people in need for mental or physical health support.

4.1.2 UA end-user/customer segment

The total addressable market for urban farming is estimated to worth $233.5 billion in 2020 and it is expected to reach $289 billion by 2026.[12] As UA is used for many purposes such as producing fresh local food, utilizing cities' empty spaces and creating social ties among residents, the end-users and potential customers of UA can vary significantly across age, gender and even income especially during the last years when UA practices have become more and more available for the less endowed members of agricultural community. Hence, among the end-users of UA are home gardeners, rooftop growers, community farmers, commercial farmers, schools, universities, SMEs, other professionals, etc.

More specifically, for the SiEUGreen outputs customers and end-users may differ based on the type of UA exploitable output (concepts, solutions, software, etc.)**:**

[12] Total Addressable Market is the total market for the product. This is everyone in the world who could buy your product, regardless of the competition in the market.

Table 4: Customers/End-Users for SiEUGreen UA exploitable outputs

SiEUGreen UA solutions, concepts	Potential Customers/End-Users
Multiscale analysis framework on UA typologies	Various departments in municipalities (strategic planning, detailed planning and parks departments), UA practitioners and associations, Private sector urban developers can regenerate cities taking into account this typology, General public, Researchers involved in R&D in the field of UA technologies.
UA systems to empower disadvantaged communities (Hatay Showcase)	Municipalities, Disadvantaged community members (refugees), Women's Associations, Students (internships).
High Efficiency Aquaponic System	Framers for mass production of fish and vegetables, General public for entertainment, School-children for educational purpose.
Paper-based Microgreen Technique	Residents to grow vegetables and microgreens, for own consumption, Commercial growers & SMEs, sell to market.
Vegetable and Fruit Planter	Urban residents, balcony/home growers, for own consumption.
COMMURBAN App	Public authorities to engage residents in urban farming, Health, Social and Educational Organizations, to use it for care farming activities with the purpose to improve patients' mental health, social inclusion of disadvantaged people and for educational purposes, respectively, Farmers or residents to generate income or create their own food, respectively, by granting them access to the methods, tools, training information and urban techniques on the COMMURBAN App.

Integrated multiscale analysis framework on UA typologies: various departments in municipalities (strategic planning, detailed planning and parks departments) as this typology is especially useful for policymakers that lack instruments to assess the benefits and drawbacks of UA for the development of cities; UA practitioners and associations; private sector urban developers can regenerate cities taking into account this typology; the general public; academia and researchers involved in R&D in the field of UA technologies.

High Efficiency Aquaponic System: Growers and mass producers of vegetables and fish, general public for entertainment and educational purposes.

Paper-based Microgreen Technique: Residents to grow vegetables and microgreens in their balconies or rooftops for their own use or to sell them to companies in order to process them into soap and nutritious food and resell them. Commercial growers and SMEs.

Vegetable and Fruit Planter: urban residents to produce balcony vegetables and succulent plants and consume their own organic food.

COMMURBAN App: public authorities can use it to engage citizens in urban farming projects. Moreover, it is a tool for health, social and educational organizations to engage their stakeholders in care farming activities in order to strengthen their mental health, include underprivileged members in communities and for educational purposes, respectively. What is more, COMMURBAN can be used by general public or professional growers to create their own food and generate income, respectively, by providing them with access to a number of urban farming techniques, resources, tools, training material and consultancy on urban cultivation methods.

UA systems to empower disadvantaged communities (Hatay Showcase): Municipalities to engage underprivileged members of the community, to include of women and refugees in the labor force, to provide internships for students.

4.1.3 Competitive Landscape

In this section we conduct a detailed analysis of main competitors of the SiEUGreen UA commercially exploitable outputs on Global, European and Chinese level. Table 5 below provides a brief summary of major competitors for SiEUGreen urban farming solutions and consultancy.

Table 5: Major Competitors in urban farming solutions and consultancy market

Competitor	Geographical Coverage	Services/Solutions	Customers	Strengths	Weaknesses
Agritecture Consulting **(Est. 2014 in the US)**	NA, Central America and the Caribbean, Europe, the Middle East, China, New Zealand & Madagascar.	Digital platform for planning urban farms including: farm designs, economic and market analysis, workshops and courses, feasibility and due diligence services, etc.	Cities, governments, economic development groups, real estate developers, individual farmers and businesses.	• Data driven insights based on 100 completed and many years of urban farming experience. • Team Interdisciplinary experts (experienced growers, agri-engineers, marketing experts, etc.)	• Only consulting services

Urban Crop Solutions **(Est. 2014 in Belgium)**	25 plant factories in the US, Canada, Europe and Asia.	Fully automated container farms for small, mid and large scale production of wide range of crops. Indoor biological research and end to end consulting and support of customers.	Retail, restaurants, and food service, plant based medicine & nutraceuticals, universities & research institutes nurseries & floriculture.	• Variety of solutions depending on the scale of production (small, mid & large-scale). • Strong in house R&D capabilities and strategic partnerships with universities and companies to stay on the top of UA innovation.	• Limited spatial coverage. • No smart app software to collect and analyze UA data from the container farms.
Freight Farms **(Est. 2013 in the US)**	45 of the US States and 28 countries in Europe, Canada, Caribbean, UAE & Asia.	Container hydroponic farm (Greenery), software to control the farm & optimize operations (Farmhand). Complete farmer support and consulting service from the launch of the farm and training to on-site support visits, etc.	SMEs, corporates, education and Non-Governmental Organization (NGOs).	• Complete service support from the start of the farm that continuous with the ongoing service and consultation. • Farmhand, software to collect and analyze data and suggest best practices in order to optimize the operation of the container farm.	• Not identified
Intelligent Growth Solutions **(IGS)** **(Est. 2013 in the UK)**	Europe and the US	Designs and sells automatic controlled environment growth systems (Growth Towers).	Farmers & other growers, governments, farming	• Collaboration of IGS Crop Research Centre with the James Hutton Institute for indoor growing innovation.	• Limited spatial coverage

		Provides various indoor ecosystem growing solutions for farmers, governments and businesses.	entrepreneurs, pharmaceutical organizations, consumer food businesses.	• Fully automated indoor ecosystem (highly efficient, energy saving with the cutting edge AI and ML technology)	• No extended services provided
SpourtsIO **(Est. in the US)**	US	Automated indoor growing device (SproutsIO Smart Garden) and software to monitor and control the device.	General public, home growers or gardeners.	• Cutting edge fully automated device and software to control and manage it.	• Weak customer service support (provides only Frequently Asked Questions). • Operates only in the US
REFARMERS **(Est. in France)**	Europe	Offers consulting and R&D services in indoor and urban farming	corporates, entrepreneurs, investors and public organizations.	• End to end consulting service, from design until operation.	• Spatial coverage only across Europe.
Sanabio US **(Est. 2015 in China)**	US, Canada, Japan, China, S. Korea, Singapore, the UAE, the UK, Saudi Arabia & Germany	Vertical farming grow module (RADIX), complete package of consulting services and training.	Commercial farms (large, medium and small) and education.	• Strong in-house Research, Development and Innovation R&D&I. • Sanan Group parent company	• Not identified

				• Cutting-edge LED technology of sister company Sanan Opto • Start to finish consulting services • Vertical farm leader in China	
Integrated Multiscale Analysis Framework on UA Typologies (NORDREGIO, Sweden)	Potentially Europe and China	UA typology help to address the lack of instruments to assess the benefits and drawbacks of UA for the development of cities.	Municipalities, UA practitioners and associations, private sector developers, researchers and the general public	• Unique and useful tool for decision making planning and consulting for urban farming. • Head start in terms of demonstration (Aarhus showcase).	• Highly dependent on public funding. • Limited flexibility for application in other municipalities.
UA Systems to Empower Disadvantaged Communities (Hatay Metropolitan Municipality & SAMPAS, Turkey)	Potentially Europe and China	Training of refugees to operate greenhouses, inclusion of disadvantaged women in the workforce, access and enrichment of innovative UA technologies (e.g., aquaponics and hydroponics), production of organic food.	Municipalities, disadvantaged community members (refugees, poor citizens), women's associations, researchers and students.	• Demonstration of how UA activities can achieve social goals within local community (e.g., engaging refugees, support underprivileged women, production of high quality food, etc.).	• UA systems specifically created for the Hatay Showcase.

High Efficiency Aquaponic System (BAEISU & CAAS, China)	Potentially China and Europe	High efficiency aquaponic system for the integrated ecological fish-vegetable production with zero pollution and zero emissions in water. shortage area or around megacities.	Researchers, students, citizens, SMEs and local restaurants	• Can be used for mass production and agriculture entertainment. • As part of SiEUGreen project stands better chances to access European markets compared to competitors.	• Limited variety of plants produced.
Paper-based Microgreen Technique (BGVS, China)	Potentially China and Europe	Engage residents to cultivate vegetables and microgreens at home. Buy these vegetables from residents, in order to process them into soap and nutritious food and later sell them to the market.	Balcony gardeners, SMEs and general public.	• Demonstration in European showcase (Campus Ås) provides a head start in accessing European markets.	• Limited scale of production.
Vegetable & Fruit Planter (PHOTON, China)	Potentially China and Europe	Home growing device that allows urban residents to produce balcony vegetables and succulent plants and consume their own organic food.	Urban residents, balcony/home growers.	• Demonstrated at Chinese showcases of the SiEUGreen project gives an edge over its competitors both in Europe and China.	• Limited variety of vegetables and fruits that can be grown using the planter and also limited productive capacity.

COMMURBAN APP (DRAXIS ENVIRONMENTAL SA , Greece)	Potentially Europe and China	UA service, software (Mobile App) to engage residents in urban farming and raise awareness food security and resource efficiency.	Farmers, residents, public authorities, Health, Social & Educational Organizations.	• Appeals to a wide range of end-user & customers. • Greatly demonstrated through SiEUGreen Showcases.	• Not identified

Case Study: UF002 De Schilde a non-successful experiment [13]

Before providing a thorough examination of the competitive landscape by looking at successful companies in urban farming market and focusing on their market strategies and success, it is worth to consider an example of a company that has failed in this market and examine the causes that led to its failure.

In July 2018 one of the biggest European rooftop greenhouse projects called "UF002 De Schilde" went bankrupt.[14] This project was developed in the city of The Hague (Netherlands) in 2016 by a Swiss company named Urban Farmers AG. Despite the project being developed by experienced urban growers and despite the fact that the company had already piloted a similar rooftop greenhouse in Basel (Switzerland) the UF002 De Schilde project failed. The failure of this project is attributed to many factors but those factors that stand out are the following: important incoherencies in the strategy development, challenges in production techniques and internal management issues.

At the beginning, the model of the project looked strong enough to convince investors especially as the pilot in Basel was declared as quite successful. The greenhouse of the project was meant to produce tomatoes, leafy greens, eggplants peppers, and fish (tilapia species). Firstly, the company contacted local professionals (restaurants and canteens) in order to establish its B2B strategy in the local market but unfortunately this strategy did not work. More specifically, the company did not manage to differentiate its produce from the one existing in the local market. The business customers (restaurants, canteens, etc.) found the quality of the produce same as the existing in the market but significantly more expensive. Moreover, it was a common practice among those professional customers to store vegetables and fish in refrigerators for days. Hence, the main comparative advantages of the products grown in the rooftop greenhouse (meaning the freshness and taste) did not matter as the customers were not taking advantage of this.

[13] Source: The information for this case study was taken from Ancion et al., 2019.
[14] Source: Sijmonsma, 2018.

Thus, after the first unsuccessful attempt, the company changed its business model from business oriented (B2B) to consumer oriented one (B2C). More specifically, it diversified its offers through a set of services like guided tours to the greenhouse, training venue and direct selling of produce. However, due to a customer and competition misunderstanding this strategy was condemned to fail. Apparently, being located in one of the poorest neighborhoods in the Netherlands and selling high quality, high price products did not work. In addition, the company chose tomatoes as the main product overlooking the extremely high peri-urban competition in the Netherlands. Unlike the big cities like New York or Paris where local producers are far away from city consumers and do not constitute direct competition to urban farmers, small cities like The Hague have a lot of producers growing just around the corner and hence the competition is very high. Regarding the fish production, besides the fact that The Hague is located very close to the sea and has a large supply of fresh fish, Tilapia is a relatively unknown fish in Europe and hence not particularly demanded by the consumers.

On top of the aforementioned problems, there were also several production challenges that contributed greatly to the failure of this project. Although, the aquaponic system used in the project was an impressive innovation at the time it could not deliver high productivity targets especially compared to alternative techniques like hydroponics (almost three times higher yield). Moreover, the rooftop greenhouse used way too much energy compared to other conventional (on the ground) greenhouses and hence was not at all cost-effective.

Last but not least, there were serious disagreements among the team members of the project even before the construction was completed. The stakeholders could not agree on what strategy to follow resulting in the exit of many of the initial members and consequently to lower revenues that could not keep up with the extremely high cost of the project, eventually resulting in the bankruptcy of the company.

Lessons Learnt

- It is significant to try the pilot in the same environment (country/city, customers, etc.) as the project. Different countries even different cities may have major differences in elasticities of demand for specific products. Moreover, it is paramount to understand who are your customers and what do they want. Products and services that will be offered have to be in coherence with customers' needs and understanding.
- Understand well the competitive environment. In specific contexts, what is thought to be an indirect competition can turn out to be direct. Failing to understand what is

direct and what is indirect competition can have serious repercussions for the business development.

- It is crucial to check for the technical constraints beforehand. We have to make sure that the technique/system that is going to be used has already proven its performance in terms of yield (kg/m^2/year) and its cost-effectiveness.
- Business partners have to share the same long-term vision for the company. In addition, it is capital to avoid changing strategies too often and to have a common understanding of were the business is heading.

GLOBAL

Agritecture Consulting (US)[15]

Agritecture Consulting was founded in 2014 and is the global leader in UA planning services. The mission of Agritecture is to empower impact-driven organizations to develop feasible urban farming solutions, turning their business ideas into practical and sustainable projects. The vision is to create a world where commercial UA is economically feasible, reduces the environmental impact of the food system, and improves food security.

Services: Agritecture offers variety of services and solutions in UA, among other:

- Farm Design service: Providing initial concept development, farm layout designs, and 3D farm models to clients.
- Feasibility service: feasibility study provided before beginning the project construction. Design and engineering of the project, economic analysis to find a viable economic model for the farm, market research to identify market trends and preferences of local customers and finally select the appropriate site.
- Due Diligence service: the expert team of the company prepares the business plan and ensures that the project is ready for the investment based on the extensive industry experience and data.
- Research and Analysis: carbon footprint analysis, case study research, and market assessments are a common part of Agritecture's practice.

[15] Source: https://www.agritecture.com/

- Agritecture's Commercial Urban Farming Course: planning urban farms with real operational data and key insights from the interdisciplinary team of horticulturists, system engineers, and financial experts.

Markets: Agritecture has more than 120 projects in more than 50 cities in more than 25 countries. More specifically, Agritecture has so far covered NA, Central America and the Caribbean, the Middle East, China, Europe, New Zealand.

Customers: Agritecture advises cities, governments, economic development groups, real estate developers, individual farmers and businesses. Global audience of more than 100,000 followers and subscribers, one of the largest media presences in the industry. Most of the company's clients operate vertical farms, then greenhouses.

Hoffman Hayes (Canada)[16]

Hoffmann Hayes specializes in design consultation for UA, gardens, and healthy food & community development programs.

Services:

- Condo Garden Programs: offer input on the garden design and then guide the communities to grow food and run a community garden programs.
- Community engagement services: Mentoring aspiring entrepreneurs to start businesses; helping new farmers get to market; sharing seeds, design support, and other resources and to under-resourced groups and communities.
- Consulting & Design: strategic and master planning consultation; generating, improving and enhancing site designs; support the development of detailed plans.
- Farmer's market planning: help to create an innovative Farmers' Market that feeds and inspires the community.

Customers: businesses, institutions, and people who are planning, building and developing communities. Also provide services to real estate managers and property managers to design commercial foodscapes, community gardens, rooftop garden amenities, and other community and tenant engagement programs.

Markets: Canada

[16] Source: https://www.hoffmannhayes.com/

SproutsIO (US)[17]

The SproutsIO system integrates the high performance device with intuitive software controls, and comprehensive seed refills. SproutsIO enables its clients to cultivate a wide range of produce rapidly and efficiently.

Solutions:

- SproutsIO Smart Garden: high performance automated indoor growing device to grow herbs, microgreens, fruits and vegetables. SproutsIO utilizes machine learning (ML) technology and proprietary growing profiles to optimize for the seeds the client chooses and care for the plants automatically. This device collects 27 data points every 30 seconds, monitoring environmental conditions and plant health. It requires less than 2% of the water required by traditional growing methods.
- sIO seed refills: organic seeds, media, and nutrients. Client can choose from a wide range of leafy greens, herbs, fruiting plants, and root vegetables.

Services:

- SproutsIOGrow app: Software services enable the customer to participate in the growing process. The SproutsIOGrow mobile app keeps the customer connected to the garden from anywhere through intuitive controls, real-time sensor reports, and camera feed.

Market: SproutsIO mainly covers the US market but also ships overseas.

Customer: General public, home growers or gardeners.

Freight Farms (US)[18]

Freight Farms was incorporated in 2013 and it is now a world leading manufacturer of container farming technology (was first to introduce it) that works to empower anyone to grow food in their communities. The company is dedicated to making fresh food accessible to anyone, anywhere, any time with a complete platform of products and services.

Solutions:

[17] Source: https://www.sprouts.io/
[18] Source: https://www.freightfarms.com/

- **Greenery:** smart hydroponic farm inside of a shipping container. Greenery's plants grow vertically indoors without soil, getting their nutrition from water and light energy from powerful Light-Emitting Diodes (LEDs). The Greenery arrives preassembled all it is required is to connect the farm to water, electricity, and Wi-Fi, hang the plant panels, and calibrate the farm sensors and controller.
- **Farmhand:** is a complete software platform that allows hydroponic growers to remotely control farm components, automate tasks, and analyze growing data to make the most of their operation. Optimizes all growing variables based on the desired crop creating the perfect environment no matter where in the world.

Services: Company's service team provides complete farmer support including technical help, online/digital resources and also logistics support using the well-established shipping channels of the company, among other:

- **Launch the farm support**: service team ready to work closely in order to set-up the farm as soon as it arrives at the customer's site.
- **Certified farmer training:** at the Head Quarters (HQ) of Freight Farm, at customer's location and online training.
- **Ongoing service support:** On demand technical support, on-site support visits, data analysis and optimization of the farm.

Markets: 45 of the US States and 28 countries across five continents and in particular strong presence in Europe, Canada, Caribbean, UAE and Asia.

Customers: The type of clients/farmers ranges from SMEs, corporates, education and NGOs.

Innovation: In 2013, Freight Farms released the first hydroponic container farm into the market. Since then, it has innovated 8 different models, improving the system each time. Control of farming operations with cutting edge technology farm management software, farmhand.

Latest Developments:

To help farmers build the most sustainable businesses possible, the company has partnered with Arcadia–the only nationwide technology company focused on clean consumer energy–to provide easy and cost-effective access to solar and wind energy power.

Urban Farm Plans (US)[19]

Empowering individuals and communities to grow their own edible gardens and build productive urban farms by providing design services, infrastructure, consulting and workshops. Company's mission is to help others to incorporate some of urban farming practices into their own lives as well by teaching about urban farming and edible gardening as well as providing the ideas, skills, designs and infrastructure to utilize available land to best suit needs and desires of the clients.

Solutions: among other:

- MODEL C- SINGLE BIN COMPOST SYSTEM: single bin compost machine large enough to achieve thermophilic composting while fitting attractively in the urban farm.
- COMPOST KNOX: Designed to maximize composting efficiency scalability, and deployability, while still being extremely long lasting.
- RAISED BEDS: can increase the productivity of an urban farm by avoiding compaction, increasing soil temperatures, reducing weed pressure.
- Hoop houses: season extension, wind blockage, and moisture control are only some of the benefits provided by this simple yet powerful mini-greenhouse.

Services:

- On-site installation: Design, build, and install all of the infrastructure to successfully grow an urban farm or edible garden.
- Consulting: Customize solutions or guidance on how to get started from UA/compost and soil fertility experts.
- Workshops: Provide training on how to build UA infrastructure and tips on growing methods.

Markets: United States

Customers: UA practitioners and communities, home growers.

[19] Source: https://www.urbanfarmplans.com/

EUROPE

Urban Crop Solutions (Belgium)[20]

Founded in 2014 in Belgium, Urban Crop Solutions offers end-to-end solutions for Urban Indoor Vertical Farming. It designs, manufactures, and install automated Plant Factories that can scale and be customized to the needs of the business/clients. Urban Crop Solutions is Europe's largest automated hydroponic vertical farming company by production volume.

Solutions:

- FarmPRO: Productivity container farm that is fully equipped in stainless steel, with a hydroponic Nutrient Film Technique (NFT) gully irrigation system and with 2 automated crop-to-person carousels, resulting in the industry-leading labor efficiency. Features a growing surface of 68.6 square meters (m^2).
- FarmFLEX: Flexible container farm works with an ebb and flow irrigation system on growing benches and is fully equipped in stainless steel. It offers larger flexibility in crop mix and features a growing surface up to 55 m^2.
- ModuleX Plant Factory: can be configured between 2 to 64 Grow Modules, with each separate module allowing for an independent climate and nutrient system to grow mix of crops and be adaptable to the needs of client's customers.
- Large Scale Plant Factory: is custom engineered and constructed within an existing or new stand-alone building. It is a fully automated solution featuring a growing surface larger than 5,000 m^2. Suitable for production of leafy greens, herbs, microgreens, and medicinal plants.

Services: Company offers indoor biological research and consulting. The indoor plant scientists, with a combined more than 30 years of experience, created the ideal controlled environment for plants. Company serves customers with more than 200 plant growth recipes.

Moreover, Urban Crop provides end-to-end support to clients and helps them understand their objectives in order to set up a farm. It also conducts crop research, trials, gathers data and monitors plant growth and then presents the results and research conclusions to the

[20] Source: https://urbancropsolutions.com/

customers. Crop research is conducted for a wide range of applications and industries, ornamentals, pharmaceuticals, edible flowers, staple food and fruits.

Market: More than 25 plant factories in the US, Canada, Europe and Asia.

Customers: Urban Crop Solutions covers many applications and industries: retail, plant processing, restaurants, and food service. Also plant based medicine and nutraceuticals Universities and research institutes nurseries and floriculture.

Innovation: The Research Center of the company contains 10 state-of-the-art climate chambers, which can mimic any climate on earth. To test yields and improve plant growth recipes in commercial solutions that the company offers, it operates a full-scale container farms. Main activities of the research labs include crop variety screening, enhancing nutrient formulations, and perfecting plant cultivation techniques. Company has developed its own LED light technology, and continue the experiments to enhance plant response to LED light spectrum and intensity.

In order to stay on top of innovation company has created many partnerships and joint venture with various partners, leading agricultural research centers, major universities and businesses. For example:

- The **SpaceBakery Project** is a consortium with Puratos (global bakery and chocolate supply company) and Magics Instruments, Ghent University, The University of Hasselt and Flanders' Food to research whether people could bake bread from wheat grown on Mars.
- **Urban Health Farms** is a partnership between Urban Farms Capital and Urban Crop Solutions. Urban Crop Solutions do not operate their own farms but will provide the full technology solutions, whereas Urban Health Farms will operate and manage the farms. By 2022, Urban Health Farms aims to be the largest indoor farm operator in Europe.

Intelligent Growth Solutions (UK)[21]

Founded in 2013 in the United Kingdom – UK (Scotland), Intelligent Growth Solutions (henceforth, IGS) brings together many years of experience in UA and engineering to create an aggrotech business with a vision to revolutionize the indoor growing market. The company

[21] Source: https://www.intelligentgrowth.io/

is committed to continuous innovation and develops patented plug-and-play vertical farming technology systems which deliver consistently high-quality food produce onsite at a customer's location. IGS supplies the technology, infrastructure, training to set up and operate totally controlled environment vertical farms. Provide further data and software updates to support the successful production of crops time after time.

Technology:

- Growth Towers: An indoor ecosystem where plants (variety of herbs, brassicas and leafy greens, soft fruits, etc.) grow through automatically (manages light, temperature, relative humidity, water, nutrients and Carbon dioxide (CO_2) levels) generated and applied growth recipes. Internet of Things (IoT)-enabled remote monitoring, control of all systems and data collection. Smart growth using Machine Learning (ML) and Artificial Intelligence (AI) capabilities ensuring optimum data capture to identify repeatable crop algorithms. Moreover, this system provides 30-50% faster crop cycles of the highest quality by saving 50% on energy and 80% on labor.

Solutions: among other**:**

- For farmers: IGS systems can germinate and propagate an ever-widening range of early stage crops. High value crops such as leafy greens, salads and herbs grow especially well in IGS systems. Highly efficient lighting system reduces costs compared to other systems on the market.
- For Farming Entrepreneurs: IGS systems are modular, scalable and highly flexible (open ground or existing buildings). Hydroponic growth is supported to grow crops free of pesticides with efficient and minimal water usage.
- For Governments: Delivery of wide range of crops for local diets, all year round, in any location in the world in a sustainable (carbon neutral) self-sustaining (water recycling) and efficient way (less power needed).

Customers: Farmers, farming entrepreneurs, governments, pharmaceuticals, other food producers.

Markets: Europe and the US

Innovation: IGS collaborates closely with James Hutton Institute (world-renowned crop and plant science research facility) to help advance the understanding of plant science for indoor growing. A team of plant scientists works alongside the company's software and hardware

teams to ensure that customers can access the best and most up to date information which is tailored to their requirements of operation and growing.

Refarmers (France)[22]

REFARMERS is an international network of senior consultants with many years and hands on experience. REFARMERS offers consulting and R&D services in indoor and urban farming. The company has designed, built & operated a vertical hydroponic and aquaponic greenhouse, worked with dozens of urban farmers across Europe, with a variety of purpose: food production, education, social inclusion, biodiversity, waste-to-food recycling.

Services & Solutions:

- Urban Farming, among other:
  - Market Research Strategy: Helps clients to design business plans analyzing the urban farming market main business challenges and opportunities. Also provides consulting, training and workshops.
  - Feasibility study: Help customers to decide if the project is worth to take forward based on financial analysis of investment's operational costs and revenue forecasts.
  - Project Design and management: design of urban farming project from an urban planning perspective down to the individual farm project. Provide on-going support and reporting for the project (coordinate stakeholders, follow-up execution).
  - Corporate ventures: help clients to define the best strategy to enter the world of urban farming, whether through in-house innovation projects, strategic partnerships with start-ups, research institutes or other large-scale companies, the creation of an early-stage fund or an incubator.
- Indoor Farming, among other:
  - Custom design: engineers will design client's farm system. The company will choose technical solutions being mindful of initial costs as well operational expenses and define a layout that optimizes operational performance.

[22] Source: https://refarmers.co/

- Operational excellence: risk analysis with mitigation & resolution plan, standard operating procedures, compliance certification support: good manufacturing practices or good agricultural & collection practices.
- Due diligence: audit the target company, assessing their business model, technology, capabilities & processes, so the client can make an informed decision in this emerging industry.
- R&D programmes: design and conduct controlled-environment R&D programmes. For example: speed breeding or researching the impact of specific light spectra on active ingredients.

Markets: European countries.

Customers: corporates, entrepreneurs, investors and public organizations.

Veolia (France)[23]

Global conglomerate in optimized resource management. Veolia mainly provides water, waste and energy management solutions but it is also engaged in providing urban farming solutions. Based on a circular economy approach and its traditional business lines, Veolia is actively involved in various urban farming projects through its Fertile Cities projects:

Solutions: among other:

- Permaculture Project: a form of cultivation aimed at producing a large quantity of fruit and vegetables on a small plot of land using organic farming practices.
- Aquaponics: a form of cultivation combining fish and plants to recreate an ecosystem in an aquarium.
- Aquaculture: a form of aquatic agriculture that allows species such as fish to be raised.
- Veolia make use of its expertise in wastewater treatment to provide fertilizers, and irrigation.

Customers: Cities and municipalities.

Markets: Europe

[23] Source: https://www.veolia.com/en/solution/urban-farming-solution-helping-feed-cities/

CHINA (& Asia)

Sanabio U.S.[24]

Sananbio was created in 2015 by the Institute of Plant Research at the Chinese Academy of Sciences and the Fujian Sanan Group. Sananbio is the vertical farm leader in China with expertise in vertical farming construction and equipment considerations, plant science, photobiology, and the optimization of cultivation processes. Sanabio provides hardware and vertical farming solutions to farmers who want to innovate and companies looking to enter agriculture. The aim of the company is to empower a generation of modern farmers that understand food production must adopt more sustainable methods in order to protect the future generations. Sananbio grows more than 300 types of plants.

Solutions:

- RADIX: vertical farming grow module with fully-integrated electrical and plumbing, built-in patented LED lights with optimized spectrum to support plant growth at all life stages. Quick set-up and installation to grow crops like whole head lettuce, leafy greens, micro-greens, and culinary herbs.

Services: Teams of experts provide consulting among other on:

- Farm Design and Construction: team of experts in CEA works with clients from start to finish in designing and building their farms.
- Farm Operations and Management: corporate growers and engineering team work with clients to provide guidance from labor planning to harvesting schedules (crop selection, planning, and yield expectations.) and overall management support.
- Interactive Training: learning the ins and outs of running and managing an indoor vertical farm and how to build a RADIX grow system.

Markets: More than 50 indoor agricultural facilities in the US, Canada, Japan, South Korea, Singapore, the United Arab Emirates (UAE), the UK, Saudi Arabia and Germany use Sananbio facilities.

Customers: Commercial farms (large, medium and small), education.

[24] Source: https://www.sananbious.com/

Innovation: The company has a large innovation team of 38 scientists and another 100 R&D professionals, with deep expertise in photobiology, plant nutrition, and plant cultivation techniques. Moreover, Sanabio draws upon cutting-edge technology development (LED-technology of Sanan Opto)[25] of its parent company Sanan Group and its vertical integration that gives Sananbio competitive advantage and unmatched flexibility in the production capacity, global reach, and technological know-how.

Edible Garden City (Singapore)[26]

Edible Garden City was launched in 2012 with the ultimate objective of increasing Singapore's resilience and people's connection to food within the city. Edible Garden City is an urban farming consultancy company that aims to change the way people eat and live. The mission of the company is to promote the production and consumption of locally-grown fresh food instead of industrially-produced food shipped halfway across the globe. This company applies the circular economy principle to its urban farming model, meaning that the agricultural byproducts are composted and upcycled into fertilizer, which goes back into nourishing the soil and plants in order to grow the best quality produce with the least amount of resources and waste. Edible Garden City has received numerous awards and accolades.

Solutions & Services:

- Foodscape: Building and maintaining food gardens on city buildings for property developers and restaurants, schools, malls, offices and private residences. Tailored to the customer's needs and goals, the consultancy consists of building a holistic plan to design, build, maintain and manage the urban farm, besides providing the necessary support and tools for its financial viability.
- Education: Design and conducts farming workshops and tours for schools and companies around Singapore.
- Citizen Box: supply fresh produce (herbs, flowers and vegetables) grown and harvested at the company's urban farms in the heart of Singapore for customers (families, food industry and companies).
- Citizen Farm: sustainable farming model for the community of local farmers that produces fresh, tasty and nutritious harvests that are available to everyone living in the city.
- Care Farming (therapeutic horticulture): building gardens and creating programmes to guide participants in five aspects of holistic well-being: physical movement, social synergy, mental engagement, nutrition and knowledge and psychological well-being.

[25] With 470 PhDs and 502 engineers from all over the world, Sanan Opto possess the largest talent pool in the world dedicated to active research into LED technology.
[26] Source: https://www.ediblegardencity.com/

Customers: residents, families, school children, food operating companies, municipalities.

Markets: Singapore, China.

4.1.4 PESTELI Analysis

In this section we use PESTELI as an analytical tool that is applied to identify external factors which determine macro elements of the environments (mainly in China and Europe) within which the SiEUGreen UA commercially exploitable outputs will be positioned. The main factors for this analysis are summarized in

Table *6*.

Table 6: PESTELI analysis for UA

PESTELI	Relevant Factors	Projection
Political	No significant initiatives/policies targeting specifically UA in the EU. China set to develop indoor urban farming and become world leader in urban farming applications.	EU (Common Agricultural Policy - CAP) funds to reward urban farming with social or environmental goals. Counties will seek to ensure food security and self-sufficiency amid COVID-19 and trade wars.
Economic	Rebound of economic activity. Increased demand for organic products in EU and China.	Further growth of the UA market due to improved living standards of the middle class in China.
Social	Changing preferences in EU favor health, social inclusion, environment, hence boosting UA practices, consumption of organic food, social bonding through UA. Increase in health consciousness of the growing middle class of China. Aging of farmers coupled with rapid urbanization provides enormous opportunities for UA market growth in China.	Main trends in preferences are reinforced by the COVID-19 pandemic. UA as alternative solution to rapidly urbanized China as young people abandon the traditional farmer's lifestyle.
Technological	High-efficiency LED have increased enormously the productive capacity of indoor farms. Chinese Ministry of Agriculture has 40 research institutes working on indoor and vertical farming. China to develop partially automated indoor farms.	R&D to produce wide variety of UA products. Arrival of 5G networks to enhance smart urban farming, better communication of data for better farm management.

		Development of fully automated indoor farms run completely by AI and robots.
Environmental	Unfavorable weather conditions, droughts, floods, soil erosion that are resulted in decreased soil fertility and reduced tillable land both in EU and in China. Cultivated land in China represents just 40% of the world average. Tillable land in EU was 106.5 million hectares in 2017.	As tillable land is projected to dwindle both in China and in Europe the adoption of UA is expected to expand drastically. Overall the climate change will foster the adoption of indoor farming techniques to grow food locally.
Legal	UA can be affected by legislation such as land use, building, environment, and health codes as well as other regulating instruments (i.e., crop quality or purity standards). Overall, the regulatory framework of UA is not well developed in Europe and even less so in China.	It is expected that both China and EU will take significant steps to generate solid legislation framework in order to make use of unutilized spaces within cities for sustainable development and food production.
Institutional	International commitment to develop sustainable food systems "Milan Urban Food Policy Pact" (211 cities and 350 million people). On the European and Chinese level there is no specific institutional framework for UA. In EU, UA is considered neglected by CAP (2014-2020) because it does not fall under Pillar I or II.	However, the new CAP (2021-2027) aligns the EU Green Deal with sustainable agriculture that can be achieved through UA practice. EU's "From Farm to Fork" strategy aims to reduce environmental damage and support organically produce food. Urban farming that promotes the idea of sustainable and organic agriculture and it is aligned with the EU environmental targets is expected to thrive in the near future.

Political

In the EU, the European Agricultural Fund for rural development has created positive spillover effects for UA during the programming period 2014-2020. More specifically, the fund has financed policies with specific relevance for young farmers to foster innovative farm technologies, small farms and short food supply chains and shift agriculture to low-carbon economic paradigm. However, the measures of the programming period have not explicitly targeted and promoted UA (McEldowney, 2017).[27] Nevertheless, due to unfavorable

[27] See also https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/rural-development_en.

environmental developments and the rising demand for organic food, the EU is expected to focus its actions on UA in the context of its new Green Deal, in order to meet the objectives of sustainable development in the EU area. To this end, by 2030, 25% of EU farmland will be farmed organically, with the help of the EU Farm to Fork Strategy (European Union Commission, 2020b).

In China the population is projected to reach 1.5 billion in 2030 with 80% living in cities by 2050. Hence, without no doubt there is an urgent need for urban farming to enhance food security and safety. Indeed, China invests its efforts in developing indoor vertical farming systems to feed its burgeoning urban population. In the context of its long term planning, China seeks to become a world leader in urban farming applications.

On a global scale, the political stability is threatened by the recent trade war between China and the US. This trade war which started well before the current pandemic has increased the concerns over food security and self-sufficiency within countries. Undoubtedly, these concerns have been reinforced by the COVID-19 crisis, as countries have become more aware of dangers related to the international supply chain of food. Hence, in the years to come we can expect countries to follow policies in the direction of re-nationalizing agricultural production in order to ensure food security and self-sufficiency within their borders. However, given the climate conditions, availability of land and soil fertility various countries will not be able to produce enough agricultural produce to feed their own populations. In such circumstances, urban farming is expected to thrive and grow rapidly across the entire world.

Economic

Although the global economy shrunk by 4.3% in 2020, the worldwide monetary and fiscal expansion followed by numerous governments in response to the COVID-19 crisis is expected to rebound the global economic activity in 2021. More specifically, the World Bank predicts global economic expansion of nearly 4% amid vaccine deployment in 2021.[28] More specifically, China is expected to grow by 7.9% while the EU is anticipated to grow by 3.6% in the same year. The forthcoming economic recovery is expected to have a positive effect on the

[28] Source: World Bank Press Release on 5 January 2021, available at: <https://www.worldbank.org/en/news/press-release/2021/01/05/global-economy-to-expand-by-4-percent-in-2021-vaccine-deployment-and-investment-key-to-sustaining-the-recovery>.

development of UA owing to the increasing demand for organic food that is expected to surge due to the rising awareness of health during the ongoing coronavirus pandemic.

Social

Although the consumption of organic food is not something new in Europe, during the last years there is an unprecedented surge in demand for organically produced food. More specifically, in 2017 the consumption in Europe accounted for 37% of the global market of organic food and drink (European Commission, 2019). The changing preferences of consumers follow the overall shift towards a healthier and environmentally friendly lifestyle that has been observed in Europe during the last decades. Furthermore, it is observed that people are more willing to be engaged in social bonding, community building and ecological activities where urban farming finds a lot of applications such as community gardens, leisure farms, non-profit urban farms, etc. What is more, after months of austere lockdowns throughout the world people are expected to be more inclined to participate in the social bonding initiatives involving urban farming.

Regarding China in the last years it has been observed a significant shift of consumers towards organically produced food. The main reason is that urbanization has increased the living standards of a growing middle-class and this in turn, has resulted in the increasing health consciousness of population. This trend is expected to be reinforced by the current pandemic crisis not only in China but also in the rest of the world as people are expected to become even more concerned about their health and wellbeing.

Moreover, on the supply side due to rapid urbanization China is facing an aging of farmers as 60% of them are over 50 years old. What is more, the young people that prefer the life in the cities are reluctant to work the land and become farmers in the countryside. Hence, there is a shortage of farmers engaged in conventional farming. This creates a lucrative opportunity for urban farming to expand as farmers are moving into cities abandoning traditional farmers' lifestyle.

Technological

The R&D&I of the LED technology have significantly increased the production possibility frontier of indoor farming. The LED innovations are cost effective as they are estimated to decrease energy lighting costs by 50%. Furthermore, it is expected further innovations in the near future will increase the variety of crops that can be produced in controlled environments and can boost the popularity of urban farming one step further.

The Chinese Ministry of Agriculture possesses more than 40 research institutes working on aspects of indoor and vertical farming (Thorpe, 2017). Various climate control technologies being developed as hydroponics, LED lighting, heat pumps and the active heat storage to achieve production targets in various temperatures because of climate variabilities in China. As an essential feature in the future, China also plans to develop partly-automated indoor farming as a response to its aforementioned aging farming population.

Finally, the arrival of 5G networks (that is the fifth generation technology standard for broadband cellular networks) will encourage the development of smart urban farming by supporting the communication between data from the field and smart devices used for farm management. It will enhance significantly the ability to make faster and better decisions for precision farming. Moreover, it will make easier to develop and operate partially or fully automated indoor farms that can be run entirely by AI and robots.

Environmental

Unfavorable weather conditions such as droughts, floods, soil erosion coupled with the overuse of chemical fertilizers have substantially shrunk the size of tillable land and reduced soil fertility all over the world. These changing climate conditions are the main drivers behind the market growth of urban farming.

China's agricultural land is diminishing due to natural disasters and poor land management at a shocking rate of 300 square km/year. Cultivated land is down to only 0.08 hectare/person, nationwide, a figure which is just 40% of the world average. These facts coupled with the large-scale climate variability in the country are expected to foster the growth of urban indoor farming in China in the near future.

The projection for the EU shows that the amount of arable land is expected to decline up to 2030, continuing the long-term path of the past. More specifically, according to the European Commission (2017) the tillable land was 106.5 million hectares in 2017 and it is projected to be 104 million hectares by 2030. This declining tendency of cultivable land is mainly attributed to increasing urbanization in Europe and other artificial land development (e.g., transport, infrastructures, and construction sites).

All these facts advocate the need to move towards a different agricultural model both in the EU and China. Moreover, as environmental and climate predictions are not very promising for the coming years we can expect lucrative opportunities for the development of urban farming as it is the best alternative solution to conventional farming.

Legal

UA is regulated through a variety of laws, rules, regulations, and programs. Legislation affecting UA includes land use, building, environment, and health codes. Enforcement of the laws falls under the jurisdiction of local governments. National governments are responsible for introducing and enforcing environmental and health regulations and laws. In addition, international codes, on which many national and local codes are based on are other less obvious regulating instruments that can set crop quality or purity standards. For example, in 2010 the European Commission introduced the EU organic logo to protect consumer (easier to identify organic products) and support farmers to market their organic produce across the EU. To carry the logo products must fulfill strict set of conditions on how they are produced, processed, stored and transported.

In the last two decades China has put in place policies (like National General Land Use Planning, Basic Farmland Protection Regulation) for land-centered urban development to control the rapid urbanization and fragmentation of the farmland (Cheng et al., 2015). These policies have resulted in unsustainable urbanization with increased food insecurity and widespread degradation of agricultural land. In 2014, China by implementing the New Urbanization Plan 2014-2020 made the transition from land-centered to people-centered urban development. Although, the new policy resolved some of the past issues it has not delivered yet sustainable urbanization results including sustainable UA. In China there is some form of unregulated UA practiced by residents that capitalized on unutilized land (wasted spaces). However, in some regions like Jiangsu Province growing food within public green spaces in residential neighborhoods is prohibited since 2013 (Si and Scott, 2016).

All in all, we can say that the regulatory framework of UA is not well developed in Europe and even less so in China. Most of agricultural laws and rules affect but do not directly target urban farming activities. However, in order to support the expansion of urban farming it is capital to have a solid legislation framework for urban farming in order to support its sustainable development within cities. Local authorities must clearly define the land use codes in order to avoid circumstances where city ordinances have barred certain UA activities such as urban gardening and utilization of unused spaces. Hopefully, local authorities in the EU member states have already started the process of defining the use of land within their cities so it becomes clear which areas can be or cannot be used for urban farming practices.

Institutional

In the absence of a general institutional framework for urban farming in Europe and the rest of the world, public authorities of more than 100 cities around the globe signed the Milan Urban Food Policy Pact in 2015. This pact is the first international agreement/commitment to "develop sustainable food systems that are inclusive, resilient, safe and diverse, that provide healthy and affordable food to all people in a human rights-based framework, that minimize waste and conserve biodiversity while adapting to and mitigating impacts of climate change".[29] Nowadays, more than 210 cities and a population of 350 million inhabitants have joined this pact fostering the city to city cooperation and exchanging best practices for sustainable UA.

On the European (and Chinese) level there is no specific institutional framework for UA which has been considered neglected by the previous European CAP period (2014-2020). The main reasons for this is that urban farms are usually small scale and not concentrated in one place to be covered by Pillar I (that is direct payments) of the CAP and they are located within cities which keep them out of funding under Pillar II – support for rural development - (Piorr et al. 2018).[30]

In the new programming period (2021-2027) of the CAP the European Commission aligns its Green Deal with sustainable agriculture that can be achieved through UA practice. The "From Farm to Fork" strategy aims to reduce environmental damage and support organically produce food using less (or no) pesticides and chemical fertilizers, less nutrients and water (European Union Commission, 2020b). Urban farming promotes the idea of sustainable agriculture and it is aligned with environmental targets of circular economy Action Plan and the European Green Deal.

4.1.5 SWOT Analysis

In this section we present the SWOT analysis for the SiEUGreen UA commercially exploitable outputs indicated in Table 4. More specifically, we analyze the internal strengths and

[29] Source: Milan Urban Food Policy Pact website: <https://www.milanurbanfoodpolicypact.org/>.
[30] Pillar I concerns direct payments and market measures. Pillar II aims to support growth in rural areas through economic and social schemes. Source: <https://www.agriland.ie/farming-news/cap-what-is-different-and-what-remains-the-same-under-pillar-i-and-pillar-ii/>.

weaknesses of each SiEUGreen UA commercially exploitable output separately. Then we describe the common external threats and opportunities for the SiEUGreen UA outputs, summarized in Figure 4 below.

Internal Strengths & Weaknesses

Integrated Multiscale Analysis Framework on UA Typologies

Strengths: The UA typology appears to be a unique and useful tool for decision making, planning and consulting for urban farming. It can support policymakers that lack instruments to assess advantages and drawbacks of UA for the development of cities and integrated urban planning. More specifically, the typology can potentially help to achieve particular goals, such as strengthen the green infrastructure, improve public health, boost social inclusion and bonding, embellish public areas (parks, gardens, districts) and improve the local economy through the consumption of local goods. Furthermore, the Aarhus showcase represents another strength for UA typology as it lays out its utility for the local authorities in an optimal manner.

Weaknesses: Limited flexibility in application of UA typologies for policymakers from other municipalities, as it might be too specific to be used by other locations. Generating a sustainable business model needs to take into consideration, that the development of the UA typology was publicly financed (through the SiEUGreen project) and that it will be made available as published free access data.

UA Systems to Empower Disadvantaged Communities (Hatay Showcase)

Strengths: The internal strength of the UA activities employed in Hatay Showcase is the ability to demonstrate how these activities can achieve to enhance social cohesion and boost social inclusion in a local community and simultaneously accomplish other important goals. First, engaging refugees in UA practices and training them to operate greenhouses. Second, help underprivileged women to join the workforce through practicing UA (growing vegetables, flowers, etc.). Third, production of high quality fresh and organic food with the minimum use of resources, more specifically, 90% less water consumption, use of renewable energy and no use of common pesticides or fertilizers. Fourth, practicing new innovative UA methods and techniques such as aquaponics and hydroponics.

Weaknesses: The main weakness of UA systems to empower disadvantaged communities is that it is specifically created for the Hatay showcase and might not necessarily achieve all its

advantages and goals in other municipalities and under the operation of other local authorities.

High Efficiency Aquaponic System

Strengths: The strength of the high efficiency aquaponic system is that it can hit two birds with one stone, as it can be used in mass production of vegetables and fish and at the same time for entertainment and recreational purposes as it is demonstrated in two Beijing showcases, Pinggu and Sanyuan, respectively. Another major strength stems from the SiEUGreen partnership itself. Being part of a partnership between the EU and China, the high efficiency aquaponic system has potentially better chances to penetrate both markets compared to its Chinese competitors, especially, at showcase locations.

Weaknesses: Limited variety of plants (lettuce, rape and celery) that can be produced using this aquaponic system, limiting its potential growth and adoption in China.

Paper-based Microgreen Technique

Strengths: The strength of this innovative technique developed by BGVS is its demonstration in the Norwegian showcase, which can potentially serve as an entry point to the European market. What is more, the SiEUGreen project provides an opportunity for the inventor (BGVS) of the paper-based microgreen technique to expand its market share in China.

Weaknesses: Quite limited scale of production.

Vegetable and Fruit Planter

Strengths: Being demonstrated at the Chinese showcases of the SiEUGreen project gives this device a small edge compared to similar appliances in Europe and especially in China.

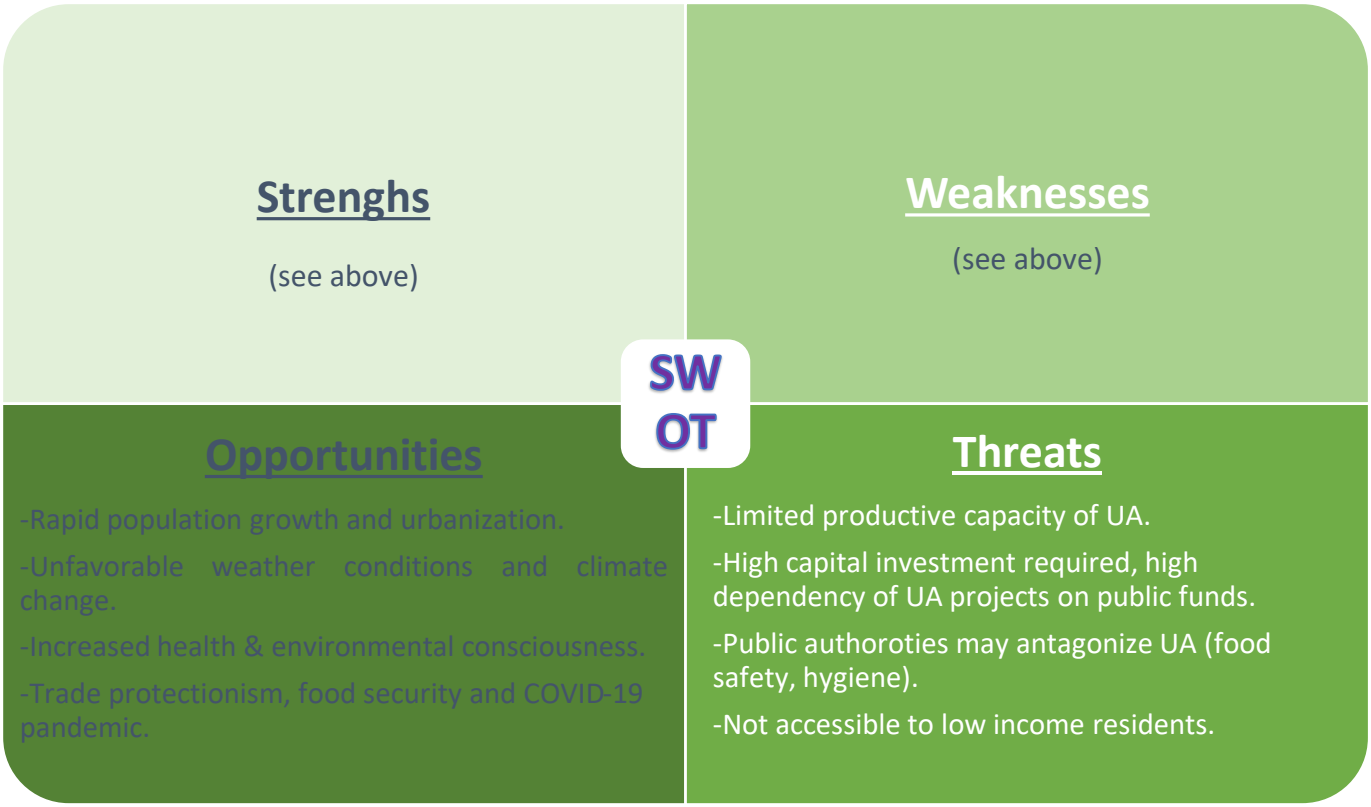
Weaknesses: Limited variety of vegetables and fruits that can be grown using the planter and also limited productive capacity. Moreover, the appliance still remains at the promotion and demonstration stage.

COMMURBAN App

Strengths: COMMURBAN is an DIY app and may potentially appeal to a wider range of users than it is today. The list of end-users may potentially include public authorities (engaging residents in urban farming), health organizations (care farming for patients), small farmers, balcony gardeners, educational care services (socially excluded community members), etc.

Weaknesses: The mobile app has not yet been widely promoted. There are many apps available that may not be doing the same thing, but similar, so there is high supply for the respective demand. Moreover, the app is not yet fully adopted and promoted by the partners mainly due to the COVID-19 pandemic and the cancelation of all the public events that were planned on each showcase to promote the adoption and use of the app.

Figure 4: SWOT Analysis for SiEUGreen UA commercially exploitable outputs.



External Opportunities and Market Trends

The main trends and opportunities for the development of UA and hence the use of the SiEUGreen UA marketable outputs are:

1. Rapid population growth and fast urbanization;
2. Increase in health and environmental awareness of people;
3. Environmental degradation
4. The current coronavirus pandemic.

Over the last decades, tillable land has shrunk substantially on a global scale as a result of the unfavorable weather conditions like droughts, floods, soil erosion, etc. Moreover, the excessive use of chemical fertilizers in agriculture production to feed the rapidly grown

population of developing and underdeveloped countries (in Asia, LA and Africa) has severely affected the fertility of soil. What is more, there are rising concerns over food security and food safety in the highly urbanized cities. All these trends constitute a lucrative growth opportunity for UA market on a global scale. UA can serve as an optimal method to achieve urban sustainability, food security and make urban life more friendly for its citizens and the environment. Besides providing fresh food to urban areas, UA is a source of significant environmental, social and health-related benefits as well as economic development opportunities.

Another major trend that has been observed over the last decade is the increase in social environmental and health consciousness of people mainly in developed but also in some developing countries. Now more than ever, as a result of better education, information and transparency a growing number of people worldwide is interested in sustainable methods of food production. Also, more people demand fresh food that can be produced locally with the minimum amount of resources and without the use of chemical fertilizers or pesticides. This rising awareness about health and environment provides a great opportunity for the UA market. To fulfill their healthy and environmentally friendly lifestyle people can use UA to produce their own organic food (balcony, roof gardening) using less resources; to participate in social bonding activities (community-based farms) and protect the environment by consuming locally produced food.

Finally, the current coronavirus pandemic has been a major worry for farmers around the world, threatening access to agricultural labor (seasonal workers from other countries) and creating major disruptions to international supply chains. The pandemic has prompted a spike in interest for urban farming where the production requires less labor and can be done in a more efficient and cost effective manner. What is more, the current pandemic has highlighted the risks of relying on produce grown far away from where it is consumed. The fragility embedded in the international supply chain of food have raised many concerns over food self-sufficiency and food security. It is expected that re-nationalizing agricultural production and growing food locally is going to be a major priority for several countries around the world. However, even if countries will choose this path they will face the following problems: excessive demand in the absence of imports and limited possibilities for conventional crop production (scarcity of land and labor, machines, etc.). In order to address these problems countries will seek smart solutions such as UA to guarantee food security and reduce transportation costs.

Considering the force and isolation due to COVID-19, strengthening food production and distribution systems is key to ensure global food security and meet the increasing demands for food. The development of urban farming embraces all dimensions of food security and hence can serve not only as an ideal alternative solution to conventional crop production, but also can make a lot of people to rethink how they want to grow food from now on. These developments and the post COVID-19 era will most likely bring about potential upside to UA market.

External Threats and Market Barriers

First and foremost, there are several economic issues that constrain the general UA market development. The high capital investment arising from the retro-fitting of buildings and other investments required to practice urban farming might hamper its market growth. In addition, according to the report on UA in Europe (McEldowney, 2017) most of the UA projects are funded and sustained on public funds, initiatives and volunteer work rather than revenues from food selling. Hence, some UA projects due to the high dependency on public funds do not continue beyond the horizon of public contribution and hence do not develop into self-sustained businesses. However, we have to take into account that although, this can be the case for UA projects with a strong non-commercial aspects and social targets (e.g., Taste Aarhus) it is not necessarily true for high-tech projects that are profit oriented (e.g., indoor vegetable production ventures).

Furthermore, the productive capacity of urban farms is still quite limited compared to the conventional mass agricultural production. The significant efforts to increase the productive capacity of UA are not yet sufficient to contribute adequately to food security (ability to access food) within cities. Hence, it is not yet possible to rely entirely on UA produce –perhaps it would be in the future- in order to feed the rapidly growing urban populations.

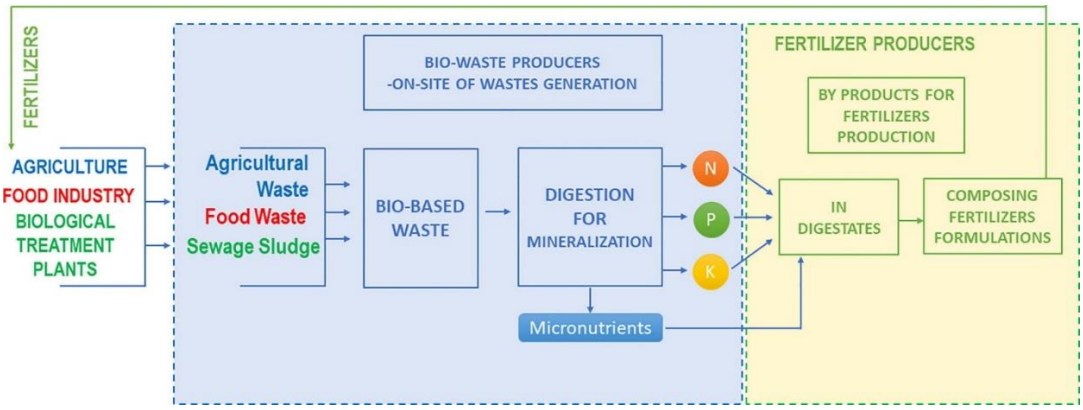
Moreover, UA activities and their products may not be available both on demand and supply side for certain underprivileged segments of urban populations. On the demand side, low income inhabitants are price sensitive and cannot afford the high prices of urban farming produce (organic food). On the supply side, low income residents do not necessary have the time, training or the proper resources to be engaged in safe food production through UA. These reasons can significantly constrain the spread of UA across less developed cities throughout the world. The local authorities have several reasons to be against UA, slowing the spread of the UA practices across those cities. The lack of hygiene, lack of safe production of

food and acceleration of communicable diseases are the main reasons for municipal officials to antagonize UA (White and Hamm, 2017).

4.2 Bio-Fertilizers (BFs) Market

During the last 25 years, agriculture has been progressively moving towards new paradigms of sustainability and ecological efficiency. The technological and scientific breakthrough obtained in recent years have revolutionized practically all phases of the production and distribution chain of agricultural products. New range of products known as bio fertilizers (BFs) are leading the evolution of biotechnological applications aimed at improving the efficiency of crops.

Figure 5: BFs production process.



Source: *The graph is taken from Chojnacka, et al., (2020).*

BFs are produced from the nutrient-rich side-streams, sewage sludge and organic (human and food) waste (see, Figure 5), among other.[31] The BFs have gained more popularity due to the increasing demand for organic fruits and vegetables and the growing focus of governments worldwide to reduce agriculture's growing carbon footprint and make it more sustainable. They have proved to be beneficial in many ways, by improving the quality, shelf-life and yield of fruits and vegetables. Moreover, the use of BFs minimizes the environmental impact in contrast to common fertilizers (mineral phosphate and nitrogen fertilizers) the production of which is highly energy-consuming, causing greenhouse gas emissions (University of Amsterdam, 2019).

[31] BFs are defined "as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil" (European Biomass Industry Association, 2020).

Furthermore, the large-scale use of chemical fertilizers in modern agriculture - to enhance crop production and meet the nutritional needs of a growing global population - has caused soil degradation and had a severe impact on soil fertility. On top of this, the use of chemical fertilizers significantly increased air and waterway pollution. As pressure on food production and crop yields increase in the midst of progressively worsening climate change conditions, there is an even greater urgency to adopt the BFs in order to restore the fertility of the soil and make farming more resilient and efficient in an eco-friendly manner. BFs are low cost, effective, environmental friendly and renewable source of plant nutrients to supplement or replace common fertilizers. In Table 7 we present the main advantages and disadvantages from the use of BFs.

Table 7: Advantages vs Disadvantages of BFs

ADVANTAGES	DISADVANTAGES
1. high yields of crops 2. cost effective 3. enriching the soil with nutrients and useful microorganisms 4. replace the chemical fertilizers 5. eco-friendly protecting the environment against pollutants 6. destroy harmful components from the soil which cause diseases in plants	1. lower nutrient density, larger amounts required to be applied 2. employs different machinery than chemical fertilizers 3. difficult to store 4. plant specific 5. requires skilled labor 6. inadequate information about the use and benefits of BFs in farmers

Source: *European Biomass Industry Association, 2020.*

4.2.1 Global Market Insights

The BFs market size is estimated to be valued at $2.3 billion in 2020 and it is expected to reach $3.98 billion by 2025, recording a CAGR of 11.6% during the forecast period (Market and Markets, 2020). The market is driven primarily by the increasing organic farmland as well as the rising acceptance of BFs among farmers in developed countries. Another important factor behind the growth of BFs market is the increasing consumption of organic food. Consumers, are becoming highly concerned about food safety issues, the rising residue levels in food, and environmental issues, due to the rising concerns about their health. This rise in awareness of health and wellbeing has induced them to prefer chemical-free food products. On top of this the global outbreak of COVID19 pandemic has raised the awareness of the general public about the organic food consumption and hence it is expected to boost the growth of BFs market. These factors have already increased organic retail sales in many countries, such as China, Denmark, Germany, Switzerland and the US.

The demand for fertilizers is expected to pick-up as consequence of rapid population growth in APAC countries - the largest consumers of commonly used fertilizers. However, as it is well known the extensive use of chemical fertilizers causes pollution and contamination of soil and brings about negative effects on human health. Governments in their effort to fight this situation are implementing favorable regulations and incentive to adopt the eco-friendly BFs. The Market and Markets (2020) report shows that the APAC BFs market is forecasted to have significant growth during the 2020-2027 period. In addition, it is anticipated that emerging economies of this region with large farming land areas such as China and India will offer the most profitable opportunities and will be the leading players in the BFs market.

NA is projected to witness potential growth in the BFs market during the period up to 2027 (Markets and Markets, 2020). Stricter regulations on the use of chemical fertilizers in agriculture, due to environmental concerns and the rise of organic food popularity and production (organic farms), are among the most significant factors behind the projected growth of the NA market. According to the United States Department of Agriculture (2020) the demand for organic goods has shown an impressive double digit growth over a period of 30 years. This has boosted the supply side of organically grown products and incentivized farmers to produce organic goods. In 2019 according to the National Agriculture Statistics Service (NASS, 2020) the number of certified organic farms in the US were 16,585 a 17% increase since 2016 that accounted for 5.50 million certified acres (or approximately 2.23 million hectares).

EUROPE

In Europe the intensification of the agriculture activity over the past century has contributed significantly in the degradation of soil quality and undermined the sustainability of the farming sector. More specifically, the wide-spread use of mineral fertilizers increased the concentration of the key nutrients (i.e., nitrogen and phosphorus) to levels that significantly exceed the capacity of soil to absorb them. In 2012, it was reported that 45% of the soils experienced infertility due to severe organic carbon deficits (JRC, 2012). To improve the quality of soil, governments of several countries in Europe has designed various policies against the use of common fertilizers and in support of organic farming.

The European BFs market is expected to register a CAGR of 7.7%, during the forecast period 2020-2025 (Mordor Intelligence, 2019a). The EU Circular Economy Action Plan and the general direction of policies towards the transition to a circular economy are creating positive environment to maintain a steady growth in the European BFs market (European Union

Commission, 2020a). Governments of many countries have already designed various policies in support of sustainable organic farming and against the sporadic utilization of chemical fertilizer. Removing barriers in legislation that prevent the development of the BFs market, providing incentives (i.e., subsidies) and pursuing a range of initiatives to increase organic agriculture through the number of organic support programs are some among other measures that can enable farmers to adopt organic farming practices. For instance, in 2018 and 2019 the Denmark Government spent $147 million to support organic farming and more specifically to increase the number of farmers opting to produce organic as they are one of the world's largest consumers of organic products (Forencis Research, 2020).

This favorable regulatory environment makes Europe the region with the highest demand for BFs. The consumption of the European market is concentrated between Germany, Italy, France, the United Kingdom, and Spain, as these account for more than 60% of the market's share. Organic farming has seen impressive developments in those countries over the last years. For example, the land under organic farming has increased in Germany by more than 20% only between 2014 and 2016 (Mordor Intelligence, 2019a). The rapidly increasing interest of farmers in growing organic products advocates great potential for the BFs' market.[32]

CHINA

The Chinese market is projected to grow at a CAGR of 3.5% during the forecasted period 2020-2025 (Mordor Intelligence Report, 2019b). In 2019 China accounted for 43.2% of the biofertilizers market share for the Asia-Pacific region (Research and Markets, 2020c). China's BF market has undergone tremendous changes and showed promising opportunities and rapid development over the last few years. The Chinese Ministry of Agriculture has invested in the R&D of biotechnology and its application in ecological agriculture for green food production system and the promotion of biological fertilizers. Moreover, the Ministry has introduced in 2015 the "Zero Growth Policy of Pesticides and Fertilizers by 2020" to achieve sustainable agricultural development (Jin and Zhou, 2018). The organic area under cultivation has grown about 40% only between 2016 and 2018 and reached 3.13 million hectares in 2018. However, this goal is yet to be achieved as country must reduce the use of chemical fertilizers by at least 21.80 million tons (He et al, 2020). According to the Mordor Intelligence Report

[32] The European Consortium of the Organic-Based Fertilizer Industry was founded in 2014 to promote the contribution of the organic based fertilizers for environmentally friendly and sustainable organic farming growth (see, ECOFI: http://www.ecofi.info/).

(2019b) with government policies supporting the growth of BFs in the country, the demand for BFs is expected to grow during the forecast period.

Furthermore, to support the regional development of BFs, many Chinese companies across the country have come to a common platform such as China Biofertilizer Industry Development Forum organized by National Microbial Fertilizer Technology Research and Promotion Center to share and introduced the latest research results.

4.2.2 BFs end-user/customer segments

Total addressable market of BFs is estimated to be $2.3 billion in 2020 and it is expected to reach $3.98 billion by 2025. As BFs are used on a global scale nowadays, customers can differ across age, gender and income. However, as BFs require skilled labor and some training in order to be used properly customers need to have a certain educational level and training to handle the BFs. The demand of the customers can be influenced by many factors such as increasing awareness for ecological damage imposed by the use of chemical fertilizers, sustainable agriculture and the transition towards a circular economy.

Potential customers for GREENergy BFs have been identified by the partners in the Deliverable 5.4 Sustainability and Exploitation Plan.

- Municipalities that are interested in turnkey green and sustainable solutions in order to apply the innovative GREENergy concept in their city districts. Municipalities can use the produced BFs to enlarge urban green spaces, support local food producers, maintain parks and urban community gardens.
- Residents can use them in home/balcony gardening and be engaged in small food production for their own consumption.
- Flower companies, local farmers and gardeners can use BFs for private commercial purposes.

Customer relationships can be done via direct interaction, personal contact and assistance in urban communities. Moreover, cooperation and training is another way to approach potential customers. In addition, customer channels and dissemination of BFs can be supported by the existing partners, social media, SiEUGreen website, etc.

4.2.3 Competitive Landscape

In this section we conduct a detailed analysis of main competitors on Global, European and Chinese level. Table 8 below provides a brief summary of major competitors for GREENergy BFs.

Table 8: **Major Competitors in BFs market**

Competitor	Geographical Coverage	Outputs/Services	Customers	Strengths	Weaknesses
NOVOZYMES A/S **(Danish-based company est. in 1921)**	Europe, NA, LA, APAC Middle East & Africa	Enzymes & microorganisms used in biocontrol and bioyield enhancement, or to produce BFs.	Farmers, Beverage & Food industry, other industries.	• strategic alliances • global leader in biological solutions • close proximity to customers	• The company is not solely focused on BFs production due to the variety of products and operations.
RIZOBACTER S.A. **(Argentina, est. 1977)**	Africa, Europe, LA & NA 30 countries 9 subsidiaries	BFs for organic agriculture of wheat, corn and sunflower seeds.	Farmers	• 30% of profits invested in R&D • its plant growth promoting rhizobacteria • strategic alliances	• BFs for limited range of crops.
T STANES & COMPANY Ltd **(India, est. 1861)**	APAC, Africa, Europe, NA & LA 32 countries	BFs containing phosphate potash, sulphur, BFs for atmospheric nitrogen fixation, testing services.	Farmers	• dominant position in the global market • variety of BFs products covering wide range of crops	• Lack of strategic alliances.

KIWA BIOTECH (China)	Mainland China	BFs, soil testing services for customers, customized fertilization plans	Farmers	• BFs applied to all kind of crops • after sale services • cooperation agreement (selling channel)	• Limited spatial coverage
SYMBORG (Spain, est. 2009)	Europe, the US, LA & Asia 40 countries 9 Subsidiaries	BLUEN nitrogen BF with maximum efficiency. VITASOIL revitalizes poor soils.	Farmers	• hyper active R&D department • strategic partnership (with SOPEF) to enhance international growth	• Not identified
IPL BIOLOGICALS Ltd (India , est. 1994)	APAC, Africa, Europe, LA & NA	• large variety of BFs products • training (seminars and workshops) & consulting in organic farming • soil testing and check of soil health	Farmers	• global leader in biological products for pest management, plant nutrition, soil health, etc. • offers wide range services & consultancy for farmers • BFs effective under extreme weather conditions • strong in-house R&D capability	• Recently rebranded may suffer short term losses.
GREENergy BFs (SCANWATER, NIBIO, NMBU, HHEPSTI)	Potential markets in Europe and China	OFs produced by recycling waste and/or wastewaters.	Farmers & home/balcony gardeners.	• Showcase to demonstrate the GREENergy concept. • Partnership with China	• High cost of equipment and installation. • Limited productive capacity.

GLOBAL

The global BFs market is competitive owing to its high-technology intensity which requires partnerships and collaborations and strategic alliances among companies. The R&D is a leading strategy for the most companies of this market as it plays a crucial role in the development of more efficient and superior BFs. Hence, constant technological innovation to launch new products and improve the existing ones is a number one priority for the key players of this market. Moreover, mergers and acquisitions, are adopted by the market players to accelerate their market share. Many strategies involve increase its share in agriculture with a comprehensive portfolio, offering new products, services and customized solutions to farmers for all crops, in all geographies.

NOVOZYMES A/S (Denmark)[33]

Novozymes is a world leader in biological solutions with a major stake in BFs market. In 2013 Novozymes was ranked as the most sustainable company in the Biotechnology Industry and it is currently ranked among top 6% of companies in the total chemical industry sector.

Main products: Novozymes produces high quality enzymes and microorganisms. Novozymes applications for crop production include biocontrol and bioyield enhancement. The former is a method to protect crop production from insects, disease and weed pests and the latter fuels the performance of plants. These solutions are derived from naturally-occurring microbes like bacteria and fungi that can replace or complement traditional fertilizers and pest control solutions and provide an enhanced yield.

Services: The technical service team helps customers to adopt innovations and optimize product use making the necessary adjustments tailored to the needs of individual customers.

Markets: Novozymes has a global presence in markets in Europe, NA and LA, Middle East, Africa and APAC.

Customers: Farmers, industries (food & beverages, household care). By working closely with customers Novozymes gains a deeper understanding of their needs and those of their

[33] Source: https://www.novozymes.com/en

consumers. Due to various plants over the world, the company is able to showcase to customers exactly how its products work for their specific product or industry.

Cooperation and partnership: Novozymes forms alliances with major industrial players to enter the new business areas faster and more efficiently by combining the strong innovation and know-how with manufacturing expertise of partners:

- *Biostimulants Products Industry Alliance:* Industry association created to promote the development of effective and safe biological products such as BFs, biostimulants and biobesticides.
- *Partnership with Bayer:* Developing groundbreaking innovation (BioRise2) to offer next generation bioyield and microbial solutions in order to promote efficient and sustainable farming.
- *BioAg Alliance:* Monsanto's and Novozymes' collaboration to improve crop harvests through products containing naturally-occurring microbes. New products on the market that will help farmers produce more crops in a sustainable manner.

Innovation: R&D facilities in multiple regions where researchers screen thousands of microorganisms to track down the one that produces the enzyme with the exact characteristics we need for a specific product.

Financial developments and 2020 outlook:

At the end of 2019, Novozymes had more than 52,000 shareholders, of whom 95% were private shareholders in Denmark. Novo Holdings A/S (owned by the Novo Nordisk Foundation) held 25.5% of the total common stock in Novozymes and controlled 72.0% of the votes.

Organic sales are expected to range from -2% to +2 % due to the uncertainty created by COVID-19 pandemic. The Earnings Before Interest and Taxes (EBIT) margin is raised and now expected at 26-27%. Cash flow before acquisitions is expected a little over $ 500 million.

RIZOBACTER S.A. (Argentina)[34]

Established in 1977 in Argentina, Rizobacter is an international leader in agricultural microbiology that investigates, develops and commercializes innovative solutions for sustainable agriculture around the world. The mission of the company is to develop high

[34] Source: https://www.rizobacter.com/en

value-added products by using state-of-the-art technology. Rizobacter seeks strategic alliances (e.g., Bioceres and De Sangosse) with a goal to deliver products and solutions to the national and global agricultural market.

Main products: BFs for wheat, corn and sunflower seeds, elaborated on the basis of growth promoting microorganisms (*Plant Growth Promoting Rhizobacteria*). It solubilizes phosphorous in the soil improving the performance of phosphorus fertilizers and allowing the development of roots and the evolution of the crop. This BFs is apt for use in organic agriculture.

Also Rizobacter produces inoculants (leader, with 250 million dosages sold in 2018), seed treatments, adjuvants and specialty fertilizers.

Markets: Operates in more than 30 countries providing cutting-edge technologies that allow to increase yield potential for farmers around the globe. It has 9 subsidiaries companies and operates in Africa, Europe, Latin and NA.

Customers: Farmers around the world.

Strategic Alliances

- 2016: Partnership with French company De Sangosse. Investment of 33 million to build a plant for micro-granulated fertilizers, Microstar. Productive capacity for micro granulated fertilizers of 50.000 tons to supply Latin-America.
- In 2016 and 2019 Bioceres acquired 51% and 29.9% of Rizobacter, respectively.[35] This partnership enhances the development of biotechnology trying to develop a righteous seed that would allow for a better performance per hectare.
- 1998: Alliance with Syngenta world leader in the development of agricultural THERAPY. This cooperation allows the combination of the most advance technology with a highly efficient service for producers.

Innovation: Invests its own resources with 30% of the profits being reinvested in R&D. Moreover, the company has 45 active projects ready to hit the market within 5 years.

[35] Bioceres is a fully-integrated provider of crop productivity technologies including crop protection (adjuvants, insecticides and fungicides) crop nutrition (inoculant & BFs and micro-beaded fertilizers), among others.

T STANES & COMPANY Ltd (India)[36]

The company was stablished in 1861 in India by Sir Robert Stanes. In 1961, T. Stanes and Company Limited was acquired by the Amalgamations Group. The company produces a whole range of bio-products, from OF mixtures to growth regulators and biologicals for the control of pests and diseases in plants. It offers a variety of crop care solutions, BFs, micronutrients, biostimulants and OFs.

BFs products among other:

- BFs based on bacteria and is used for atmospheric nitrogen fixation in leguminous plants (Rhizobium), major non-pulse crops (Azospirillum) and cash crops (Azotobacter).
- BFs that contains phosphate (Symbion-P), Potash(Symbion-K), Sulphur (Symbion-S) solubilizing bacteria which solubilizes and mobilizes the available phosphate, potash, sulphur in the soil and makes it easily available to the plants.

Services: The company has a Phyto-Pharma Testing Lab offering the highest quality testing services meeting the statutory & regulatory requirements and striving to ensure total customer satisfaction.

Markets: The company has international presence in 32 countries, in Africa, APAC, Europe and LA and NA.

Innovation:

The aim of R&D is to develop new products as well as improving the properties and functionality of the older products. R&D is mainly focused on:

- creating new and innovative products on nutrient, pest, disease management;
- new active ingredients that can control crop pests and improve yield and productivity.

Collaboration with the Indian Council of Agricultural Research Institute and State Agricultural Universities for new product and technology development.

[36] Source: https://tstanes.com/

IPL BIOLOGICALS (India)[37]

Formerly known as International Panaacea Limited (established in 1994), IPL Biologicals specializes in biological solutions for agricultural applications. IPL Biologicals has the widest portfolio of products in disease and pest management, plant nutrition & health and soil management. The company offers more than 50 registered products and helps millions of farmers around the globe to control diseases and pests, improve plant health for better yields, simultaneously reducing chemical residues in foods and supporting a sustainable future. In addition, company offers training to farmers in safe integrated farming practices, seminars and workshops on good farming practices, among other services. The vision of the company is to work towards a safer and healthier planet by leveraging its research capabilities and bringing sustainable, safe, technological solution to consumers globally.

Products: Wide variety of BFs (Acetobacter Diazotrophicus, Azospirillum, Azotobacter, Phosphate solubilizing and Potash mobilizing bacteria, Sulphur iron solubilizer, etc.), bio fungicides, bio insecticide, botanical insecticides, bio nematicides, among other.

Benefits & Advantages of IPL products: high efficacy as compared to competitive products, effective in wide range of ambient conditions of temperature, humidity, soil pH; zero contamination, long shelf life of up to 36 months for some products, among other.

Crop Solutions: Nutrient, disease, insect and pest management, growth promotion and decomposer.

Services & Consultancy: Adoption, training and certification in organic farming; consultancy in organic farming; soil testing and check of soil health.

Markets: Strong global presence in APAC, Africa, Europe and the Americas.

Innovation: Two High Tech R&D labs, manned by highly qualified and experienced microbiologists, chemists, entomologists, pathologists and agronomists have created over 50 registered products and are in the process of launching 70 new products. The strong in-house R&D capability allows for constant innovation and improvement of the existing products and it constitutes the driving force behind company's growth.

[37] Source: https://www.iplbiologicals.com/#

Latest developments: In 2020 International Panaacea rebrands as IPL Biologicals for better alignment of the company with its core competency and business focus. IPL Biologicals is a part of prestigious M2K Group a leading Indian business organization with significant presence across diverse industries.

SYMBORG (Spain)[38]

Symborg was established in Murcia in 2009 and is a leading company specialized in biotechnology R&D with agricultural innovation. The vision of the company is to be global leader in the BioAgro sector and help farmers maximize their yield while overcoming the challenge of sustainability through innovative biological solutions.

BFs products:

- **BLUEN:** The first nitrogen biofertilizer with maximum efficiency. Saves on nitrogen fertilization while reducing our environmental impact.
- **VITASOIL:** It revitalizes poor soils by increasing microbial populations and activity in the crops' rhizosphere.

Markets: Today, the company has 9 subsidiaries in Europe, the US, South America and Asia, and its products are used in more than 40 countries.

Innovation:

The continuous investment in research, development and innovation is the key of success for this company. Symborg works to improve existing products, constantly refining production research processes and validating the progress of our R&D department. There is 30,000 m² experimental farm dedicated to biotechnological agricultural experimentation. Symborg finds new microorganisms by conducting microbial extractions in forests, deserts, icy areas, sea beds or agricultural soils. The candidate strains are tested in experimental farm and the result is an active substance that can potentially become a biotechnological solution. The R&D staff has collected more than 10000 strains that can become products eventually. Symborg mainly produces and sells biostimulants, biobesticides and BFs

Latest developments

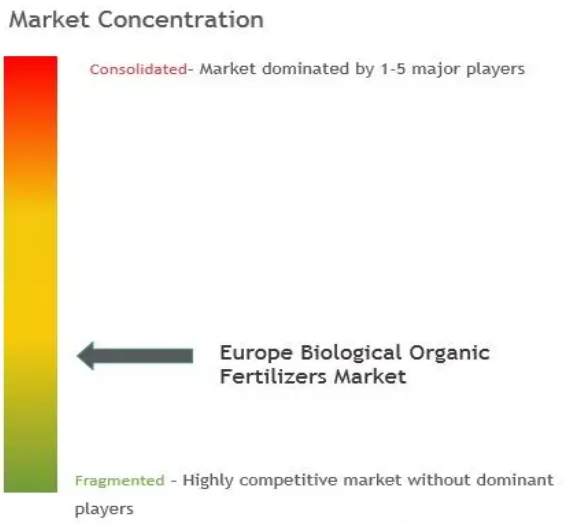
[38] Source: https://symborg.com/en/

Recently, Spain Oman Private Equity Fund (SOPEF) has made a minority investment in Symborg through a capital increase. As a result of the agreement, Symborg reinforces its shareholding structure by a strategic partner who adds a markable contributions to promote and consolidate the international growth strategy of the company and its expansion plan. The latter includes the construction of a production plant in Murcia to incorporate new products into the existing portfolio. This will facilitate the international expansion to key agricultural markets such as the US and LA.

EUROPE

The market assessment report of Mordor Intelligence (2019a) shows that the European BFs market is competitive and without a dominant player (see, Figure 6). The major players in the market include Novozymes AS, Symborg SL, Ficosterra, UAB Bioenergy, Lallemand Inc., etc. The key players in the market are focused on new product launches to cater to a wider consumer base and expand market share in the local market. All the major players have a presence in Europe and the regional market place is divided among the major players along with some regional ones. Mergers and acquisitions and joint ventures are the preferred strategies adopted by major players to increase their respective market shares in Europe.

Figure 6: European BFs market concentration



Source: *Mordor Intelligence (2019a).*

FICOSTERRA (Spain)[39]

Ficosterra is a Spanish marine biotechnology company that produces BFs and biostimulants suitable for ecological and conventional agriculture application (as well as applications in sport pitches, gardening and flowerpots) in order to increase the profitability of the crops in a sustainable and eco-friendly way. The mission of the company is to help farmers to improve their crop yield through innovative biological solutions that are vital for the environment and increasingly in demand.

Products: In its factories in Burgos (Spain) and Ensenada (Mexico) Ficosterra produces: Biostimulants, BFs and biological fortificants, ecologically certified, that regenerate the soil, stimulate crops, improve their productivity and increase the resistance of plants to environmental stress.

BFs products:

- **FicosGreen** accelerator of crop metabolism. This BFs is produced using the Booster Crop Technology that provides the crop with growth-promoting substances.[40]
- **FicosArgo:** Organic soil activator using liquid bio-stimulant with algae and bio regenerating microorganisms (namely BFs). Increases the growth of plant roots and improves the absorption of nutrients from the soil. This product is registered by the Austrian Federal Office for Food Safety and is suitable for use in organic farming.

Innovation

Innovation through investigation and develop of innovative technologies with active principles from the sea that benefit agriculture. The company transforms algae into fertilizers and biostimulants that promote the maximum development of crops. In 2019, Ficosterra received the QIA Quality Innovation Award in Beijing by the Finnish Government Quality Association. Moreover, Ficosterra has received funding from the European Regional Development Fund of the EU through the Institute for Business Competitiveness of Castilla y León.

[39] Source: https://www.ficosterra.com/en/
[40] Booster Crop Technology combines microbial complexes with algae extracts to achieve very high densities of soil regenerating microorganisms and allows the soil to return to the natural state of microbial life. See more here: https://www.ficosterra.com/en/technology/

UAB BIOENERGY LT (Lithuania)[41]

Bioenergy is a Lithuanian innovative technology company that develops and produces biological products. Bioenergy through advanced production technology and scientific research produce exclusive products for plants nutrition optimization and recovery of natural balance of the soil.

Markets: By production capacity Bioenergy is a leading company in Nordic region and its products are exported to more than 20 countries worldwide. In 2017, Bioenergy began to operate new automatic bioreactor line, which allows the company to increase its production capacity.

BFs Products:

- **AZOFIX:** biological product intended for increasing nitrogen content in the soil.
- **BACTOFORCE:** biological product, which improves plant nutrition and absorption of elements.
- **AZOFIX RHIZO**: biological product, which consists of specific bacteria Rhizobium. These bacteria are known for ability to fix atmospheric nitrogen (N2) and transform to available form(NH4) for legumes.
- **FOSFIX**: contains of bacteria Bacillus sp., when it's applied on the soil, it releases phosphorus from plant unavailable forms such as calcium, iron and aluminum phosphates, and turns them into plant available forms of organic phosphorus.

Company is committed to produce products which meet the highest quality and most advanced global biotechnology industry standards.

Services: Company. To use BFs and apply the new methods requires constant use of available knowledge and direct education of agricultural professionals. To meet these needs Bioenergy visits farmlands and offers on site education and consultancy for farmers.

Innovation:

The technology used in production of BFs enables the bacteria to become stable and resistant to adverse environmental factors. Moreover, products can be mixed with all pesticides and fertilizers increasing the effectiveness of products and bacteria. This gives a comparative

[41] Source: http://www.bio-energy.lt/en

advantage to the products of this company as opposed to BF products that have short validity time and strict application rules (cannot be mixed with other fertilizers, pesticides or bacterial products).

For the development of its products Bioenergy cooperates with universities, research centers and highly qualified scientists around the world. Investment in R&D brings the high quality products that are tested by experiments in Bioenergy's research laboratory and in many different climatic and geographic regions.

VUNA (Switzerland)[42]

Vuna means "harvest" in isiZulu, the language of the Zulu people. VUNA originated as a research project which endeavored to find a suitable use for the urine collected in dry toilets in the city of Durban, South Africa. In 2016, the company VUNA Ltd. was founded based on the outcomes of this research project between Eawag, eThekwini Municipality (greater Durban) and additional partner organizations.

BFs Products:

- **Aurin:** the first urine fertilizer worldwide with full approval of Swiss authorities. It is a liquid recycled nitrogen fertilizer that has as its main source separately collected human urine treated via nitrification, activated carbon and distillation.

Solutions & Services: Vuna provides decentralized wastewater treatment, waterless sanitary systems and nutrient recycling.

- Urine recycling technology (UniExpress): mobile version of Vuna's urine recycling technology. It is a trailer that can process up to 150 liters of urine per day into fertilizer. Ideal for sport fields, fleet markets, festivals and for everyone who has to treat large quantities of urine and wants to test the technology.

Markets: Switzerland, Germany and France.

Customers: farmers, municipalities and households.

Innovation: The Vuna process for safe and efficient nutrient recycling ensures that all pollutants and pathogens are eliminated. Activated carbon is used for the elimination of pharmaceuticals and a distiller eliminates pathogens and reduces the liquid volume. After

[42] Source: http://vuna.ch/en/

intensive testing, Aurin was officially approved as a fertilizer by the Swiss Federal Office for Agriculture in 2018.

CHINA

China BF market is fragmented with many regional fertilizer manufacturing companies having their presence in the market. Similarly, to the European Market the Chinese market is competitive and without a dominant player. Kiwa Bio-Tech Products Group Corporation, Bodisen Biotech, Inc, Shanxi Haozhida Biotechnology Co., Ltd and Genlido Biotechnology Co., Ltd are some of the prominent players in the market. These players are investing in R&D activities and developing new microbial fertilizers to improve soil and crop quality and increase crop yield.

KIWA BIOTECH (China)[43]

Kiwa provides cutting-edge biological fertilizers for environment-friendly practice of agriculture in Mainland China. The vision of the company is to promote safe agriculture and provide safe food for healthy lifestyle. More specifically, company's aim is to restore farmland to healthful condition and provide solutions for soil treatment and reduction of soil pollution. The development strategy of the company is to develop, produce, and market eco-friendly biological fertilizer products to satisfy the increasing demand for safe food.

Products: Biological OFs; compound microbial fertilizer for vegetables, fruits, tea, tobacco and flowers among other; biological water soluble fertilizer; biological soil remediation; microorganism bacterium fertilizer.

Technical Support & Services: Free soil testing services for customers; after-sale services (visits from R&D staff to monitor crop growth); customized fertilization plans by R&D staff;

Innovation and technology:

- R&D efforts to improve technology and products is focused on developing beneficial bacteria for the new products and applying various pure plants as the raw materials.
- The company has established the first agricultural experiment and demonstration station for the field-testing in 24-acre outdoor plating area in Xi'an, Shanxi Province.

Latest developments:

[43] Source: https://kiwabiotech.com/

In March 2020, Kiwa Bio-Tech signed a cooperation agreement with Huaxialitai Co., Ltd., a China state-owned enterprise that has an enormous fertilizer market channel in China. Huaxialitai will start to sell Kiwa's fertilizer products in Gansu, Jilin with the initial order of $ 7.5 million.

Kiwa plans to achieve bio-OF sales of no less than 200,000 tons in 2020 (20% increase compared to 2019).

Restructuring of Kiwa Bio-Tech, the Global Holding Group will hold 49 % of the company. Kiwa's sales will be gradually entered into the Global Holding Group's network in China.

SHANXI HAOZHIDA BIOTECHNOLOGY Co., Ltd.[44]

This company was founded in 1996 under the name Shanxi Guangda Chemical Co., Ltd. It specializes in providing plant growth regulator, BFs, water soluble fertilizer and pesticide spray adjuvant. After more than 20 years of business company has 28 products recognized by the Institute for the Control of Agrochemicals, Ministry of Agriculture (ICAMA), 5 registered patents and 25 registered trademarks. Vision of the company is to make agricultural progress through innovative technologies and products offered by the company.

In 2013, the company invested $ 10 million to build the new factory covering 3,6 hectares.

In 2016: Shanxi Haozhida Biotechnology started the R&D of BFs and bio-stimulant based on Degnite Technology and bio-pesticides to serve the sustainable agriculture and environmentally friendly growth.

Market: The company has set up sales network in 25 provinces in China having its products being applied in more than 6 million hectares.

Innovation

Innovative Degnite Technology is an environmentally friendly technology that uses microorganisms which effectively degrade lignite into humic acids and no chemical waste is generated during the production process.

BF Products:

- **BF SMYRE:** BFs based on humic acids using "Degnite" Technology.

[44] Source: http://www.hzdbiotech.com/

- BF SMYER G: Supplies macro elements, beneficial microorganisms and organic matters to the soils and it is effective for preventing soil borne diseases, and increasing quality and quantity of crops.
- Liquid SMYER: BFs based on fulvic acids and using "Degnite" Technology.

GENLIDUO BIOTECHNOLOGY Co., Ltd[45]

Founded in 2005, Genliduo Biotech is a comprehensive high-tech, joint-stock and listed enterprise. Genliduo specializes in organic-inorganic compound fertilizer, microbial OF, water soluble fertilizer, microbial agent and soil conditioner. Operating for 15 years' now, Genliduo has developed to a leading fertilizer brand and one of the largest microbial fertilizer producers in China. Enterprise's mission is to pioneer the agriculture science in order to provide high quality products and services to help farmers boost the harvest and increase their income but at the same time to improve the soil and promote ecological agriculture. The corporate strategy of Genliduo is to be an expert on soil environment and eco-nutrition.

Markets: Genliduo's headquarter is located in Wei County, Hebei province, eastern China. The company mainly operates in China and has five production plants with the overall production capacity to be nearly 660,000 tons per year. In 2017, Genliduo established Beijing Prevail Co., Ltd. to develop overseas market.

BFs Products:

- **Bio-OF:** It is made from soybean meal, bone meal, mushroom residue, furfural residue. It is suitable for a variety of vegetables, fruit trees and field crops. Improves the fertility, water retention of soil and the utilization of fertilizer as well as the yield and crop quality.
- **Bio-OF (Pure fermentation):** it is made from soybean, straw, grain extraction. It improves the fertility, water retention of soil and the efficacy of fertilizer.

Services: The company has many lecturers of agricultural technology and experts on soil testing formula-fertilization. They visit farmlands, customize formulas for soil and explain the cultivation and fertilization programs.

Innovation:

[45] Source: http://english.genliduo.com/

Genliduo has an innovative research center where company has invented a new technology to produce microbial fertilizer, called the "Microbial Film Method". The Hebei Bio-Fertilizer Engineering Technology Research Center improves Genliduo products but also serves as technical support for other bio-fertilizer companies. The R&D focus of the Center is on organic and inorganic nutrients/ plant cost reduction/ mass production/ improving fertilizer efficiency and soil conditioning.

Moreover, the innovation ability of the company is improved significantly through cooperation such as the one with Jiangxi Agriculture University and several other agriculture universities. For example, functional microbial fertilizer was fermented by a special technology. Compared with traditional fermentation technology, this special fermentation technology could save production costs which enhanced products competitiveness.

4.2.4 PESTELI Analysis

In this section we employ the PESTELI analytical tool in order to identify external factors that determine the macro environment and how they affect the positioning of SiEUGreen (GREENergy) BFs and OFs (GREENergy, Urban composting Hub and Garbage Processor) mainly in the market of China and Europe. These factors are summarized in Table 9 and presented more analytically below:

Table 9: PESTELI Analysis for BFs and OFs

PESTELI	Relevant Factors	Projection
Political	Policies and initiatives to promote organic farming and minimize the use of chemical fertilizers replacing them with OFs and BFs.	Further initiatives to encourage organic farming development and hence the adoption of OFs and BFs.
Economic	Rebound of economic activity. Increasing price of chemical fertilizers Increased demand for organic products.	Higher demand for cost effective BFs and OFs that can be afforded even by lower-income growers.
Social	Rising awareness of healthiness and wellbeing Significant shift in preferences and taste for organic food	Reinforced by the COVID-19 pandemic and further global health awareness.
Technological	High level of innovation in BFs and OFs through intense competition and extended cooperation: • New cutting edge BFs and OFs products	Further investment and closer cooperation with governments and research centers in R&D of BFs and OFs.

	• Improvement of the existing ones Efficiency of BFs increased yield and shelf life.	
Environmental	Soil depletion and reduced soil fertility Need for sustainable agriculture.	Expansion of organic farming and hence surging use of BFs and OFs.
Legal	Regulations on chemical fertilizers differ from country to country. Council and Commission Regulations EU organic logo to support consumers	Further legal restrictions on chemical fertilizers. Increased food safety and more stringent regulations and rules.
Institutional	Institutional support for promotion of organic farming and adoption of BFs and OFs.	More institutions to promote the transition to sustainable farming.

Political

In the past years, reflecting the rise of social awareness regarding environment and health, governments of developed but also of some developing countries designed policies and developed various initiatives to support and promote organic farming. They aim to mitigate the negative impact on the environment and public health from the use of chemical fertilizers by seeking alternative fertilizing methods such as BFs and OFs that are employed in organic farming. Hence, the focus of policy-makers has turned to organic farming and the benefits that come alongside this farming method.

For example, the EU recognizing the advantages of organic farming both for land and citizens has directed supportive measures towards organic farmers under the CAP for the period 2014-2020. As a matter of fact, organic farmers received more subsidies than conventional growers. More specifically, in 2016, more than 55% of EU organic lands were granted support amounting to €215 per hectare from CAP and national co-financing combined. In addition, under the EU Rural Development various measures were directed to promote and support the development of organic production including investment organic farming training, marketing and overall promotion of organic products (European Commission, 2019). Alongside EU aid, most of the member countries have shown their vivid interest to develop the organic sector. For instance, Germany has launched a program to increase the organic surface up to 20% until 2030 and many other countries set up similar programs and targets. Furthermore, in 2018 and 2019 the Denmark Government spent a substantial amount of money ($147 million) in order

to increase the number of farmers opting to go organic as they are one of the world's largest consumers of organic products.

More recently, even the governments of developing countries despite the challenge of rapid population growth have made steps forward in their transition towards more sustainable and eco-friendly agriculture. For example: in 2017, China's Ministry of Agriculture launched a pilot plan for fertilizer replacement in 100 Chinese districts aiming to reduce the use of chemical fertilizer by at least 20% by 2020. Moreover, the government of Thailand has launched a program to promote organic agriculture by encouraging a reduction in the amount of new rice planting and shift from commercial varieties to organic. Also, the Indian government has introduced a set of measures that promote and facilitate the transition towards organic and sustainable agriculture (Paramparagat Krishi Vikash Yojana, 2018).[46]

It is certain that all these policies and initiatives to develop and promote further the practice of organic farming around the world have and will continue to have a strong positive impact on the market development and further expansion of BFs and OFs.

Economic

In 2020 with the outbreak of COVID-19 and the prevailing economic uncertainty there was a significant slow-down of economic activity worldwide. However, despite the expected contraction of 5,1% of global GDP in 2020 it is projected that global growth will be revived to 4,2% in 2021 (World Bank, 2020).[47] Also, it is expected that the prices of common fertilizers are going to rise in 2021 due to the increased energy cost required for their production (Chian Koh and Baffes, 2020).[48] The price is a significant factor if we consider that BFs and OFs are cost effective and even lower-income farmers can afford to use them. What is more, this is contrary to what seems to be the popular belief that organic farming and the use of OFs and BFs can be only afforded by more affluent countries. The projected macro trends coupled with the growing global demand for organic and healthy food can boost the use of BFs and OFs and expand their markets.

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[46] Source: Ministry of Agriculture & Farmers Welfare https://pgsindia-ncof.gov.in/pkvy/Introduction.aspx

[47]Source: World Bank https://www.worldbank.org/en/news/feature/2020/06/08/the-global-economic-outlook-during-the-covid-19-pandemic-a-changed-world

[48] Source: World Bank Blogs, https://blogs.worldbank.org/opendata/fertilizer-prices-rise-moderately-2021.

Social

During the last years, we have been observing significant changes in the attitude of people towards their health and wellbeing. These lifestyle changes have shifted consumer's preferences and increased the demand for organically produced goods. More specifically, the demand for organically produced food and beverages have seen a dramatic increase in NA (mainly the US) and Europe that accounted for 47% and 37%, respectively in the global market for organics (European Commission, 2019). Currently, with the outbreak of COVID-19 this trend has been reinforced and the demand for organic food and hence the use of BFs and OFs is expected to grow even stronger.

Technological

In the BFs market constant innovation is crucial in order to stay profitable. For this, companies invest a lot of resources in R&D in order to create cutting-edge market superior products and claim larger market share. These investments seem to have paid out as it can be observed by the phenomenal innovation in BFs and OFs products. The increased efficiency (high yields of crops) and improved resilience to extreme weather conditions have boosted their use in organic agriculture around the world. Although, there are still some caveats in substituting completely the common fertilizers the innovation in BFs and OFs seems quite promising.

Environmental

The need to feed a growing world population has led to an excessive agriculture production around the globe and especially in Asia. This in turn has resulted in excessive use of chemical fertilizers causing soil depletion, reduced soil fertility, increased air and waterway pollution. The growing environmental concerns over soil quality and the overall ecological footprint have created an urgency for development of sustainable agriculture and the use of BFs and OFs as the best alternative solutions in order to prevent further ecological damage and environmental degradation.

Legal

As we have already mentioned above many countries have taken seriously the environmental challenges arising from the use of common fertilizers. The EU Circular Economy Action Plan, the "Zero Growth Policy of Pesticides and Fertilizers by 2020" of Chinese Ministry of Agriculture are among other, health and safety regulations that were passed in the last years in order to prevent further environmental degradation.

Moreover, in the EU there is a strong legal protection and support for organic food. For example, in 2010 the European Commission introduced a specific EU organic logo, complementing earlier legislation in setting up an extensive framework of rules and requirements on the production, processing, handling and certification of organic foods (Council Regulation 2007 and Commission Regulation 2008). According to these regulations foods are labelled as organic if at least 95% of their agricultural ingredients are organic and fertilizers may only be used if they have been approved for use in organic production. (European Parliamentary Research Service, 2015). However, there are no specific regulations in the EU that set parameters for BFs. Each country locally regulates this matter.

Institutional

Environmental impact and pressure from governments around the globe to solve/reduce it has brought forward some initiatives by supranational institutional authorities. Recently the EU launched the initiative, "From Farm to Fork", a set of targets and an ecological strategy that clearly supports the development and growth of OFs and BFs (European Union Commission, 2020b). More specifically, it establishes set of initial specific objectives, such as, reducing the use of chemical fertilizers by at least 20%, reducing the use of pesticides by 50%, reaching 25% of agricultural land dedicated to organic farming, among other.

In 2018, the Ministry of Agriculture and Rural Affairs together with other 7 departments issued a supply-side structural reform of agriculture, the National Strategic Plan for Promoting Agriculture by Quality (2018-2022). The main goal of this plan is to vigorously promote the benefits of high-quality organic farming in order to strengthen the quality efficiency and competitiveness of the Chinese agriculture. This implies substantial reduction of chemical fertilizers and pesticides and widespread use of BFs.

Furthermore, there are several organizations/institutions around the globe that provide education, training, resources and practical advices to farmers and in general to crop growers in order to raise the awareness regarding organic farming. Among those organizations we have the International Federation of Organic Agriculture Movements, the International Society of Organic Agriculture Research, the Midwest Organic and Sustainable Education Service, the Northeast Organic Farming Association, the Organic Federation of Australia, the Organic Federation of Canada, and the Organic Growers School (Meticulous Research, 2020). All those organizations play an important role for the development of organic farming and its

worldwide expansion. This in turn constitutes a significant boost in adoption of OFs and BFs by organic growers around the globe.

4.2.5 SWOT Analysis

In this section we present the SWOT analysis (summarized in Figure 7 below) for the BFs produced by the GREENergy concept (nitrification of liquid streams).

Internal Strengths

A major internal strength of the GREENergy method for nitrification of liquid streams stems from the fact that it is a part of the integrated GREENergy concept. More specifically, the integrated GREENergy concept demonstrates the role and usefulness of BFs in a framework of a circular economy. In contrast with other competitors these BFs are not just produced and sold but they are also part of an integrated solution for future smart cities. What is more, the Campus Ås showcase adds to the aforementioned internal strength by displaying the technology/solution in a best possible manner.

The SiEUGreen partnership can serve as a strategic cooperation between the EU and China and provides an access to the Chinese market. As we have seen in the section about competition above, competitors of this market form strategic cooperation and partnerships to distribute their BFs products in a greater geographical area.

Internal Weaknesses

The method of production constitutes a major weakness as it requires a high fixed cost of installation to produce BFs. What is more, such a system of production has a limited productive capacity making it quite difficult to compete or cover the needs of such a growing market as the market of BFs. On top of that the variety of BFs (by application) produced is quite limited.

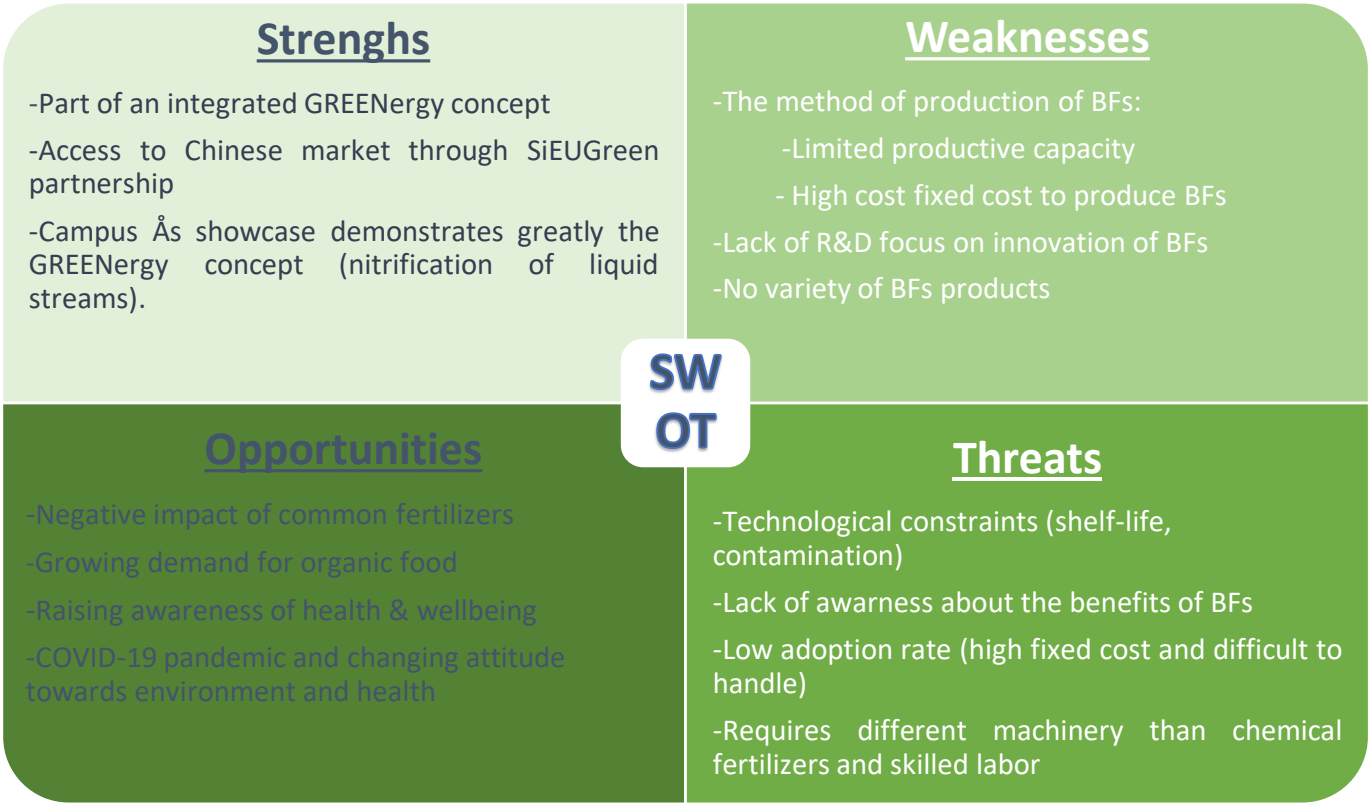
Moreover, as we have seen above, companies strive to seize the market by creating market superior new BFs products and by constantly improving the existing ones. For this they create strategic R&D cooperation with other companies, research centers and governments. In the case of the SiEUGreen, partners might not necessarily have their focus only on the production of BFs but rather on the integrated GREENergy concept. Hence, we can argue that there is a lack of R&D focus on BFs innovation to create market-leading products.

External Threats and Market Barriers

The main challenges for the market development of BFs are the lack of awareness in farmers about their benefits and their low adoption rate. More specifically, the lack of information in underdeveloped and developing countries significantly restricts the use of BFs and their market growth. Moreover, the low adoption rate of BFs by farmers is attributed to the associated difficulty to handle them compared to chemical fertilizers.

Furthermore, high initial investment is required in order to be able to use BFs. This creates a disincentive for the farmers to opt in BFs and keeps a large part of them away from using the BFs. Moreover, farmers prefer the use of chemical rather than BFs because the application of the latter involves more skills, labor and the fixed cost of the BFs technology is high.

Figure 7: SWOT Analysis for GREENergy BFs



A major technological constraint for BFs is that they should be used before their expiration date and should be taken care while storing because they are alive. Moreover, BFs run a high risk of not being effective if growers use the wrong strain or if the other microorganism contaminates the carrier medium or if the soil is too hot or dry. All these factors can

significantly restrain the market growth of BFs versus common chemical fertilizers, that have high temperature resistance and are easier to store and use.

External Opportunities and Market Drivers

The intense use of raw materials to produce chemical fertilizers is an energy intense process that depletes the non-renewable natural resources (e.g., phosphorus) and it is resulted in high CO2 emission release (Chojnacka, et al., 2020). Moreover, the widespread use of chemical fertilizers leads to reduced soil fertility and degradation of soil quality. The growing environmental impact caused by the production and use of chemical fertilizers is one of the driving forces behind the growth of the BFs market.

In view of these environmental challenges governments have imposed stricter regulation with respect to the use of chemical fertilizers in order to limit their negative impact. The Chinese Ministry of Agriculture has set to develop its green agriculture and establish a green food safety based on biotechnology and its application in agricultural production. More specifically, the Chinese authorities have allocated research funds to the National Microbial Fertilizer Technology Research and Promotion Center for the development of sustainable agriculture. The aim of the research is to promote the use of biological fertilizers by demonstrating how can they help to reduce soil pollution and environmental impact by substituting the use of chemical fertilizers.

The EU went one step further by launching an ecological initiative “From Farm to Fork”, that clearly benefits the development and growth of BFs (European Union Commission, 2020b). These food safety regulations and initiatives coupled with the growing world population and increasing demand for food constitute major growth opportunities for the BFs market. It will not be long before other countries will follow this trend and start regulating the usage of chemicals in agriculture production. This trend is likely to be reinforced due to the current COVID-19 crisis as voices grow to call for a new sustainable food system that responds to the current needs and demands of society.

Finally, the foreseeable trend within the BFs market is potential switch from powder based to liquid BFs as they are superior. More specifically, liquid BFs are expected to have longer shelf-life, reduced risk of contamination, higher temperature resilience, more cost effective with higher production efficiency and easier to be used by farmers.

4.3 Organic Fertilizers (OFs) Market

Organic fertilizers can be derived from human and animal waste, vegetable and plant matter. OFs are naturally rich in nitrogen, phosphorus, and potassium, the three major nutrients needed in plant growth. They can also serve as soil refiners, as they improve the quality of the soil and restore its physical–chemical characteristics. OFs enhance the fertility of the soil unlike synthetic fertilizers that destroy the microorganisms present in the soil, thereby reducing its fertility. Furthermore, OFs mitigate the risk of environmental damage, as they are extracted from substances already existing in nature or in other words the nutrients are derived from natural organic ingredients. In addition, with the use of OFs we avoid a wide range of human health hazards (e.g., headaches, nausea, reproductive harm, endocrine disruption and even cancer) that have been linked to the use of chemical fertilizers.

The market of OFs has many similar characteristics and elements in common with the market of BFs that we analyzed in the section 4.2. OFs just as BFs represent a significant tool for "green" agriculture production and extenuate the negative impacts of common agriculture that employs chemical inputs in production. Hence, by using OFs we minimize the environmental pollution, reuse and recycle organic waste, improve biodiversity and enhance soil productivity.

4.3.1 Global Market Insights

The global OFs market was $7.42 billion in 2020 and it is expected to worth $15.9 billion by 2027, growing at a CAGR of 11.5% during the forecasted period from 2020 to 2027 (Meticulous Research, 2020). The growth behind the OFs stems from similar factors as in the case of BFs. On the demand side, the increasing demand for organic food and the rising awareness concerning the environmental safety seem to be the main driving forces of this market. The global market of organic food and drink reached €92 billion in 2017 of which 47% accounts for the US market and 37% for the EU market (European Commission, 2019). On the supply side, the R&D advances in OF production and the abundant availability of organic waste enhance market expansion even further. However, this market is challenged by the high demand for synthetic fertilizers that prevents new companies entering the organic market, thereby hindering the growth potential of OFs market.

The OFs market is mainly divided by source (animal, plant, and mineral), by form (dry and liquid) and geography. First, regarding the source the segment of the animal-based OFs are

projected to see the strongest growth in demand through 2027 in the OFs market. This rapid uprise in demand is supported mainly by the high nutritional value (ideal source of nitrogen content and of other vital nutrients for crops) of animal-based OFs, easy and abundant availability of animal waste and low quantity requirements. Second, concerning the form, the dry segment of OFs holds the largest share owing to its long-lasting effects, high efficiency in wide range of climatic conditions, rising rate of adoption in lawn and garden applications, its abundance and availability of raw materials required. However, it is expected that the liquid segment will record rapid growth during the forecast period due to its easy and cost-effective application, high efficiency and uniformity of application.

Lastly, by geography, APAC is estimated to command the largest share of the OFs market in 2020, followed by Europe and LA. Moreover, the APAC is projected to witness its highest CAGR during the forecast period (2020-2027). This is mainly attributed to the increasing health awareness, huge areas under organic cultivation and rapid population and income growth in this region. What is more, favorable political initiatives and policies to promote and expand the organics industry further support the growth of the OF market. Finally, it is projected that the demand for OFs will rise significantly in NA and Europe over the next few years owing to favorable climate conditions, ample land and most significantly to a dramatic increase in consumption of organically produced food in these continents.

EUROPE

The European OFs market was valued at $2.45 billion in 2016 and it is projected to reach $3.26 billion by 2023, growing at a CAGR of 4.2% from 2017 to 2023 (Allied Market Research, 2018). The growth of the European market of OFs is led by two main forces, government support and the increasing awareness of benefits linked with the use of OFs. More specifically, governments across Europe implement stringent regulations on the use of synthetic fertilizers. Strict government policies and regulations are further expected to drive Europe's OF market size. Moreover, although, OFs are still technologically constrained and substantially behind chemical fertilizers in terms of nutrients and potential yield, harmful effects caused by prolonged use of chemical fertilizers fuel the adoption of OFs. The growing demand for organic products is observed over the last ten years in Europe. This growing demand for organic products is matched by a rapidly growing production: EU organic area increased by 70% in the last ten years and organic retail sales reached €34 billion in 2017 (European Commission, 2019). This upsurge in demand and supply for organically produced goods is projected to offer lucrative opportunities for the European OFs market growth.

By source the highest revenue was derived by the animal-based OFs that were accounting for approximately 50% share in 2016. By geography, according to the European Commission (2019) the largest EU markets for organic products are Germany, with €10 billion (5.1 % organic in total retail sales), and France, with €7.9 billion (4.4 %). This upsurge in demand for organic goods has encouraged farmers to switch to organic production. Germany and France have the largest stakes in the European OFs market. However, Spain is estimated to witness the most lucrative growth in the European market by 2023, owing to rise in awareness toward the benefits of OFs and rise in number of organic farms in most agricultural regions of the country.

CHINA

The growth of the China OF market is anticipated to register a CAGR of 11.6% during the forecasted period from 2020 to 2025 (Research and Markets, 2020c). Just as in the case of BFs (Section 4.2), increasing demand for organic food is the main market driver for OFs market in China. The growing popularity for organic food has been phenomenal during the last years in China. More specifically, in 2017 the total market size for organically produced products (food and beverages) in China was worth $2.8 billion, making the Chinese market of OFs the 4th largest in the world.

China is one of the major market for OFs in APAC region. Green agriculture practice has become a top priority for the Chinese government and the development of the economy. Farmers are encouraged to reduce the use of chemical fertilizers and switch to alternative methods such as OFs or BFs. More specifically, in 2017 the Chinese Ministry of Agriculture initiated an experimental scheme for replacing fertilizers in about 100 Chinese districts with a target to curb the use of chemical fertilizers by at least 20% by 2020. The use of OFs has been growing ever since expanding the market of OFs and attracting large fertilizer manufactures to step into the industry. Now China has over 300 organic producing companies with an annual output of about 0.5 million metric tons.

4.3.2 Organic Fertilizer end-user/customer segments

The total addressable market is estimated to be $7.7 billion in 2020 and it is expected to be $15.9 billion in 2027. Just as in the case of BFs, OFs can be used by a variety of customers that differ across age, gender and income. However, compared to common fertilizers the application of OFs may require a certain level of education, training and skilled labor to be

properly used. The demand for OFs can be directly impacted by the increasing health and environmental consciousness of people.

The list of potential customers includes more or less the same group of people as they are identified in the section of BFs (Section 4.2): farmers that would like to make the transition from common to organic production; municipalities can use OFs to enlarge green spaces and engage people in organic production, residents who are engaged with balcony gardening to grow their own organic products at home; and SMEs that can use OFs to produce vegetables and flowers in order to sell them to the market.

4.3.3 Competitive Landscape

In this section we conduct a detailed analysis of main competitors on Global, European and Chinese level. Table 10 below provides a brief summary of major competitors for SiEUGreen OFs.

Table 10: Major Competitors in OFs market

Competitor	Geographical Coverage	Outputs/Services	Customers	Strengths	Weaknesses
Suståne Natural Fertilizer, Inc. **(Est. 1980 in the US)**	60 countries in NA, Central America & the Caribbean, Europe, the Middle East and APAC	OFs for various crops	Professional turf and landscape managers, farmers, growers and horticulturists.	• 30 years of independent research experience on diverse crops and ecosystems. • unique base of products through aerobic composting	• Absence of services offered to customers
AgroCare Canada Inc. **(Est. 2012 in Canada)**	APAC, Europe, the Middle East and Africa as well as NA, LA and Central America	Liquid and powder OFs	Business farms, gardens and lawns.	• Uses customer surveys to optimize its products. • Continuous research and innovation to develop new OFs from new raw materials.	• No services provided to customers
ILSA S.p.A. **(Est. 1956 in Italy)**	49 countries mainly in Europe, Asia, LA, Morocco and South Africa and New Zealand.	14 different organic and organo-mineral fertilizers suitable for vegetables, cereals, trees, vines,	Companies growing industrial crops (sugar beets, cotton, soybean, tobacco,	• Corporate Research Center collaborates with major Italian Universities for continuous	• Weak presence in the US (one of the world's largest markets).

		fruits & other crops and plants, turf, etc.	etc.), farmers cultivating cereals, vegetables, etc.	improvement of the solutions & products. • OFs cover great variety of plants and crops.	
Qingdao Future Group **(Est. in China)**	China, Southeast Asia, NA, LA, Africa, Oceania, Middle East.	Crop protection, crop immunity, biostimulants and Organic Granular Fertilizers. Crop nutrition solutions, fertilizer and packaging customization services.	Fertilizer manufacturers, commercial farmers, fertilizer wholesalers.	• Quality assurance of the highest standards (EU & NOP standards) • Scientific research cooperation with domestic & international research centers.	• No presence in the significant market of Europe.
Italpollina S.p.A. **Rebranded as Hello Nature** **(Est. in 1970s in Italy)**	80 countries in NA and LA, Europe, Asia, & the Middle East 5 production sites 14 commercial offices around the world.	OFs for soil application and enhanced nutrition. Agronomic advice and personalized product use plans to its customers.	Farmers growing crops for industrial use, ornamental and flowers, forage, small fruits horticultural, vineyards and orchards, etc.	• Strong in-house research and innovation (3 research labs) • Research collaboration with international universities and significant research centers. • Significant penetration of the US market.	• Recently rebranded from “Italpollina” to “Hello Nature” that may result in short run loss of customers.

SiEUGreen OFs: **GREENergy Concept (SCANWATER, NIBIO, NMBU & HHEPSTI);** **Garbage Processor (PHOTON, China)** **Urban Compost Hub (IGZ, Germany)**	Potential markets in Europe and China	OFs produced by recycling waste and/or wastewaters.	Organic farmers and balcony/home gardeners of fruits and vegetables.	• Showcases to demonstrate the method or concept. • Partnership with China, easier to access its market. • Eco-friendly production of OFs.	• High cost of equipment and installation. • Limited productive capacity.

GLOBAL

Italpollina S.p.A. or Hello Nature (Italy)[49]

Founded in 1970s in Italy, Italpollina is a world leader in producing is a global leader producing OFs, 100% vegetal-based biostimulants, and beneficial microbials for use in agriculture. This company offers wide range of biotechnological and certified solutions for modern and sustainable agriculture aiming to focus on a sustainable and natural approach to agriculture, maintaining human and environmental health as paramount.

Main products: The company provides wide variety of OFs for soil application and enhanced nutrition, among other:

- Phenix: OF with a high content of organic matter and nutrients (phosphorus, totally organic nitrogen, and potassium), ideal to grow fruits and vegetables even in soils with high salinity and alkalinity.
- Guanito: OF made of exclusive raw material named Guano.[50] It contains high quantity of organic nitrogen and phosphorus that is not subject to insolubilization processes and remains available for crops during months.
- Madeira: OF that combines the advantages of organic and chemical fertilizers. Provides great quantity of nutrients during the entire cycle of plant's growth. It is high in content of potassium that improves the fruit quality.

Services: The agronomic office of Italpollina provides agronomic advice and personalized product use plans to its customers.

Markets: Present in over 80 countries in NA and LA, Europe, Asia, and the Middle East with 5 production sites and 14 commercial offices around the world. New commercial offices in China, South Korea, Russia, Canada and the United States.

Customers: Farmers growing crops for industrial use, ornamental and flowers, forage, small fruits horticultural, vineyards and orchards.

[49] Source: https://www.hello-nature.com/int/
[50] Guano is accumulated excrement and remains of birds, bats, and seals, valued as fertilizer. Source: https://www.britannica.com/science/guano

Innovation: The company owns three research labs and its research philosophy is based on eco-efficiency model for optimal agricultural production with decreased environmental impact and a commitment to sustainable agriculture. To create new products that comply with the highest quality standards and the eco-efficiency principles Italpollina utilizes renewable resources and economize on water and soil.

To advance its products and systems Italpollina conducts high level in-house research but also maintains scientific collaborations with international universities and significant research centers.

Recent Developments:

- In 2021, Italpollina was rebranded as Hello Nature.
- New US manufacturing facility in Indiana (US) dedicated to the production of natural biostimulants.
- In March 2019, Italpollina acquired the Florida-based (USA) Horticultural Alliance, Inc. specializes in an organic approach to plant health and maintenance. This acquisition empowered the company in its effort to expand its market share in the US.

Suståne Natural Fertilizer, Inc. (US)[51]

Founded in the US in 1980, Suståne is the world's leading manufacturer-exporter of organic and natural base slow release fertilizers for all green industries. Suståne controls the raw materials, the composting process and manufacturing process from start to finish. Suståne utilizes renewable agricultural resources to create a unique base of products through aerobic composting.

Main Products: Suståne has a great variety of OFs for various crops, among other:

- **SUSTANE 3-7-4:** granulated OFs made from nutrient-rich, concentrated compost. For use in the production of certified organic crops, as a general soil builder, crop starter fertilizer, organic phosphorus source, erosion control, and remediation.
- **SUSTANE 4-6-4:** is an organic slow-release starter fertilizer and soil builder for all types of plants. Ideal for vegetables, roots, herbs, fruits, and flowers.
- **SUSTANE 5-2-4:** is a natural organic slow-release nitrogen fertilizer that provides a high amount of organic nitrogen for lasting plant nutrition (6-12 weeks). For use in the

[51] Source: https://www.sustane.com/

production of certified organic crops, greenhouses and bedding plants, and annual establishment.

Turkey litter provides the base for most of Suståne's Natural Fertilizers. Turkey litter consists of manure and the softwood shavings that is used as bedding. When the barns are cleaned the turkey litter collected is transported to The Suståne Compost Facility.

Markets: Suståne has a wide international presence exporting its products to more than over 60 different countries in all 50 states in the US and the rest of NA, Central America & the Caribbean, Europe, the Middle East, APAC, Algeria and Mauritius.

Customers: Suståne Natural Fertilizers are used by professional turf and landscape managers, farmers, growers and horticulturists worldwide.

Innovation: Suståne is the most thoroughly researched OF product available. Suståne products are backed by over 30 years of independent applied research on diverse crops and ecosystems. Since 1980 Suståne has compiled over 500 independent research studies to create the most effective and user friendly fertilizers available.

ILSA S.p.A.(Italy)[52]

Founded in 1956 in Italy, ILSA is a global provider of OFs, organo-mineral fertilizers and biostimulants. The mission of the company is to meet the needs of an increasingly specialized agriculture by helping farming business people increase the quality and production yields of their crops in a socially responsible and environmentally friendly fashion.

Main Products: The company owns three production facilities, two in Italy and one in Brazil. ILSA has a huge range of OFs:

- BIOILSA LINE: more than 14 different organic and organo-mineral fertilizers characterized by a high content of slow-release nitrogen suitable for organic farming of vegetables, cereals, trees, vines, fruits and many other crops and plants. Among other:
  - **BIOILSA 777:** Export is a pelleted nitrogen-phosphorus-potassium (NPK) organo-mineral fertilizer able to provide complete nutrition to vegetable, grass and tree crops.

[52] Source: https://www.ilsagroup.com/en/home/

- **BIOFRUTTETO KS:** organic-mineral pellet fertilizer with high nutrient efficiency used both in underground and enrichment fertilizations and in particular on crops in need of potassium.
- **BIOILSA:** is an organic nitrogen fertilizer characterized by organic nitrogen naturally sloe-released.

- ILSAGRO LINE: organic and organo-mineral fertilizers for turf.

Markets: ILSA has a global presence in 49 countries mainly in Europe, Asia, LA, Morocco and South Africa and New Zealand.

Customers: Industrial crops (peanut, sugar beet, hemp, cotton, sunflower, soybean, tobacco), farmers cultivating cereals, legumes and potatoes, (leafy) vegetables (stone) fruits, tropical crops, etc.

Innovation: In order to be able to compete globally ILSA has to constantly innovate and meet the highest standards of the industry. For this since 2005, the Corporate Research Center collaborates with major Italian Universities occupying their highly skilled staff (chemist, agronomists, engineers and biotechnologists) for continuous improvement of the solutions/products in order to stay on the top of the biotechnology industry for nutrition and biostimulation of plants**.**

As a result of over 60 years of innovation, research and experimentation, organic matrix AGROGEL is a completely natural hydrolyzed gelatin for agricultural use that is capable of combining agronomic efficiency with the increasingly pressing environmental issues.

Latest Developments:

The most important industrial and commercial Group at a world level in the bio-stimulant sector was established in 2017 when BIOLCHIM S.p.A. acquired 60% of the share capital of ILSA.[53]

AgroCare Canada Inc. (Canada).[54]

AgroCare was founded in 2012 in Canada and it is one of the leading OF manufacturers. The manufacturing facility is based in Ontario and the company has an efficient distribution

[53] The Group also includes the Italian company - CIFO, the Canadian company - West Coast Marine Bio Processing, producer of seaweed extracts and the Hungarian company – Matècsa.
[54] Source: http://www.agrocarecanada.com/about.html

network around the world. The vision of AgroCare is to provide affordable, high efficient, biodegradable and environment-friendly soil enhancement products, technology and solutions to agricultural partners around the world.

Main Products: AgroCare products are 100 % natural and are derived from organic material designed to increase agricultural yield by improve the quality of soil in all type of farms, among other:

- **ALGACan:** 100% fresh seaweed extracted from brown varieties of seaweed that contains more than 70 minerals and it improves the soil condition as well as stimulates plant growth.
- **FULVICan:** is highly concentrated Fulvic Acid extracted from natural vegetable source. It encourages healthy plant growth by allowing absorption of more nutrients and increasing the water storage capacity within the plant. It also prolongs the time that essential nutrients remain in the plant maximizing the nutritional potential.
- **AMINOCan** is extracted from soybean cake and it contains 18 varieties of L-Amino Acids which are widely used as base fertilizer in all kinds of agricultural crops.

Markets: AgroCare has an international presence that includes countries in APAC, Europe, the Middle East and Africa as well as NA, LA and Central America.

Customers: All types of business farms, gardens and lawns.

Innovation: The research model of the company is based on involving the end-users throughout the product's R&D cycle and by giving to the expert customers guiding roles in the research process. Company conducts customer surveys around the globe and then gathers all the relevant information and data in order to optimize the existing fertilizers, develop new ones and implement new agriculture solutions and advanced technologies. Future research and innovation includes the development of new fermentation process and new raw material to enhance effectiveness, improving soil quality and enhancing water-holding capacity.

NOVOZYMES A/S (Denmark)

NOVOZYMES A/S (click the link) is already analyzed in the subsection 4.2.3 Competitive Landscape for BFs.

EUROPE

PLANTIN SARL (France)[55]

Established in 1880, PLANTIN is a French manufacturer of fertilizers with international scope. For more than 140 years, the company has supported its development on its industrial know-how, its culture of innovation and its responsiveness in order to offer its customers effective and sustainable fertilizing solutions. PLANTIN has a turnover of €10 million, 40% of which is exported. The company works in close collaboration with its customers getting important feedback from customers in order to optimize its products and achieve the recognition and satisfaction of its customers.

Main Products: The company produces innovative and highly technical fertilizers, adapted to each crop: field crops, viticulture, fruit arboriculture, vegetable crops, green spaces, ornamental crops, etc. PLANTIN provides huge variety of granular, pellet, liquid fertilizers, water soluble powders, among other:

- ORGAPLANT (organo-mineral fertilizers): made from a mixture of organic matter of animal origin and mineral matter, adapt to all types of crops.
- ORBYOPLANT: organo-mineral fertilizers ensuring quality nutrition and providing farmers with all the essential nutrients to feed their crops while remaining within the framework of organic farming.

Services: The team of technicians and the R&D department supports and guides customers in their cultivation practices. The R&D department develops new products and manufactures formulas on demand.

Markets: present in more than 20 countries around the world with the distribution of the product extending mainly to Europe and LA, the US but also Africa, the Middle east and Asia.

Customers: Farmers

Innovation: PLANTIN invests in R&D activities to improve process technology, crop nutrition strategies and environmental solutions.

[55] Source: https://www.fertilizers-plantin.com/who-are-we/

AGRIBIOS ITALIANA S.r.l. (Italy)[56]

AGRIBIOS ITALIANA has been working since 1973 in the field of fertilizers, specializing in the production of fertilizers, OFs, mineral organs and fertilizers for organic farming.

Main Products: The organic matrix of AGRIBIOS ITALIANA's products are initially obtained from a mixture of manures from different origins and after a long period of fermentation and natural drying being characterized by a high quality level. The company produces large variety of soil conditioners and correctives, OFs among other:

- Organic Nitrogen Fertilizers (Agriorganico 5%, 7% and 10%): It delivers slow-release organic nitrogen, rich in aminoacid and humic acids, facilitates the development of soil micro-organisms
- Organo-Mineral BFs (Biocomplex): ideal for the biological fertilization of vineyards and orchards, it delivers all the key nutrients.
- NPK Organo-Mineral Fertilizers: High content of active organic substance, increases cation exchange capacity, improved in chelating and acidifying action.

Markets: Europe

Customers: Farmers

Fertikal NV (Belgium)[57]

Fertikal is a Belgium based leading producer of OFs and organo-mineral fertilizers.

Main Products: Company produces wide range of fertilizers, among other:

- Organic fertilizer (NPK 4-3-3): it contains a high percentage of organic material as well as important trace elements. This OF is made of 100% chicken manure.
- Organic compound fertilizers (NPK 8-3-3): used as base fertilizer for a range of different crops. They mainly contain organic matter, phosphorus, nitrogen, potassium and in addition important trace elements
- Organo-mineral fertilizers (NPK 4-2-10): combines the advantages of organic and mineral fertilizers. Fits standard organic NPK formulas to the customer's specific requirements

[56] Source: https://agribiositaliana.it/en/
[57] Source: https://www.fertikal.be/en/

- All products can be tailored to the customer's requirements.

Services: customized advices by the company's agronomists.

Markets: Fertikal has significant international presence and sells its products to over 55 countries in Europe, Africa and Asia.

Customers: Farmers

CHINA

China's OF market is fragmented in nature as there are many players with small shares in the market. Various strategies are adopted by the major companies that operate in China, such as product launches, partnerships, and acquisitions, to gain a larger share in the market. In 2018 for example, KIWA BIOTECH established a joint venture with Postal Savings Bank of China Co. Ltd to provide financial assistance to its clients, including professional farmers, crop growers, family farms, etc.

Qingdao Hibong Fertilizer Co Ltd[58]

Qingdao Hibong is located in Shandong, China. The company is mainly engaged in R&D and manufacturing of OFs, organic liquid fertilizers, seaweed fertilizers and others. Qingdao Hibong carries many years of experience in the OF industry and possesses top OFs innovative technologies, advanced production facilities and highly-qualified service team. The mission of the company is to contribute to organic green agriculture with the focus on the environment and human health.

Main Products: The company produces a variety of OFs in solid or liquid form, among other:

- Humic Acid Granular Fertilizer: slow released OF containing 70% humic acid from leonardite.
- Organic Bacterial Column Fertilizer: made of high temperature puffed food leftovers, contains NPK elements, calcium and silicon. Ideal application for vegetables, fruit trees and flowers.
- Seaweed Organic Granular Fertilizer: made of raw material seaweed processed under high temperature fermentation. Contains NPK elements, humic and amino acids and trace elements.

[58] Source: http://www.hbfert.com/en/

Markets: The company has a strong presence in China operating mainly in Shandong, Hebei, Henan, Guangxi, Yunnan, Xinjiang, Liaoning, Inner Mongolia, Jiangsu, Zhejiang and Sichuan provinces. Moreover, company has developed a wide international network around the world exporting to over 60 countries including Japan, South Korea, Pakistan, Turkey, the US and the Middle East countries, etc.

Customers: Chinese and overseas organic farmers.

Innovation: The company has strong R&D focusing on innovation and development of new fertilizer products. The highly qualified research team of the company is equipped with cutting edge technology labs, large scale testing farms. Moreover, the company is engaged in cooperation with agricultural universities and research centers and overseas research labs. Recently the company has established banana trial fields in Guangxi Province, wheat trial fields in Shandong Province and vegetables trial fields Jiangsu Province.

Qingdao Future Group[59]

Qingdao Future Group is a worldwide leading manufacturer of OFs and biostimulants and a supplier of organic agriculture solutions and services. The company understands the transition from total reliance on chemical and synthetic fertilizers towards sustainable agricultural solutions that are environmentally friendly. The approach of the company is to work closely with manufacturers, sellers and most importantly with farmers in order to address the environmental degradation in a responsible way.

Main Products: The company has a big variety of products for crop protection, crop immunity, biostimulants and innovative fertilizers, among other:

- Organic Granular Fertilizers:
  - Star Bio Bacteria: composed of bio-bacterial manure, increases the organic matters in soil and provides crops with NPK elements.
  - QFG Organic pure G45: made of raw material cassava residues after fermentation. Rich in organic matter, can improve soil and serve as soil conditioner.

[59] Source: http://www.cnfuture.com.cn/

- OFs made of plant source, it provides organic matter, humic and amino acids from natural resource and NPK elements to the plant. It can regulate well the soil and act as soil conditioner.

The product quality assurance is of the highest standards, more specifically it meets the EU and NOP (National Organic Program)[60] organic standards and each product is monitored according to these standards through the entire process of production.

Services: On top of its wide variety of products for organic agriculture the company also provides wide range of services, among other:

- **Formula raw material:** Supplies fertilizer factories around the world with raw materials - guarantying the price, quantity and quality - so they can produce fertilizers for local crops.
- **Crop Nutrition Solutions:** provides scientific nutrition solutions for various crop needs and plants. The company cooperates with more than 20 countries to develop scientific and efficient crop nutrition solutions for local farmers.
- **Fertilizer Customization:** Fertilizer OEM service aims to produce fertilizers according to the customer's fertilizer specifications. Basically, providing customers from different countries with customized fertilizers that fit their purpose better depending on the climate, soil and water quality.
- **Package Customization:** The company provides customers with free packaging design and customized packaging services.

Markets: China, Southeast Asia, NA, LA, Africa, Oceania, Middle East.

Customers: Fertilizer manufacturers, commercial farmers, fertilizer wholesalers.

Innovation: Scientific research cooperation with domestic institutes such as Qingdao Agricultural University, China Agricultural University in Beijing, Beijing Forestry University, Wenshan Academy of Agricultural Sciences and the Southwest Forestry University. Moreover, the company is engaged in cooperation with international research centers such as Griffith University (Australia) and the European Biostimulant Industry Council.

[60] Source: https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program

Seek Biotechnology Co. Ltd (Shanghai)[61]

Founded in 2008 in Shanghai Seek is a global leading company of carbon fertilizer. Company's strategy is to build strong partnerships and long-term relationships around the world and make joint efforts to develop the local market, to provide better solution for the local growers and satisfy their requirement.

Main Products: Seek supplies biochar based OFs and water soluble fertilizer with carbon power (extracted from biochar).

- OFs with Bamboo Biochar: base fertilizer to improve soil health and increase yield, suitable for vegetables, melons, solanaceous, fruits, horticultures, high value crops, field crops, etc. Must be stored in sealed packing to keep cool and dry and avoid direct sunlight.
- Bio- OFs

Markets: Company has strong presence in APAC region (S. Korea, Japan, Shanghai, mainland China, Taiwan, Malaysia, Pakistan, Iran Australia and New Zealand) but also in Europe (France, Portugal, UK and Turkey), the Middle East (Jordan and Iran), the US and Brazil.

Customers: Farmers

Innovation: Intensive research cooperation with several international institutes such as the Griffith University in Australia, the Chung Chou University of Science and Technology in Taiwan and the Nanjing Agricultural University in China.

Latest Developments:

In 2018 Seek built the biggest carbon fertilizer factory in the world alongside a research center settled in Guizhou, China.

KIWA BIOTECH (China)

KIWA BIOTECH (click the link) was already analyzed in the subsection section 4.2.3 Competitive Landscape for BFs.

[61] Source: http://www.seekfertilizer.com/

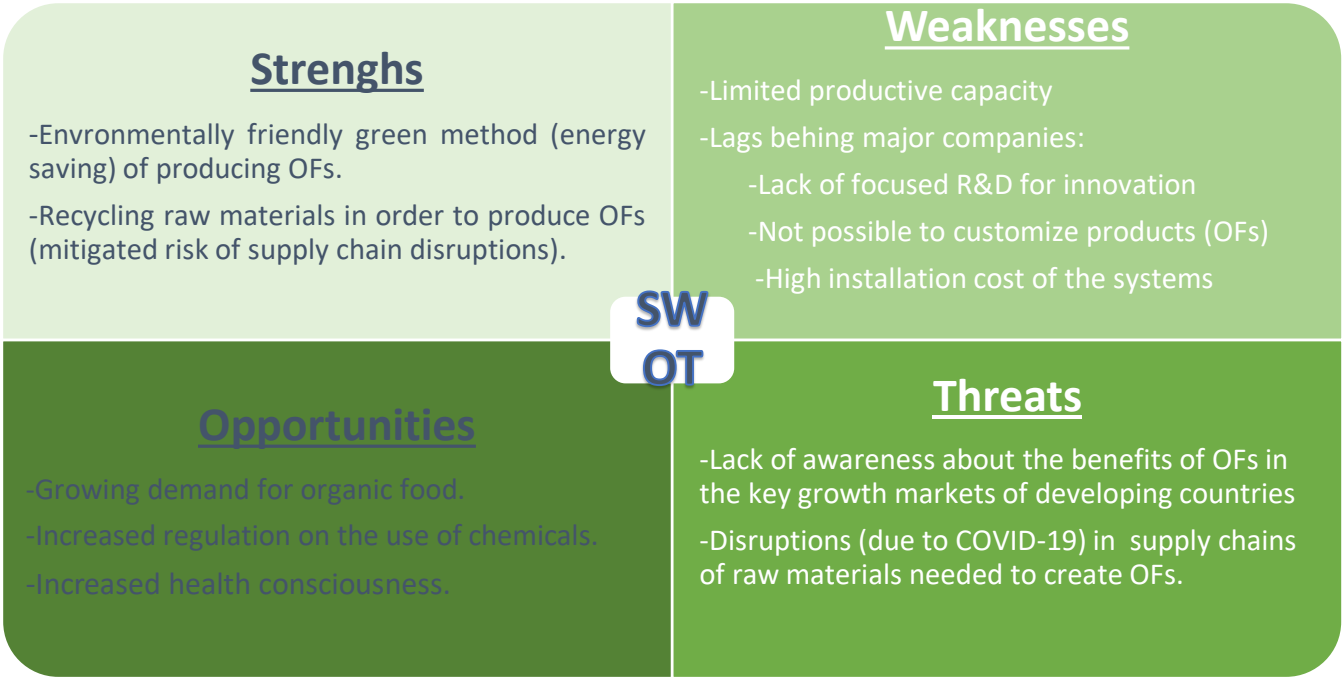
4.3.4 PESTELI Analysis

OFs share the same PESTELI analysis as the BFs so see 4.2.4 PESTELI Analysis for the PESTELI analysis of OFs.

4.3.5 SWOT Analysis

In this section we present the SWOT analysis (summarized in Figure 8) for the OFs produced by the Urban Composting Hub, Garbage Processor and the GREENergy concept.

Figure 8: SWOT Analysis for SiEUGreen OFs



Internal Strength

The eco-friendly method to produce OFs using SiEUGreen technologies constitutes itself an internal strength for SiEUGreen OFs. The entire method of production is based on the principle of circular economy and more specifically on recycling and processing already existing (organic household/kitchen) waste or wastewaters into OFs that can be used in the production of plants, flower, fruits and vegetables, etc. Competitors may be using more efficient ways to produce OFs but surely those methods require higher amount of energy and raw materials.

Furthermore, most of the companies that produce OFs in the market use as primary inputs raw materials provided by third parties. This makes the production of OFs vulnerable in circumstances such as those that we currently experiencing due to the current pandemic. Restrictions and delays in the provisions of the inputs needed for the production of OFs can

cause significant disruptions in the production of OFs and hence in their supply to the market. In the case of SiEUGreen the production of OFs does not depend on raw materials coming from third parties but instead it is based on the circular economy principle of recycling local waste streams and processing them into OFs.

Internal Weaknesses

Just as in the case of the SiEUGreen BFs (see, 4.2.5 SWOT Analysis) the SiEUGreen OFs lag behind the OFs of other major companies in the market. The base for this claim is rested on four main points. First, the leading companies in the field of OFs focus their research on the continuous improvement of their products and constant innovation to produce new more efficient and widely applicable OFs. Second, these producers of OFs offer advanced services including highly customized solutions for their client and field testing of more and more efficient products with specific customization for clients. Hence, it would be difficult to compete such companies we an ad-hoc product that is not widely applicable (in terms of variety of crops and plants) and cannot be easily customized to meet the needs of clients. Third, another major weakness over competitors is the high cost to install technologies/systems used in GREENergy concept (or the Urban Composting Hub) in order to recycle waste and wastewaters and process them into OFs. Finally, the SiEUGreen OFs are not produced on a large scale because they are bounded by the limited productive capacity of the Garbage Processor and Urban Composting Hub.

External Opportunities

Many countries are facing the challenge of a rapidly growing demand for food due to the fast population growth and hence the need to increase their agricultural production. In order to increase their agricultural output, farmers around the world have been overusing chemical fertilizers to meet the needs of the surging demand for food. However, as it is known the use of the chemical inputs have been linked to a wide range of threats to human health and adverse effects on the environment. This has led agricultural producers in the high-income countries to increasingly prefer the OFs as a safe alternative to chemical fertilizers. OFs don't contaminate the soil, ground water or the environment as they are naturally derived from the nature. What is more, OFs are a much cheaper and cost-effective alternative to chemicals and excellent plant and soil conditioner. Therefore, factors such as the growing need to increase agricultural production and increasing awareness about the harmful effects of chemical inputs augment the demand for OFs.

Moreover, governments around the world have launched initiatives, imposed new regulations and followed new policies as a means to mitigate the heavy ecological impact from the use of chemical fertilizers. Faced with environmental degradation countries are promoting organic farming and encourage farmers to adopt alternative methods to grow their crops. Clearly, these efforts to reverse the environmental damage and impose more stringent restrictions on the use of chemical fertilizers constitute another major driver for OFs market.

Furthermore, in the last years even prior to COVID-19 outbreak we have witnessed a changing attitude towards health and the environment in many countries around the world. People have become more conscious of their health and of the environment that they are living and this has a tremendous impact on their consumer behavior. It seems that more and more people now are inclined to consume organically produced food which they consider beneficial for their health -because they avoid the chemicals used in commonly produced agricultural products- and the environment -due to the eco-friendly production that is involved in the organic production.

External Threats

The major threat to OFs market seems to be the lack of awareness about the benefits of OFs in the key growth markets. Farmers across developing and underdeveloped countries continue to use synthetic/chemical fertilizers as they are considered to be cheap and easily available in their markets. Thus, it is expected that the lack of understanding of the benefits of OFs would hinder the business development in the less developed areas of the world. However, the continuous promotion of organic farming and its advantages over conventional farming alongside with the training and education provided by various international organizations can raise the awareness regarding OFs and encourage their adoption even in the less developed countries.

One current external threat is the impact of COVID-19 on the OFs market. More specifically, the OFs market is challenged by the lockdowns, supply-chain disruptions, curtailment of production, and overall economic impacts of the current pandemic. The world's largest producers and consumers of OFs such as the US and China but also the markets of Australia, Brazil, India, Germany, France, Italy, Spain and the UK have been affected from the outset of the pandemic. The OFs are directly affected by the international restrictions and lockdowns as their production majorly depends on raw materials such as animal and plant waste that in many cases are imported from other countries. Many markets are focused on fulfilling their requirements for OFs through domestic providers but obviously there is a big gap between

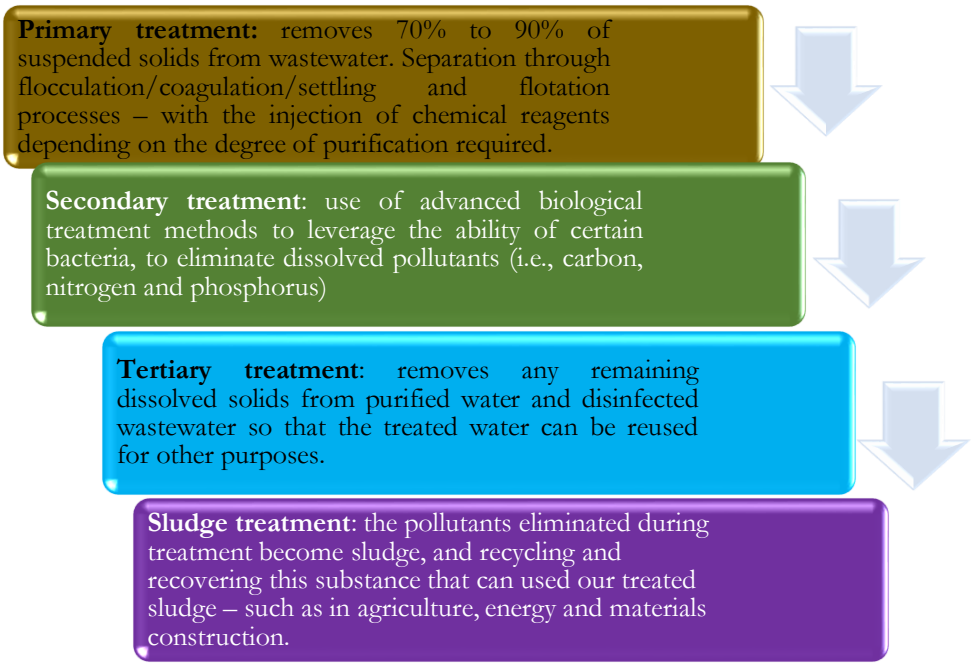
demand and supply. Thus, in the view of the current circumstances market players are compelled to create new supply chains, increasing costs and the time to supply the organic farmers. All in all, this situation has adversely affected the OFs in terms of revenue in 2020 and it is expected to have a negative impact also in 2021 (Meticulous Research, 2020).

However, as we have mentioned in the Section 4.2.5 SWOT Analysis for BFs, the current pandemic can also have a positive effect on OFs due to the increased awareness of people regarding health. Being more conscious of their health people are likely to change their preferences towards more natural and organically produced food, increasing the demand for OFs in agricultural production.

4.4 Water and Wastewater Treatment Market

Wastewater is used water that includes substances such as human waste, food scraps, oils, soaps, chemicals (US Geological Survey n.d.). This includes water from sinks, showers, bathtubs, toilets, washing machines, dishwashers, storm water and wastewaters from businesses and industries. The major aim of wastewater treatment is to remove as much of the suspended solids as possible before the remaining water is released back to the environment (see, Figure 9). If not properly treated wastewater can negatively affect the environment and human health i.e., harm to fish and wildlife populations, contamination of drinking water and oxygen depletion, respectively. Therefore, the water and wastewater treatment plants have become imperative to reduce the pollution. These plants collect

Figure 9: The cycle of wastewater treatment



effluent from industrial, municipal and agriculture sources and treat it to a level of purification that enables its reuse in agriculture, industry, and even as a potable drinking source.

It is estimated that globally about 80% of wastewater and over 95% in some least developed countries returns to the ecosystem without being treated or reused (UN World Water Assessment Programme, 2017). This puts at high risk of contracting infectious diseases (e.g., cholera, typhoid, polio, etc.) around 1.8 billion people who use a contaminated source of

drinking water. As it is obvious, the management of the wastewater is of a great importance to a circular and therefore more sustainable economy and it will play a major role as population grows and the demand for water is increasing rapidly.

4.4.1 Global Market Insights

The water and wastewater treatment (W&WWT) market was $154 billion in 2020 and it is expected to grow at a CAGR of 6.7% from 2020 to 2027 to reach $242.6 billion by 2027 (Meticulous Market Research, 2020).[62] The major factors driving this market include the rapid population growth and urbanization, quickly diminishing freshwater resources across the world, rising focus on water quality and public health, increasing prevalence of waterborne diseases and stringent government regulations on treating wastewater.

The APAC region is developing and expanding at a significant pace and it is estimated to command the largest share of the W&WWT market in 2020, followed by NA, Europe, LA, the Middle East and Africa. The large share of APAC region is primarily attributed to the fact that the treatment of the wastewater is one of the highest priorities of several countries of this region (e.g., China, India and Japan). Moreover, the increasing population, rising demand for advanced residential water treatment, increased environmental deterioration and the declining availability of clean water in this region create the urgency for public-sector investments in water infrastructure and R&D. Moreover, as APAC countries are adopting tougher laws on water usage and its discharge to the environment, the wastewater treatment systems market in these countries is expected to have the highest growth during the forecast period 2020-2027 and is likely to dominate the market. China is expected to dominate the APAC market due to huge population base and industrialization, rising untreated sludge, and large wastewater discharge.

Based on the application the W&WWT market is classified into municipal and industrial segments. On a global scale the municipal segment had the largest share of the market in 2020. This is mainly driven by the raising awareness of the general public about water quality and health. In developing countries, governments have intensified their efforts in developing

[62] The global wastewater treatment system market is expected to grow at a CAGR of over 5% during the forecast period 2019-2025 and reach $15 billion by 2025 (Infoholic Research, 2019). Major driving force of this market is the great advancement in research has led to the development of more efficient membranes (i.e., biomimetic and carbon nanotube-based) to be used in of wastewater treatment systems.

W&WWT projects in their rapidly growing cities. At the same time, governments of developed countries have pushed forward projects to renovate their aging municipal W&WWT infrastructures and invest mostly to refine their processes and make them cost effective and resource efficient.

However, the segment of the industrial wastewater treatment is projected to grow at the highest CAGR due to the growth of the global industrial and commercial activities - mainly in Asia. In simple terms, industrial wastewater is a by-product of those activities and the increasing pressure from public authorities on the industry to improve water efficiency and reduce pollution discharges is expected to bring about substantial increase to the industrial segment of W&WWT market.

Increased amounts of untreated sewage have concentrated the focus of several countries, such as the US, China, and India, and the rising need for potable water provide significant opportunities for municipal applications of W&WWT in these countries. Furthermore, the majority of drinking water used in Middle East countries (e.g., Israel and Saudi Arabia) is generated from the desalination process, which is likely to boost the demand for municipal W&WWT technologies. Hence, it is safe to say that the municipal W&WWT is likely to dominate the market of the Middle East, during the forecast period.

EUROPE

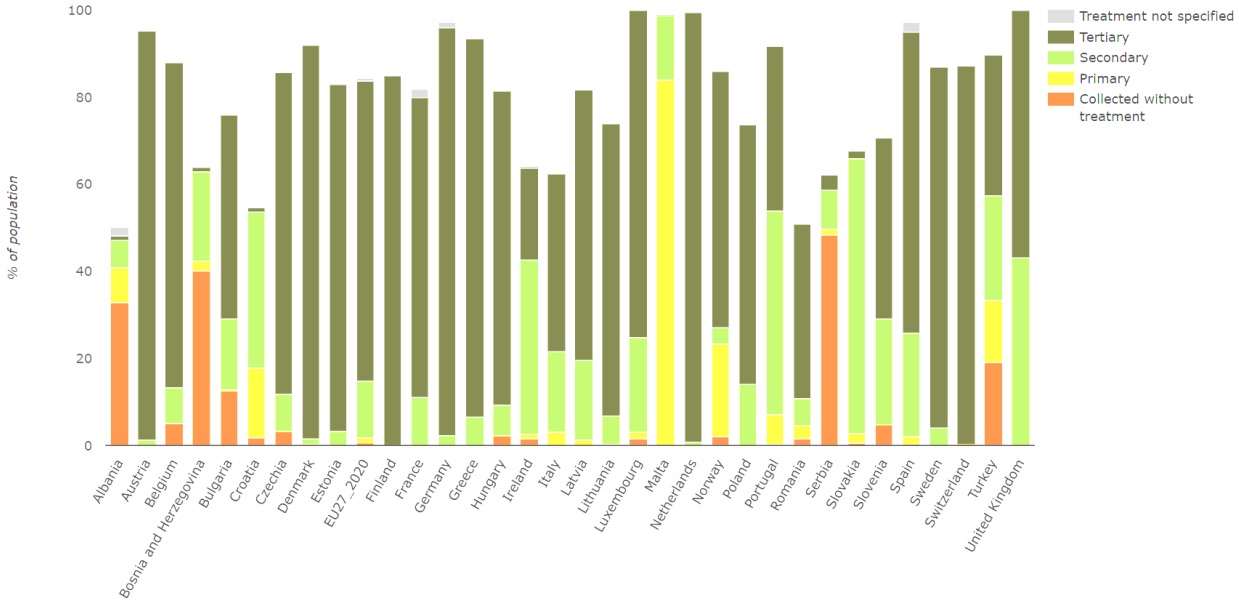
The European market is expected to grow at CAGR of 3.6% in the period from 2020 to 2025 (Market Data Forecast, 2020a). Although W&WWT industry in the EU is mature and has been subject to continuous tightening of water quality regulations (Council Directive 91/271/EEC, 1991) the market drivers are still dominated by the implementation of stricter regulations and the need to reduce energy costs in treatment processes. Innovation is therefore focused on applications that will produce higher quality water at lower costs.

The latest report on the implementation of the Urban Waste Water Treatment Directive shows that the 95% of waste water is collected within EU and the 85% is biologically treated (Urban Waste Water Directive, 2020). However, there is still 1% of urban wastewater not collected and over 6% that is not sufficiently treated to meet the high standards of biological treatment. The investment in many member countries seems quite low to follow the standards of the directive. Hence, there is a need to renovate and modernize the existed infrastructure to collect wastewater and develop new state of the art treatment plants. It is expected that in order to follow the directive's mandate many of the member countries,

especially those with low level of wastewater treatment (see, Figure 10) will invest in this area and drive the EU market growth.

In 2018, Germany and the UK were the leaders in Europe with over 20% and 16% of the EU market revenue, respectively. This can be attributed to the rising initiatives of the governments in these countries to reuse the industrial wastewater and the increasing investment in residential and industrial wastewater treatment applications. The UK alone has over 7,000 sewage treatment plants over the country. However, the highest market growth is expected to take place in France due to the focus of local municipalities on wastewater treatment and strict regulation. In addition, the recent development with the merging of two world leaders in water, Veolia and Suez places France at a dominant position in the market.[63]

Figure 10: European urban wastewater collection



Note: *Shows the proportion of urban wastewater collected and the level of treatment applied as a percentage of the population in 2017. Data Source: Eurostat, 2020,* ***http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ww_con&lang=en.*** *Raw* ***yearly data*** *on connection rates of resident population to wastewater treatment collected biennially by means of the OECD/Eurostat Joint Questionnaire - Inland Waters. Data aggregation: national territories.*

Furthermore, European countries were the wastewaters are not treated sufficiently can be considered as those with the potential market upside for the years to come. The pressure to

[63] Veolia press release on 5 October, 2020. https://www.veolia.com/sites/g/files/dvc2491/files/document/2020/10/Finance_CP_Veolia_Engie_Suez_051020_ENG.pdf

comply with the European regulation and converge to the target levels on wastewater treatment may generate growth opportunities in the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Ireland, Italy, Lithuania, Poland, Romania, Serbia, Slovakia and Slovenia, where less than 80 % of the population were connected to public urban waste water treatment systems (see Figure 10).

In Europe on the basis of technology tertiary treatment is quite likely to expand due to its intensified application in municipal sewage treatment across European cities. In accordance to the circular economy models the treated effluent can be reused for urban, agricultural, industrial and recreational uses. The call for wastewater treatment and for innovative equipment to dispose water and wastewater in a cost effective and resource efficient manner has picked up for both municipal and industrial applications due to public concerns over environment.

CHINA

The Chinese wastewater treatment market should reach $58.2 billion by 2022 from $42.1 billion in 2017 at a CAGR of 6.7%, from 2017 to 2022 (BCC Research, 2018). Increasing demand from the industrial sector is a major driving factor for the Chinese market. According to the China's National Bureau of Statistics, the industrial sector grew by 7.2% between January and February of 2018, as compared to the same period a year earlier, exceeding economists' forecasts (6.1%). China is expected to dominate the Asia-Pacific market through 2027, mainly due to its large population base and industrialization, rising volumes of untreated sludge, and significant wastewater discharge (Meticulous Market Research, 2020).

4.4.2 W&WWT end-user/customer segments

The total addressable market was $154 billion in 2020 and it is projected to be $242.6 billion by 2027. With the start of a widespread use of W&WWT it can be argued that customers do not differ significantly by age, gender, education or income. Countries all over the world including developed, underdeveloped and developing countries make use of W&WWT systems but obviously to a different extent. The end-users/customers might be influenced by the global trends regarding the worsening of the environmental conditions and the increasing global awareness of health and ecological benefits associated with the treatment of water and wastewaters. In addition, the rise in the public awareness for health and wellbeing due to the current pandemic (COVID-19) is an important reason for customers to adopt more efficient and effective methods for the W&WWT.

Potential customers have been identified by the partners in the Deliverable 5.4-Sustainability and Exploitation Plan:

- **Green building developers** can install such systems in the context of circular economy in order to recycle the water and wastewaters and reuse them for the needs of residents.
- **Public authorities and city planners** can make use municipal water and wastewater treatment in order to design smart and resilient cities,
- **Urban farming companies & practitioners** can use W&WWT for irrigation and fertilization of agricultural crops,
- **SMEs** can use W&WWT to produce various products (chemicals, food and beverage, etc.).

4.4.3 Competitive Landscape

In this section we conduct a detailed analysis of main competitors in on Global, European and Chinese level. In the Table 11 below we provide a brief summary of major competitors for SiEUGreen W&WWT system.

Table 11: **Major Global Competitors in W&WWT market**

Competitor	Geographical Coverage	Solutions/Services	Customers	Strengths	Weaknesses
Veolia Water Technologies (est. in 1853 in France)	Transnational company operating in Europe, NA, LA, South East Asia, Middle East, South Africa & Australia	wastewater recycling, sanitation & sludge treatment technologies; recovery of reusable materials wastewater.	Municipalities, Industries (Food & Beverages, Oil & Gas, Pharmaceutical), Public Authorities	• Large market share (acquisition of SUEZ) • No. 1 in wastewater recycling (sewage treatment know-how) • able to manage the entire water cycle for industries and public authorities	• Not identified
Suez Water Technologies & Solutions (France est. 1869)	Europe, Africa, Asia, the Middle East, LA & NA	water management, recycling and waste recovery, water treatment, and consulting services	Individuals, Local Authorities, &Industrial Clients	• Strategic acquisitions and penetration of key growth market (Greater China) • Wide range of customized services and solutions and high expertise in W&WWT	• Not identified

Evoqua Water Technologies Corporation (est. 2013 in the US)	Europe, the US, Canada & APAC 160 locations across 12 countries	Municipal drinking water and wastewater treatment Industrial wastewater treatment	Municipalities and Industries (food & beverages, pharmaceutical), recreational customers	• Extensive experience and great expertise in municipal W&WWT. • Large variety of solutions and services	• Does not cover the key growth markets in LA & Africa
Gradiant **(est. 2013 in Singapore)**	China, the US, India Australia & South East Asia	Water and wastewater solutions for various industries	textiles & tanneries, power generation, food & beverages	• Strong focus on innovation • Solutions that enables the treatment of wastewaters that have previously not been treated • Strategic acquisitions to penetrate key markets	• No presence/share in the European market
Beijing Capitol Co., Ltd **(est. 1999 in China)**	100 cities in 27 provinces in China, serving 50 million people	water transmission, water system management, water network maintenance	Public authorities, municipalities, autonomous regions.	• China's top company in W&WWT • State-owned corporation (easy market access)	• Limited spatial coverage • Limited range of services
GREENergy W&WWT system **(SCANWATER NIBIO, NMBU & HHEPSTI)**	Potentially China and Europe.	Integrated solution across the entire process of W&WWT.	Municipalities and public authorities, private developers.	• Integrated decentralized solution for W&WWT. • Partnership with China. • Showcase demonstration.	• High cost of equipment & installation. • Ad-hoc method not easily adaptable.

GLOBAL (& EUROPE)

The market for W&WWT technologies is moderately fragmented, as the market share is divided among a large number of players. However, companies like Veolia and SUEZ are considered to be leaders in the W&WWT as they offer integrated solutions, variety of products and services that cover the entire cycle of W&WWT. Common strategy is mergers and acquisition in order to penetrate new growth markets and establish a dominant position. Some of the key companies of the market include Veolia Water Technologies, Suez Water Technologies, Evoqua Water Technologies, Xylem Inc., etc.

Veolia Water Technologies (France)[64]

Veolia is a top global provider of W&WWT services with a wide range of solutions in sustainable water recovery and water purification. Veolia designs and builds drinking water production and wastewater treatment plants worldwide for municipal and industrial clients. Veolia in numbers: 96 million people supplied with drinking water, 62 million people are connected to wastewater systems, 4,117 water production plants managed, 2,878 wastewater treatment plants managed.

Solutions: Veolia has a wide range of solutions including: wastewater recycling, sewage and sludge treatment technologies, sanitation technologies and recovery of reusable materials from wastewater.

Veolia has developed innovative, competitive solutions and top-level expertise that manage industries' entire water cycle: from abstraction or desalination to producing process water through to treating and recycling wastewater and sludge.

Veolia have supported and lent its years of expertise on managing the complete water cycle and know-how on all aspects of water services to public authorities. Veolia's brief is to make water safe to drink. That is to ensure it complies with the health standards as defined by the World Health Organization (WHO) and EU or by legislation passed in each individual country and improve the taste for the greater satisfaction of the consumer.

Customers: Public Authorities, Municipalities and Industries. Veolia extracts value out of wastewater by helping its customers to generate reusable water and produce fertilizer,

[64] Source: https://www.veoliawatertechnologies.com/en/applications/wastewater

nutrients and thermal and electrical energy. This spurs the economic growth of cities in a sustainable manner and improves the quality of life.

Markets: Europe, NA, LA, South East Asia, the Middle East, South Africa & Australia

Innovation: Veolia Water Technologies' treatment technologies include among other:

- **Actiflo:** high-performance water clarifier for municipal and industrial water treatment, also used in Veolia's mobile water service.
- **Biostyr:** bio solution for the filtration of water, enabling removal of pollution (organic and nitrogenous) in a compact structure, thereby presenting a low environmental footprint.
- **MBBR (moving bed biofilm reactor):** systems are active biofilm carriers with optimal bacteria culture conditions for wastewater treatment. It is compact, simple to operate and very efficient for the removal of biochemical oxygen demand, ammonia and nitrogen. Makes it possible to extract the value from sludge without generating undesirable effects.

Latest developments: In October 2020, Veolia proceeded to acquisition of 29.9% of Suez's capital from Engie to fulfill its intentions in taking control of Suez[65]. This acquisition gives an unprecedented market strength and dominance to Veolia creating the great French world champion in ecological transformation.

Financial Highlights:[66] Financial report of the Group Veolia Environmental:

- Up to September 2020 the consolidated revenue was € 18.7 billion down 5.4% from 2019 (9 months).
- Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) was € 2.5 billion down 13.9% compared to the prior year.
- Current Net Income of € 149 million down 69.3% compared to 2019.

[65] Source: Veolia press release on 5 October, 2020. https://www.veolia.com/sites/g/files/dvc2491/files/document/2020/10/Finance_CP_Veolia_Engie_Suez_051020_ENG.pdf

[66] Source: https://www.veolia.com/sites/g/files/dvc2491/files/document/2020/11/Finance_RG_Q3_2020_v06112020_EN.pdf

Suez Water Technologies & Solutions (France)[67]

SUEZ draws on the expertise it has been developing since the late 19th century (1869) to help people constantly improve their quality of life by protecting their health and supporting economic growth. SUEZ helps customers by providing wastewater systems to meet ever increasing environmental, regulatory, and financial pressures. It operates in four business segments, namely Water Europe, Recycling and Recovery Europe, International, and Other segments.

SUEZ's Global Strategy is based on four pillars:

- International development: SUEZ has a strong presence in the growth markets of Asia and LA. Enhance go to market capability in Africa and the Middle East and leadership position in the US and Europe.
- Digital and smart solutions: advanced systems and services allow customers to increase efficiency analyze data and optimize assets.[68]
- Boost circular economy: Offer water reuse and biogas technology to support industries and cities to grow sustainably in the context of circular economy.
- Develop and offer integrated solutions across the entire process of water and wastewater value chain. Full service offering to customer and solutions to clients in all major industrial sector from sites across the globe.

W&WW Solutions: Suez provides water management, recycling and waste recovery, water treatment, and consulting services. More specifically Suez provides among other W&WWT solutions and products:

- Biological water treatment solutions: high-performance water, wastewater, and sludge treatment solutions for virtually any influent condition. Suez is involved in the entire treatment project from the process design to operation training.
- Water Filtration Technology Systems: designed for drinking water, wastewater, and industrial applications.

[67] Source: https://www.suez.com/en
[68] InSight: Asset Performance Management combines advanced data and analytics to help water treatment professionals prevent unplanned downtime, increase asset reliability, extend asset life, and optimize operations

- Electrodialysis Reversal Water Treatment: a robust high-recovery brackish water desalination technology that can treat a variety of challenging waters
- Wastewater Treatment Chemicals: sustainable solutions for wastewater treatment

W&WW Services: Suez provides various Water and Wastewater services, among other:

- Augmenting or replacing permanent water treatment facilities (Temporary Mobile Water & Wastewater).
- SUEZ emergency response services in case of an unplanned water event.
- Expert Guidance Services to guaranty water quality and quantity for membrane-based water and wastewater plants.

Markets: Asia, Africa, the Middle East, Europe and the LA and the US.

Customers: The company offers water distribution and treatment services to individuals, local authorities, and industrial clients. SUEZ works closely with its customers to improve productivity, protect their assets and solve their problems.

Innovation: The combined R&D investment is more than 120 million per year.

New laboratory in Tomball, Texas, north of Houston that is expected to include further process innovation in the oil and gas industry. The new lab also will provide industrial water, oil, microbiological, deposit and metallurgical failure testing to support SUEZ's customers.

The Biofactory La FARFANA in Chile is one of the world's largest wastewater treatment plants. It treats the wastewater produced by seven million inhabitants of Greater Santiago, preserves the aquatic environment and restores quality of life (zero waste, zero environmental impact, zero fossil energy).

Latest developments: In January 2021, SUEZ announced agreement to acquire NWS' non-controlling stakes in all their common businesses in Greater China. This acquisition will enhance SUEZ's ability to win large-scale and high value-added contracts in a key growth market.

Evoqua Water Technologies Corporation (US) [69]

Evoqua Water Technologies is a leading provider of W&WWT solutions, offering a broad portfolio of products, services and over 100 years of experience and expertise to support its

[69] Source: https://www.evoqua.com/

industrial, municipal and recreational customers. Evoqua aims to utilize its treatment systems to increase water usage efficiency, provide quality water solutions for its customers and help them meet regulatory and environmental compliance. Evoqua offers a complete package of wastewater sustainable options - from design and installation to engineering, training, and service. The company operates through various segments, including food and beverage, life sciences, marine, mining, power, semiconductor and solar, drinking water and municipal wastewater treatment, industrial, institutional, and aquatics.

Products: The company has innovative, integrated products that are valuable in the industrial wastewater treatment process, including ultrafiltration (UF) membranes, clarifiers, conventional gravity filters, chemicals, evaporation, and an assortment of post-treatment technologies.

Solutions: Evoqua offers municipal W&WWT systems and industrial wastewater treatment processes. It is engaged in the designing, developing, and manufacturing of W&WWT systems such as:

- Aerobic Systems: biological treatment process for raw wastewater or further polishing of pretreated wastewater (for both municipal and industrial facilities).
- Clarification for W&WWT: to remove suspended solids from wastewater, providing clarified liquid effluent for downstream treatment processes.
- Tertiary Wastewater Filtration: wastewater is purified to higher degrees and the treated effluent can then be reused for irrigation, recreational use or water reuse.

Services: Large variety of services offered by Evoqua that includes among other:

- Mobile & Temporary Services: provides emergency and temporary water needs to keep customer's plants running.
- Water One Services: Digital water management to optimize water treatment system and ensure fully efficient performance.
- Sanitation Services: water sanitation system to keep bacteria under control.
- Service Contracts & Preventative Maintenance: customized help to take care of the operation and maintenance of water or wastewater treatment systems.

Markets: The company has its geographical presence in Europe (Germany, Italy, France, the Netherlands and the UK), APAC (Australia, China, Singapore, South Korea and India) and NA Canada and the US. The company operates in more than 160 locations across 12 countries, serving more than 38,000 customers and 200,000 installations worldwide.

Customers: Evoqua's current served market in NA is worth about $10 billion and it is comprised of 55% industrial/commercial segment and about 45% of municipal segment.[70]

Recent Developments:

In May 2019 Evoqua acquired ATG UV Technology (UK) to expand its water disinfection technology.

On January 2018, Evoqua acquired the assets of the US-based Pure Water Solutions Limited Liability Company (LLC), a leading provider of high-purity water equipment and systems, service deionization and resin regeneration.

On March 2018, Evoqua acquired Pacific Ozone Technology, Inc., a provider of advanced ozone disinfection systems, testing products and support services for a wide range of industrial applications.

Financial Highlights for 2020

- Consolidated revenues of $1.43 billion, down 1.0% compared to the prior year; organic revenue increased 1.5%.
- Net income of $114.4 million compared to a net loss of $8.5 million in the prior year.
- Adjusted EBITDA[71] of $239.6 million, up 2.0% from the prior year.

Gradiant Corporation[72]

Gradiant is a Singapore-based Global Water Treatment Company that was founded in 2013 on the premise of delivering sustainable water solutions using innovative, game-changing technologies. The core business focus is on solving the most complex water and wastewater

[70] Source: https://www.sec.gov/Archives/edgar/data/1604643/000104746918001771/a2234900z424b4.htm#bi41001_market_and_industry_data

[71] The adjusted measurement removes non-recurring, irregular and one-time items that may distort EBITDA.

[72] Source: https://gradiant.com/

challenges with innovative and sustainable solutions. Gradiant brings new technological approach to water treatment, ensuring industrial operators can meet their needs easily, often at a lower total life cycle cost than incumbent techniques. The approach to water treatment is based on the foundation that with the right technology, we can transform water use and recycling for industrial operators.

Solutions: In certain cases, Gradiant's solutions enable the treatment of wastewaters that have previously not been treated. Gradiant offers in various wastewater treatment solutions, among other:

- **Counter Flow Reverse Osmosis (RO Infinity):** desalination method that achieves maximum recovery rates (up-to 99% freshwater) from municipal and industrial wastewater providing customers with cost savings and less environmental degradation over the near and long term.
- **Selective Chemical Extraction (SCE):** is a custom-engineered, multi-step water treatment process that can treat all types of wastewater into re-usable clean water conforming to customer desired quality levels. A wide range of contaminants like free oil & grease, total suspended solids, scaling ions, heavy metals and more – can be eliminated or reduced with the SCE technology. The core of the technology is a chemical precipitation and clarification system controlled through an innovative process control algorithm which optimizes flocculation and coagulation science.
- **Free Radical Disinfection:** Provides high-volume bacteria disinfection for any customer assets that have the potential to degrade due to bacterial interaction. The mobile, deployable FRD solution is ideal for use in industrial operations in which water needs to be disinfected.

Markets: Gradiant has a strong presence in China, the US, India Australia and South East Asia and acts as the parent organization over three operating subsidiaries, each with local leadership to best serve the customer and to understand the unique needs of the market in which they operate.

China's market: Gradiant's foray into China began with projects to treat waste streams from coal-fired power generation facilities. Since then, Gradiant has found success in other industries, including chemicals and textiles, which led to the creation of Gradiant China. More specifically, Gradiant helps industrial clients to meet water recycling needs and disposal regulations. Solutions range from clarification to zero liquid discharge (ZLD) and are designed to tackle difficult-to-treat wastewaters from textile, power, refining and chemical production.

Customers: Gradiant's main customers are coming from the following industries: textiles & tanneries, power generation, food & beverages.

Innovation: Gradiant has a portfolio of over 70 patent families and over 200 patents and variety of end use applications.

Gradiant's early stage technologies include:

- **Advanced Oxidation Process:** chemical treatment procedure designed to remove biologically toxic or non-degradable materials with the strongest oxidants from water, making stubborn pollutants disappear.
- **Ultra and Nano-filtration:** utilizes a proprietary nanotube manufacturing technique to produce oil-water separation membranes at a fraction of the cost of current state-of-the-art solutions.

Recent developments:

In September of 2020, as part of its South East Asia growth strategy Gradiant acquired Sigma Water (Malaysia) an industrial W&WWT company with repeated success in various water intensive industries. Sigma has the experience, the manufacturing scale, and the reputable network bolstering Gradiant's presence throughout the region and improving upon its customer offerings.

In March 2020 Gradiant acquired CRS Water (established in 1992) in order to expand its operations into Australia. Through this acquisition Gradiant gains access to industrial customers, and relationships with leading contractors, corporations and municipalities in Australia's burgeoning water market.

Xylem Inc. (US)[73]

Launched in 2011 as the spinoff of the water-related businesses of ITT Corporation this water technology company is engaged in the design, manufacture, and service of engineered solutions for the water and wastewater applications. It operates through two water business segments, namely Water Infrastructure, Applied Water.

Solutions: Xylem has a selection of biological treatment technology, membrane filtration systems, and desalination solutions, among other:

[73] Source: https://www.xylem.com/en-us/

- Desalination & Water Treatment: energy-efficient desalination systems.
- Storm water Pump Stations & Flooding Relief: pumping away large volumes of water to prevent damage from storms and floods.
- Wastewater Recycling & Reuse: Advanced oxidation to remove metals and difficult to treat organics like pharmaceutical residuals and also offer ultraviolet (UV) and ozone disinfection systems for oxidizing contaminants present in wastewater such as bacteria, viruses, and odor-causing compounds.
- Municipal Wastewater Pumping and Treatment

Water and Wastewater Consulting Services: state of the art station design tools and customized station design in 2 & 3D, Head loss calculations (complimentary), Water hammer analysis, start calculations, computational fluid dynamics, product and applications trainings.

Products: Extensive variety of products in water market that are sold in over 150 countries.[74]

Markets: The company has its geographical presence in Europe, NA, APAC, the Middle East, Africa, and LA.

Customers: The company focuses on growth in treatment and serves industries such as food and beverage, agriculture, and residential, municipal W&WWT.

Recent Developments:

In 2018 Xylem acquired Valor Water Analytics and EmNet, LLC.

In 2017 Xylem acquired Pure Technologies, a leader in smart infrastructure assessment and management for the water industry.

Financial highlights: Company reported in 2019 full-year revenue of $5.25 billion and forecasts 1 to 3% increase for 2020.[75]

[74] Further information on the variety of Xylem brands and products is available in the following link: https://www.xylem.com/en-gr/brands/

[75] Source: Business Wire, 2020, *Xylem Reports Fourth Quarter and Full-year 2019 Earnings,* viewed on 10 December 2020, <https://www.businesswire.com/news/home/20200206005465/en/Xylem-Reports-Fourth-Quarter-and-Full-year-2019-Earnings>.

CHINA

Beijing Capital Co., Ltd. (BCC)[76]

Incorporated in 1999, is a flagship state-owned company in the field of environment protection. It is subordinate to Beijing Capital Group and directly under the supervision of the State-owned Assets Supervision and Administration Commission of People's Government of Beijing Municipality. As the earliest company engaging in environment protection investment, BCC takes the lead in practicing the market-oriented reform for the industry of Chinese domestic water and environment protection and actively promotes the development of the industry, and is committed to becoming the most trustworthy integrated service provider in the field of eco-environment.

Company's Strategy is to lead the investment, construction and operation services for smart and green cities. Striving to create an environment protection blueprint featuring "clear water, blue sky, and clean land".

Solutions & Services: Company's business extends from water services and solutions for municipalities and integrated management of water environment conservation. More specifically, BCC provides water transmission, water system management, water network maintenance, and other services.

The company is also involved in solid waste disposal to and green resources development and energy management.

Markets & Customers: Based on the business layout across mainland China, BCC has expanded its business overseas and has become the world's fifth largest water service company. At present, BCC has projects in more than 100 cities in 27 provinces, autonomous regions and municipalities and the total served population exceeds 50 million.

Beijing Enterprises Water Group (BEWG) Limited[77]

It is a comprehensive and leading professional water and environmental protection service provider covering design, construction, operation, technical service and capital operation in

[76] Source: https://www.bjcapital.com/en/content/details_160_1657.html

[77] Source: http://www.bewg.net/en/About/Profile/

full industrial chain. The focus of its business is on water services in cities and towns, water services in river basins, industrial water services, rural water services, seawater desalination services, environmental sanitation, solid waste treatment, scientific and technical services, financial services and clean energy.

Urban Water Services: BEWG actively extends the urban water service market and provides the integrated solutions to the investment, construction and operation management for the water source, water transmission, water supply, sewage, reclaimed water and pipeline operation. In 2017, BEWG had 782 water plants (including sewage treatment plants, waterworks, recycled water treatment plants and seawater desalination plants), covering 27 provinces cities and municipalities in China.

Industrial water treatment: BEWG mainly focuses on three development orientations, i.e., treatment of sewage in industrial parks, treatment of industries sewage of key sectors, and comprehensive utilization of water resources. The five technical modules are pre-treatment system, biochemical treatment system, advanced treatment system, water recycling system and zero-drainage system.

BEWG has consecutively ranked No.1 for seven years among Top 10 Influential Enterprises of Chinese Water Industry.

SUEZ Greater China and Southeast Asia[78]

SUEZ, is one of the first foreign enterprises to invest in China (presence of 45 years) whilst with a history of nearly 70 years in Southeast Asia. SUEZ draws on its global and local expertise to shape a sustainable environmental transition, developing circular business models and innovation in water and wastewater industry.

Main services and solutions offered in wastewater market:

- supplies high-quality water, suited to every type of use, and ensure the protection of this common good.
- recovers wastewater and waste to convert them into new resources.
- designs and builds water treatment facilities for both municipal and industrial customers.

[78] Source: https://www.suez-asia.com/en-cn

- helps businesses, governments and communities to protect, access and optimize the use of natural resources and create new resources through reuse and recycling of water and waste.

SUEZ has built more than 600 W&WWT plants in more than 30 cities with over 32 million people benefiting from its water and waste services.

To support China's long term goals and short term needs SUEZ's strategy is to create the win-win situations based on trust and long standing relationships with local authorities, scientists and customers. For this, SUEZ has launched joint ventures with Chinese partners and extended partnerships (joint laboratories) to have a thorough understanding of the local context and to be confident that it meets the standards expected by the government and the customers.

In 2017 SUEZ acquired GE Waters to create Water Technologies & Solutions an industry-leading player for water services, technology and smart solutions in water and wastewater market. More specifically, water recycling and recovering management, services and construction for municipal and industrial customers.

For the Chinese market SUEZ has anticipated more opportunities not only in water but also in hazardous waste. It has 9 plants in mainland China and is projected to add 2 projects per year:

1. Recycle waste to reuse or produce energy plus soil remediation
2. Industrial sector. The water sector in China still presents considerable growth potential because of the industrial demand. SUEZ acquired GE Water (WTS business unit in 2017)
3. Deliver more smart solutions in waste industry. SUEZ is committed to increase its investments in R&D, innovation and digitalization to increase by 50 % by 2024.

4.4.4 PESTELI Analysis

In this section we employ the PESTELI to identify external factors which determine macro elements of the environments (mainly in China and Europe) within which the GREENergy W&WWT system will be positioned. In the Table 12 we summarize the main factors of the PESTELI analysis.

Table 12: PESTELI Analysis for the W&WWT system

PESTELI	Relevant Factors	Projection
Political	Environmental degradation in China has led to drastic political action and stern enforcement of	In the context of the 13th Five Year Plan, China aims to spend 0.8% of its GDP: Upgrade the existing

	environmental laws emphasizing on water resources and wastewater treatment. In Europe, although the W&WWT market has been subject to strict regulation even since 1991 there is continuous monitoring and reporting on implementation of regulation (European Commission 2020).	infrastructure in the country and develop new W&WWT pants. Laws and enforcement are expected to be toughened both in China and the EU.
Economic	Rebound of economic activity. Investment in W&WWT industry by local authorities, banks and private sector.	Higher demand for W&WWT by municipalities, farmers, food and beverage industry. More business opportunities for companies involved in the W&WWT industry.
Social	Changing attitude towards the environment, health and wellbeing can enforce further regulation and boost the recycling of water through W&WWT.	Social trends for healthier lifestyle and the increasing awareness about the environment are likely to be reinforced by the COVID-19 pandemic
Technological	R&D investment and innovation of W&WWT technologies is fueled by the need to reduce energy costs in treatment processes.	High investments on R&D of W&WWT. Innovation in efficiency of treatment will drive growth.
Environmental	Environmental deterioration and increased pollution from wastewater discharges. Harm to fish and wildlife populations, contamination of drinking water. Quickly diminishing freshwater resources.	Global trend to protect environment. Projected environmental improvements in developed and some developing and countries.
Legal	Amendments of environmental protection laws (i.e., the Chinese "13th Five Year Plan"). Urban Waste Water Treatment Directive (European Council Directive 91/271/EEC, 1991). Pollution penalties. Foreign Direct Investment (FDI) screening regulations (EU).	Further regulations with strict penalties for non-compliance.
Institutional	Institutional pressure to solve the problem. No centralized management of wastewater treatment facilities (China, Europe), each province or country are subject to different regulatory procedures and standards, respectively.	Initiatives to have as same as possible regulations across European countries. Reforms to have common procedures and standards across the Chinese provinces.

Political

The fast economic and social development in China has been spectacular in the recent decades but it all came at the huge expense of the environment and ecological degradation. Water pollution constitutes large share of this environmental deterioration. In order to reverse this situation, Chinese government began to concentrate more on the reorganization of the pollutant treatment measures, including water and industrial wastewater treatments, which majorly include biological treatment that comprises of aerobic treatment, anaerobic treatment, etc. Emphasizing on water resources and wastewater treatment Chinese authorities amended the environmental protection laws by strengthening regulation and supervision and imposed a set of guideline policy called "the 13th Five Year Plan (FYP)" (Fluence, 2018).

According to the 13th FYP, China aimed to spend about 0.8% of its GDP to develop new wastewater treatment plants and upgrade the existing infrastructure. Moreover, it is expected that the central government spending will account only for the 10 to 30% of the total investment expected to take place in the wastewater treatment industry by local authorities, domestic banks and the private sector. Normally, fiscal spending goes into municipal or centralized wastewater treatment projects and the industrial treatment facilities (on site) are privately funded.

In Europe, even though the W&WWT industry is quite mature and has been subject to continuous tightening of water quality regulations since 1991 with the Urban Waste Water Treatment Directive (Council Directive, 1991) the market is still dominated by the implementation of stricter regulations and continuous assessment their implementation (European Commission, 2020).

Economic

After the unimaginable shutdowns pushed economic activity to unimaginable worldwide recession in 2020, the economic activity is projected to rebound quickly within 2021. Overall, the positive macroeconomic environment will probably result in higher demand for W&WWT by farmers, food and beverage industries due to the restore of normality that is expected to take place in the respective markets. Moreover, higher economic activity is expected to increase the demand of local authorities for wastewater treatment providing opportunities for the companies of the W&WWT market.

Social

The increasing awareness of ecological degradation and pollution of water has changed the social attitude towards the environment protection. More and more people nowadays are supportive of recycling, reusing and reducing unnecessarily water consumption. Hence, a growing number of individuals will be in favor of stricter regulation on wastewater treatment in order to limit the environmental deterioration. This provides a growing opportunity for wastewater treatment market as demand for treatment and recycling of water is expected to grow strongly in the coming years. Finally, this demand is likely to be reinforced in view of the current pandemic (COVID-19) as people become more concerned about their health and the environment.

Technological

High investments on R&D of water treatment technology is likely to offer a major growth opportunity for the market in the coming years. An important driver of the market is the need to reduce energy costs in treatment processes. Innovation is therefore focused on applications that will produce higher efficiency of wastewater treatment and better quality clean water at lower costs. Innovation is projected to drive growth in the W&WWT market.

In Europe on the basis of technology tertiary treatment is quite likely to expand due to its intensified application in municipal sewage treatment across European cities.

Environmental

According to the National Development and Reform Commission about one third of the major Chinese river systems and basins did not meet the water standards quality criteria in 2015 (National Development and Reform Commission, 2016). Moreover, in the same year the annual amount of discharged wastewater was around 74 billion tons, mainly divided among household (67%) and industrial (25%) wastewater streams (China Strategic Research n.d.).

However, China is one of the most advanced technological countries that expects quick environmental improvements. Environmental protection is one of China's top priority and it is carried out by stringent regulation and enforcement of environmental mandates. Against this backdrop, the COVID19 pandemic is expected to raise the awareness of environment even higher and the expectations of Chinese authorities can force further development and more business opportunities for companies involved in the W&WWT industry.

Legal

After used water is being discharged by households or industries, Chinese law requires that the wastewater be collected and treated before being released into the waterways. However, many factories and even local governments fail to abide these rules because due to the high cost of meeting these rules. Overall, with stricter laws on environmental protection the demand for wastewater treatment facilities has increased across all sectors. The demand amongst industrial users has also been strong due pollution penalties and stern enforcement.

It is expected that in the wake of COVID-19 pandemic countries are most likely to be engaged in some form of trade protectionism. Already in March 2020 European Commission issued a guideline regarding the protection of health infrastructure and other strategic sectors (such as water and wastewater treatment) from opportunistic foreign investors seeking to acquire distressed assets. As an example in France foreign investors now can only have a small fraction of voting rights (10%) within a company's board (Power Technology, 2020). This tightening of Foreign Direct Investment (FDI) screening regulations may impact severely the growth of W&WWT market in Europe that is fueled by cross-border merger and acquisition sales of assets.

Institutional

There is no centralized management of wastewater treatment facilities in China and in the EU. This means that potential investors looking to enter the municipal wastewater market or those looking to expand beyond a particular province or country might be subjected to different regulatory procedures and standards. However, this is something that we can expect to change due to the environmental necessities and regulation homogeneity both within EU and within China.

4.4.5 SWOT Analysis

In this section we present the SWOT analysis for the GREENergy concept (W&WWT system). The main points of the analysis are summarized in Figure 11 below.

Internal Strengths

Changsha's showcase constitutes a great demonstration of integrated W&WWT system (partial GREENergy concept) developed in the context of SiEUGreen project by partner HHEPSTI. The strength of the showcase is that it can attract the interest of local governments (potential clients) and public institution in applying the decentralized wastewater treatment system proposed in the showcase and it can generate significant public and private investments by third parties. Moreover, it offers a set of innovative technologies for smart and resilient cities and only few companies offer such integrated solutions across the entire process of water and wastewater value chain (see SUEZ).

Another internal strength of this showcase is that it is led by a Chinese investment group and SiEUGreen partner, HHEPSTI. This partnership is important and gives an advantage if one considers how much time and resources other companies spend on average in order to build partnerships and joint ventures with local stakeholders. Having an involved party in the project that is familiar with the local context, needs and standards to meet can be proved invaluable in pursuing business exploitation of the concept used in Changsha showcase.

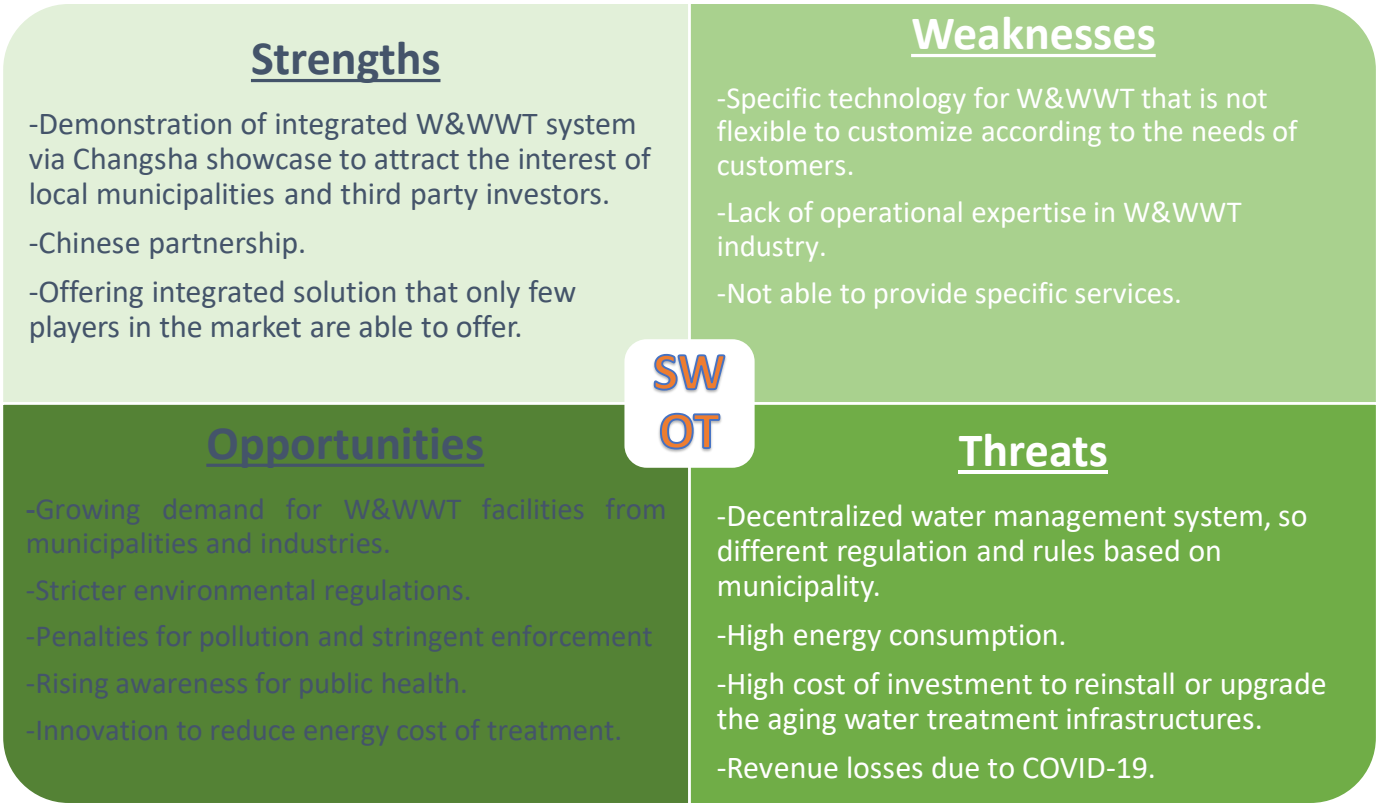
Internal Weaknesses

Market competitors can provide customized service in contrast to the integrated W&WWT solution proposed in Changsha showcase that is specific and less flexible to customize according to the needs of different customers. For example, it can fit and serve the needs of municipalities but will not be used by the food and beverage industry.

Moreover, there is a lack of operational expertise compared to market's key players. For example, companies like SUEZ, Veolia, BEWG have been operating and providing their services for more than 10 years in China. They have developed their business network and created a lot of partnerships and joint ventures with local companies, municipalities, universities and researchers. If we consider the fact that the Chinese market is quite diverse, and opportunities and threats may differ by sector (municipal, industrial) and region, this gives them an

advantage to deal with regulations, standards and procedures imposed by the local authorities.

Figure 11: SWOT Analysis for the SiEUGreen W&WWT system



External Opportunities and Market Drivers

The size of the pie has grown to proportions unprecedented in the industry, there is sufficient room for robust growth for reliable foreign companies with outstanding technology. In fact, many foreign companies like Veolia and Gradiant have already been quite active in developing various projects and cultivating joint venture partnerships to leverage on the growth opportunities in this sector. Given the growing need for water conservation and tightening environmental regulations, demand for W&WWT facilities will grow both for industries and municipalities. That provide business opportunities in both sectors.

The growing opportunities in the industrial wastewater treatment sector reflect the increased demand due to pollution penalties and more stringent enforcement of environmental mandates. This demand in the industrial sector pushes for new investments or upgrades of in-factory and centralized wastewater treatment facilities. The manufacturing sector is also projected to drive demand for wastewater treatment facilities as increased production stimulates the need for water and water recycling.

As a huge bulk of China's wastewater is generated by the household sector thus the demand from the municipal wastewater treatment sector represents large portion of the market. The demand for wastewater treatment is expected to be substantial as local governments expand their municipal coverage from urban areas to the counties and towns with few or no wastewater treatment facilities. In the urban areas, local governments faced with higher environmental goals work towards a more efficient use of their wastewater. In provinces, much investment is still needed to repair outdated and old infrastructure and build new treatment systems.

Furthermore, the raising awareness for public health due to the current pandemic can also turn out to be an opportunity for the W&WWT market to grow. The pandemic can reinforce the demand for clean and potable water in developing countries and can bring further refinement of wastewater treatment methods in developed countries. Therefore, innovation and R&D are projected to provide opportunities for the W&WWT market. NA and Europe are adopting the latest technologies in wastewater treatment at a faster rate, than in other regions. The developed regions of NA and Europe are expected to continue the momentum of adaptation of the latest technologies to increase efficiency and lower the cost of the W&WWT.

External Threats and Market Barriers

Barriers to enter the market include high cost of equipment, operations and disposal. Other major challenges are high energy consumption and aging water treatment infrastructures mainly in developed countries. These countries built them decades ago and still use these old systems. Huge investments are needed in reinstalling and upgrading the treatment infrastructures.

The major threat to this market is the outbreak of the COVID19 pandemic that affects both the supply and demand side of the water and wastewater treatment. On the demand side, the imposed lockdowns and movement restrictions on a global scale have substantially reduced the industrial and commercial demand for wastewater treatment and hence have significantly cut down the revenues of water utilities. Moreover, operations of water utilities can increase the risk of infection of the staff. On the supply side, we have seen supply chain and logistics disruptions due to the fact that companies are operating only with the minimum staff implementing the social distancing onsite. The outbreak of COVID-19 is projected to slow down investments in the water sector, worldwide (Meticulous Market Research, 2020). Thus, further revenue losses are projected across the whole spectrum of water supply chain

including wastewater treatment system technology developers, equipment providers, consultants and services, operators, chemical suppliers, etc.

In addition, Chinese companies are price competitive and more familiar with the local regulation and government standards. The latter is particularly challenging for foreign companies when they are faced with the fact that China's municipal wastewater treatment systems are decentralized and come under the direct jurisdiction of local governments. This means that depending on the municipality or province potential investors might be facing different regulatory procedures, standards and rules. It can be expected that Chinese competitors will find it easy to operate under such circumstances compared with foreign companies.

4.5 Food Waste Management

Food waste is defined as “food that completes the food supply chain up to a final product, of good quality and fit for consumption, but still doesn't get consumed because it is discarded, whether or not after it is left to spoil or expire”. Food loss is defined as “food that gets spilled, spoilt or otherwise lost, or incurs reduction of quality and value during its process in the food supply chain before it reaches its final product stage” (Think Eat Save, 2020).[79] Food loss usually takes place at production, post-harvest, processing, and distribution stages while food waste is mainly but not exclusively takes place in consumption stages in the food supply chain.

FAO estimates that one third of the food produced is wasted or lost in the supply chain and consumption system, 1.3 billion tons per year. Wasting food is not only an ethical and economic issue but it also depletes the environment of limited natural resources. When food is wasted or lost all the inputs that are used to produce this food such as energy, water, labor and capital are wasted/lost as well. In addition, disposing all this lost or wasted food in landfills creates an emergency in terms of greenhouse gas emissions (CO_2, methane-CH_4, etc.) that can cause environmental, hygiene, and safety problems.

4.5.1 Global Market Insights

The global food waste management market size is estimated to worth about $36 billion in 2020 (Grand View Research, 2020b). It is expected to expand at 5.4% CAGR from 2020 to 2027 reaching $52 billion in 2027. In general, this growth is attributed to the rising concerns over food waste globally. More specifically, the growing demand for food has led to stringent regulations put in place by governments and food management bodies, thereby augmenting the market growth.

By food waste type, fruits and vegetables that accounted for 43% of the global revenue share in 2020. According to FAO more than 45% of fruits and vegetables produced globally are wasted due to improper storage and handling. In order to avoid food waste and the accompanied CO_2 emissions, governments around the world are taking serious steps towards food waste management fueling the market growth. More specifically, governments across various countries are running food waste management initiatives with the aim to increase

awareness about food waste management. For example, also, the "Think Eat Save", a global partnership between FAO and the United Nations Environment Program (UNEP).[79]

Based on the process of food waste management, AD led the market and accounted for a 47% share of the global revenue share in 2020. The advantage of the process is that it restricts the spread of odor and diseases promoting proper hygiene and sanitation. What is more, this process helps recover energy and nutrients from the waste, thus leading to its market expansion. Another process that is expected to grow significantly (6.4% CAGR) during the forecast period (2020-2027) is the aerobic digestion. The compost obtained from this process contains potassium, nitrogen and phosphorus and can be used as fertilizer. Hence, the aerobic digestion owing to its cost-effectiveness and further use of its produce is expected to be one of the dominant processes of the food waste management market.

By source of food waste, households and municipalities are clearly leading the market with the share of more than 44% in 2020. Urban population growth combined with excessive consumption of food and improper food management are expected to magnify the food waste market for households and municipalities.

By application, food waste can be mainly used as animal feed, 54% of the revenue in 2020. Also, food waste through, anaerobic or aerobic digestion can be turned into BFs or OFs. Those fertilizers when used by farmers can significantly mitigate the contamination of land and water caused by synthetic fertilizers. Hence, food waste that is turn into fertilizers is projected to drive the market growth in the near future. Also, another segment by application that is estimated to witness significant growth (6.6% CAGR) during the forecast period is the segment of biofuels which are produced from food waste. Already many countries have adopted favorable regulation for the use of biofuels as renewable energy source.

Finally, by geography, Europe dominates the food waste management market having more than 34% share of global revenue in 2020 (see also below). NA has the second largest share in the food management market predominantly due to overconsumption of food. Following the same strategy as in Europe, the NA countries try to take advantage of food waste and turn it into fertilizers and biofuels. The food waste in APAC region is generated mostly due to exports to Europe and NA as a significant share of the food produced gets wasted along the supply

[79] Source: Think Eat Save initiative, available at: https://www.unep.org/thinkeatsave/

chain, before it ever reaches the markets. The APAC market is projected to increase by 5% CAGR from 2020 to 2027. This growth is expected as a result of initiatives by countries to improve the efficiency of temperature-controlled supply chains in their attempt to restrict the overall generation of food waste. Finally, the lowest projected market growth by geography is expected to take place in LA because of the lack of appropriate regulation regarding food waste management. In addition, the lack of logistic efficiency and the lack of cold chain technology are expected to drive-up the generation of food waste.

EUROPE

The European food waste management is estimated to worth $12.24 billion in 2020 and it is projected to experience a moderate growth at 5.7% from 2021 to 2027, reaching $17 billion in 2027 (Market Data Forecast, 2020b). Overproduction and excessive consumption are the main market drivers in Europe. The annual amount of food waste is approximately 90 million tones and it is expected to increase dramatically (by up to 35%) if no action is taken, posing significant challenges on Europe. However, many countries have already started significant initiatives to reduce food waste and simultaneously invest in food waste digestion methods in order to produce fertilizers and biofuels. For example, some of the initiatives include: “Love Food Hate Waste” in the UK and the “Stop Wasting Food” movement in Denmark.[80]

One of the most important drivers for the European market is the use of food waste as source of renewable energy (biofuels) and its use in production of OFs and BFs. The growing demand for improved technology in anaerobic and aerobic digestion is expected to generate new market opportunities during the forecast period. Moreover, stringent regulations and growing environmental issues will provide lucrative opportunities in the food waste market during the forecast period.

The UK and Germany have been proved as the best recyclers in Europe when it comes to food waste.[81] These counties alongside the waste companies and organization have taken significant measures in the direction of reducing the waste or reusing it as biofuels and

[80] Love Food Hate Waste: <https://www.lovefoodhatewaste.com/> and Stop Wasting Food: <https://stopwastingfoodmovement.org/>.

[81] The UK generates around 19 million tons of food waste per year, with the food production sector accounting for just under half of this. Source: https://www.biffa.co.uk/about-us/waste-journeys/food-recycling-and-anaerobic-digestion

fertilizers. However, recycling rates in the other major European countries such as France, Spain and Italy are still quite low due to the ineffectiveness of waste management and lack of governmental initiatives despite the high levels of food waste generation.

CHINA

China's food waste market is estimated to be $6.25 billion in 2020 and China forecast to reach a projected market size of $8.4 billion by the year 2027 growing at 4.3% CAGR over the period 2020-2027 (Research and Markets, 2020e). The increased standards of living and the rapid urbanization in China are the major reasons behind the substantial food waste generation amounted to 6% of the total annual food production in China. As this numbers are expected to keep growing over forecast period, it is projected that the Chinese government is going to adopt more stringent regulation regarding food waste in order to cope with this expanding problem. This in turn will generate enormous market growth and encourage more companies to enter the Chinese market of food waste management.

4.5.2 Food Waste End-User/Customer Segment

The total addressable market is estimated to be $36 billion in 2020 and it is projected to be $52 billion in 2027.[82] In general, the end-users of food waste management solutions and services can be households, municipalities and SMEs (restaurants, bars, food catering companies, etc.) producers of BFs or OFs.

More specifically, as identified by SiEUGreen partners in D5.4 Sustainability and Exploitation Plan the potential end-users or customers for the

Garbage Processor include private sector SMEs interested in the appliance, researchers interested in the method used to process kitchen waste and residents that can use the OFs to cultivate their own organic vegetables. Moreover, the list of end-users for the **Urban Composting Hub** includes home/balcony gardeners, allotment gardeners and urban community gardeners.

[82] Authors' calculation based on the market size in 2019 and the CAGR for 2020-2027.

4.5.3 Competitive Landscape

In this section we conduct a detailed analysis of main competitors in on the Global, European and Chinese level. In the below we provide a brief summary of major competitors for SiEUGreen food waste management solutions.

Table 13: Major Global Competitors in the food waste management market

Competitor	Geographical Coverage	Services/Solutions	Customers	Strengths	Weaknesses
Veolia Environment S.A. **(est. in 1853 in France)**	Europe, NA, LA, South East Asia, Middle East, South Africa & Australia	Commercial food waste collection and audit to assess customer's need. Renewable energy generation from food waste (Biogas). Produces BFs for local agriculture use.	Municipalities, residents, farmers, food industries and businesses.	• Largest company in the European food waste management market. • Wide range of services and long-term experience in the field. • Development of energy self-sufficient site using renewable energy from food waste.	• Not identified.
Waste Management **(Est. 1968 in the US)**	Largest company in NA	Converts food waste into green energy (e.g., CORe). Develops commercial compost facilities creating high quality compost and soil amendments.	Households, municipalities, businesses and food industries.	• Well established waste management company in NA with lots of experience in this field. • Invests in innovation.	• Limited spatial coverage.

		Trash containers for transportation of organics (e.g., BulkBin) and food waste picking up services.			
SUEZ **(est. 1869 in France)**	Asia, Africa, the Middle East, Europe, LA, Australia & the US.	Advanced digestion technologies converting food waste into energy (biogas) and fertilizers. Digital marketplace for organic waste (Organix).	Waste recycling companies, food producers, municipalities, and renewable energy producers.	• Extremely efficient AD (Biowaste treatment) of food waste with great biogas yield and reduced energy cost. • Unique service with the digital marketplace platform for organic waste. • Innovation and development of self-powered advanced digestion facility.	• Not identified.
Biffa Group Limited **(Est. in the UK)**	UK	Commercial food waste collection & food recycling. Recycling and waste management services for local authorities. Converting food waste into biogas and BFs. Food waste collection service providing customers with internal and	Residents, food businesses, municipalities, energy producers and farmers.	• Provides integrated solutions for food waste management and recycling from food waste collection until production of renewable energy (biogas) and BFs. • Award winning customer service.	• Covers only the UK. No share in growing food waste markets.

		external containers and bio-degradable bags.		• No 1 company in the UK with nationwide coverage.	
REMONDIS **(Est. 1930s in Germany)**	Subsidiaries and business locations in 30 countries in Asia, Africa, Australia and Europe (almost all EU member states).	Treatment of Organic Waste Transforming biodegradable kitchen and garden waste into high quality compost and renewable biogas.	Farmers, food industry and municipalities.	• high standards of quality, • perfect infrastructure, state of the art organic material treatment facility (Lippe Plant).	• No provision of integrated services from picking up food waste up to producing energy.
Capital Environmental Holding Ltd. **(Est. in China)**	Major cities in China and subsidiary in New Zeeland.	Integrated waste management and large range of services. Wet anaerobic fermentation for food waste, animal excrement, and food factory residues. Dry anaerobic fermentation: kitchen and garden waste.	Municipalities, households, food operating businesses, food industry.	• Wide range of anaerobically treated organic waste. • Leading Chinese company. • Wide range of services. • Subsidiary in New Zeeland with large market share.	• Limited geographical coverage. • No production of biogas or fertilizers.

FCC Environment **(Est. 2012 in the UK)**	Europe, Africa, NA & LA	AD of food and organic waste (industrial and garden waste, spoiled food, kitchen waste, good waste) Food Waste Service Package. Large containers (240litres), biodegradable bags.	Citizens, households, food industry, gardens, municipalities.	• Great variety of solutions and services. • AD that turns food and organic waste into biogas that is used to generate electricity and heat for the local community and businesses.	• Does not cover the growing market of Asia. • No other byproducts from AD (i.e., OFs or BFs).
Urban Composting Hub **(IGZ, Germany)**	Potential markets of China & Europe	Production of OFs /compost from AD of organic household waste streams.	Households, balcony gardeners, urban community gardeners, municipalities.	• Households can use their own OFs, reducing the cost of disposing waste and purchasing fertilizers for their balcony or rooftop gardens. • SiEUGreen partnership is a great opportunity to penetrate Chinese market.	• High fixed cost of installment. • No production of renewable energy (biogas).
Garbage Processor **(PHOTON, China)**	Potential markets of China & Europe	Device that produces OFs from household kitchen waste.	Residents growing organic vegetables and flowers at home/balcony.	• SiEUGreen partnership is a great opportunity to penetrate European market. • Residents can use their own OFs with no extra cost.	• No generation of biogas. (renewable energy).

GLOBAL

Major market players are heavily focused on extending their leadership position through innovation and expansion. The market players are engaged R&D to design and develop food waste management techniques to increase the production of the byproducts and reduce contamination levels in the environment. Companies focus on getting into long-term strategic relationships with municipalities, residential, and commercial complexes for their daily supply of food waste and reducing procurement costs.

Veolia, Suez, Waste Management, Inc., Republic Services, Inc., Covanta Ltd., Stericycle, Inc. Advanced Disposal Services Inc.

Waste Management (US)[83]

Waste Management (WM) was established in 1968 in the US and it is largest NA environmental solution provider and recycler employing over 45,000 employees. WM is one of the first truly integrated waste companies that collects waste but also manages the landfills it ends up in. WM provides solutions for home and businesses and residential, as well as community services. The company has invested more than $0.5 billion in alternative technologies and R&D.

Food waste Solutions & Services: Waste Management is turning leftover food into materials that positively impact the environment and economy. Around 3.6 million tons of organic material is managed by WM every year.

- CORe: organic recycling program that converts food waste from restaurants, schools, food processing plants and grocery stores into an organic slurry that generates green energy.
- BulkBin: Specifically designed containers (bins) that optimize the way organics are transported to processing facilities. They are used by businesses that generate organic materials on a large scale reducing transportation cost and carbon footprint.
- Composting at community scale: advanced commercial compost facilities that create high quality compost and soil amendment products.

Markets: NA

[83] Source: https://www.wm.com/us/en/inside-wm/sustainable-technology/organics-recycling

Customers: The company has more than 21 million customers: households, municipalities, businesses and food industries all over NA.

SUEZ S.A. (France)[84]

Established in 1869 in France SUEZ is a world leader and specialized expert in water and waste management. SUEZ draws on the expertise in waste collection and recovery activities to help people constantly improve their quality of life by protecting their health and supporting economic growth.

Solutions and Services: Resource recovery technologies of SUEZ help customers to recover the potential value from organics with safety and sustainable composting technique.

- (Monsal) Advanced Digestion Technologies (Biowaste Treatment): converts organic food wastes generated from restaurants, supermarkets, commercial facilities and source separated organic waste collected from residences into energy (biogas) and fertilizers. The full system approach of this AD method increases efficiency and reduces energy costs and at the same time achieves great biogas yield.
- Organix: is the first digital marketplace for organic waste that connects producers of organic waste (households, food industries, etc.) with energy producers who transform organic waste into energy. SUEZ provides logistics, transportation and ensures the quality of the materials. Through Organix organic waste can now be sold securely and easily on an auction platform.

Markets: Asia, Africa, the Middle East, Europe, LA, Australia & the US.

Customers: Waste recycling companies, food producers, municipalities, and renewable energy producers.

Innovation: SUEZ to develop and implement comprehensive and holistic advanced digestion solutions that effectively process organics and generate renewable energy that can be used to power the very facility that's processing the waste.

[84] Source: https://www.suez.com/en/our-offering/businesses/what-is-your-business/industry/food-and-beverage/increase-resource-recovery#anchor-4b3bff89

Veolia Environment S.A. (France)[85]

Veolia, is a French transnational company with activities in three main service and utility areas traditionally managed by public authorities – water management, waste management and energy services. Veolia is the largest share owner of the European Waste management market in terms of revenue.

Solution & Services:

- Commercial food waste collection and audit to assess customer's need.
- Renewable energy generation from food waste: creating green energy using AD. Biogas converts food waste into electricity which is injected into the gas grid, supplying energy to local homes and businesses.
- Produces nutrient-rich BFs that can be used to aid crop production on local farms.
- Food waste bins: bin sizes and internal and external waste bin options.

Markets: Europe, NA, LA, South East Asia, Middle East, South Africa & Australia

Customers: Municipalities, residents, farmers, businesses.

Innovation: Developing new energy self-sufficient biogas-fired combined heat and power (CHP) plant to increase capacity for generating renewable energy from food waste by turning it through AD facility into biogas.

EUROPE

Biffa Group Limited (UK)[86]

Biffa is a leading UK waste company with operations that cover the entire breadth of the waste management process including collection, recycling, treatment, disposal and energy generation. Biffa has over 8,000 employees and more than 100 years of experience in this field. Biffa's is committed to address the climate emergency while delivering sustainable growth and investing in green economy infrastructure and low carbon collections. Biffa aims to divert as much waste from landfill as possible, using its established network of specialist waste processing facilities.

Services & Solutions: Biffa collects 1.2 million tons of waste annually.

[85] Source: https://www.veolia.co.uk/services/commercial-food-waste-collection.
[86] Source: https://www.biffa.co.uk/business-waste/our-services/food-waste-collection

- Commercial Food Waste Collection & Food Recycling: Biffa organizes waste audit for its customers to help them understand better the commercial food waste collection needs of their business. This is a bespoke service tailored to the specific business requirements and waste volumes.
- Biffa's AD facility: to process food waste and ultimately convert it into renewable energy (biogas). The biogas is used to generate electricity and heat to power on-site equipment with surplus electricity exported to the National Grid. Moreover, further by-product of the process is bio-fertilizer, which is rich in nutrients such as nitrogen, potassium and other elements required for healthy plant growth and fertile soil.
- Food waste collection service: containers to dispose of food waste, bio-degradable bags and external containers.

Market: Biffa's solutions and services cover all of the UK.

Customers: Households, municipalities, food industries, energy producers and farmers.

REMONDIS (Germany)[87]

Founded in the German town of Lünen in the 1930s, REMONDIS is one of the world's largest waste recycling, service and water companies. REMONDIS recovers raw materials from waste, develops innovative recycled products, offers alternative fuels. With over 30,000 employees and around 900 business locations on 4 continents, the group serves more than 30 million people and many thousands of companies.

Services and Solutions: Remondis transforming biodegradable kitchen and garden waste into high quality compost and biogas.

- Treatment of Organic Waste (Lippe Plant): Brand new biogas and treatment facility. This facility has an aerobic treatment in the tunnel composting and also has an anaerobic digester which produces biogas.

Markets: 900 business locations in over 30 countries in Europe, Africa, Asia and Australia. In Europe there are about 700 locations in most of the EU member states.

Customers: farmers, food industry and municipalities.

[87] Source: https://www.remondis-lippe-plant.com/en/treatment-of-organic-waste-incl-earthworks/

Innovation: A state of the art organic material treatment facility in Lünen with the latest generation of composting plants. Besides a tunnel reactor – a modern digester, which transforms organic materials into CH_4, and then is used as renewable energy.

FCC Environment (UK)[88]

In 2012 Focsa Services (UK) and Waste Recycling Group came together under new brand, FCC Environment. FCC is a leading waste and resource management company in the UK. FCC's more than 55,000 employees worldwide. Company's approach is to minimize the amount of waste that ends up in landfill by transforming it into valuable resources. Company offers great variety of business waste solutions and municipal services. Among others FCC offers water recycling and hygiene, cleaning services, energy, management of external facilities, food waste solutions and services, etc.

FCC's business model is based on three business segments:

- Medio Ambiente: manages and treats domestic and industrial waste, cleans streets, and maintains parks and gardens, among other activities.
- FCC Aqualia provides end-to-end water management services, from operating infrastructure to supplying households and businesses.
- FCC Construction designs, build and maintains infrastructure all over the world.

Services & Solutions: Household waste collection, Hazardous waste, clinical waste, street cleaning, park maintenance, and food waste.

- Food Waste Collection Service: is available via a 240-liter container or for larger volumes bespoke service is offered to suit the customer, bio-degradable bags.
- AD: AD plants that break down the food waste producing a biogas. This gas is then used to generate electricity and heat for the local community and businesses.
- Food waste service package: free survey of customer's needs to offer a cost-effective customized solution. Labelled containers with regular pick up schedule. A sophisticated collection process to minimize greenhouse gas

[88] Source: https://www.fccenvironment.co.uk/

emissions and achieve zero waste standards. Training and consultancy to prevent food waste and ensure proper sorting of food waste.

Markets: Europe, Africa, North and South America. FCC obtained 6.476 billion euro in revenues in 2015, of which 47% came from international markets, mainly Europe and America.

Customers: Citizens, households, food industry, gardens, municipalities.

Cawleys (UK)[89]

Established in 1947 in the UK, Cawleys is full-service waste management organization, that provides a range of cost-effective solutions. The aim of the company is to help businesses save money by reducing their waste. Cawleys organizes the collection and safe disposal of the waste, and it is a driving force for innovation in waste reduction, reuse and recycling. Cawleys has facilities in in Luton, Wellingborough and Milton Keynes.

Services & Solutions:

- Commercial food waste collection service to AD: converts the food waste into green energy that is often exported to the National Grid. As a by-product, the AD process also creates BFs that are rich in potassium and nitrogen and can be used to fertilize soil for plant growth.

Markets: UK

Customers: manufacturers, retailers, coffee shops, hotels, and restaurants.

CHINA

Capital Environment Holdings Ltd. (China) [90]

Capital Environment Holdings Limited is a subsidiary of Beijing Capital Group. Capital Environment is China's fastest growing, large scale solid waste industrial leader. This company focuses on investment, construction, and operation management in the solid waste field, constructing a diversified service development system of integrated front-end collection and transportation, comprehensive back-end disposal, and resource utilization. The vision of the

[89] Source: https://www.cawleys.co.uk/
[90] Source: http://en.capitalenv.net/index.html

company is to become the leading investment operator and integrated environmental service provider in China's solid waste field.

Solutions: The list of the provided solutions for food waste include among others:

- Wet anaerobic fermentation: is suitable for the treatment of organic wastes with high moisture content, such as food waste, sewage treatment plant sludge, animal excrement, and food factory residues.
- Dry anaerobic fermentation: is suitable for the treatment of solid wastes with high organic content and relatively low moisture content, such as kitchen and garden waste in urban municipal waste.
- Municipal Waste Collection: advanced smart municipal waste collection and transportation management system, that collect, store and transport urban and rural municipal waste.

Services: Municipal solid waste incineration, kitchen and food waste treatment, environmental hygiene disposal, industrial solid waste treatment and disposal and resource utilization, and electronic waste disposal and resource utilization.

Markets: Capital ranks among the market leaders in China and in New Zealand (subsidiary with a market share of more than 30%). Company's projects extend throughout major Chinese cities 10 capital cities including Beijing, Guangdong, Zhejiang, Henan, and Jiangxi.

Customers: Municipalities, households, food operating businesses, food industry.

Innovation: Capital Environment has co-developed dry anaerobic fermentation technology with well-known domestic scientific research institutions.

4.5.4 PESTELI

In this section we employ the PESTELI analytical tool in order to identify external factors that determine the macro environment and how they affect the positioning of SiEUGreen food waste management solutions mainly in the market of China and Europe. These factors are summarized in Table

Table 14: PESTELI Analysis for the food waste management solutions

PESTELI	Relevant Factors	Projection
Political	Political initiatives to mitigate food waste, e.g., • "Love Food Hate Waste" (UK) • "Stop Wasting Food" (Denmark)	The new European Green Deal (Farm to Fork Strategy) will implement series of actions to prevent food waste and ensure food security. The EU

	• "Clean Plate" (China) China has implemented the anti-food waste action (part of 13th Five-Year Plan). The EU is committed to halve the per capita food waste by 2030 and meet the UN Sustainable Development Goals.	Commission will integrate food waste prevention in other EU policies. China and the EU are expected to take more political action to reduce food waste, this will effectively create new clientele for companies that manage food waste.
Economic	Food consumption and food waste have not been significantly affected by the economic recession in 2020, remaining at the same levels as in 2019 if not higher. In general, economic expansion can lead to higher disposable income for an average consumer boosting over-shopping and hence food waste.	Economic growth is projected to be 7.9% in China and 3.6% in the EU in 2021. This in turn is expected to boost consumption and hence food waste, providing growth opportunities for food waste management markets (and companies active) in China and the EU.
Social	Behavioral change due to increase in disposable income has led to the new habits (already existed in Europe) of over-shopping food and over-ordering in restaurants and has brought about enormous amounts of wasted food in China. Chinese culture is prone to food waste, offering to guest more than they can eat as signal of wealth. However, there is a rapidly growing number of people that recycle and sort their waste around the world.	The increased environmental consciousness of people (mainly in Europe and NA) is expected to have a positive effect on food waste. This changing attitude toward the environment is also expected to adopted by people of less developed countries over-time. The latter is expected to be reinforced by the COVID-19 pandemic amidst increasing fears for food insecurity.
Technological	Waste management companies invest heavily in R&D in order to create new innovative methods to collect, process and convert food waste into energy, fertilizers, etc.	Implementation of AI technologies to reduce food waste. Further innovation to develop more efficient food waste recycling systems.
Environmental	Currently, there are lucrative amount of food wasted annually all over the world. However, Europe and China got the largest shares to this environmental disaster. Local authorities in major Chinese cities (i.e, Shanghai) working closely with the Chinese government have already taken some measures to mitigate the environmental degradation.	In view of further environmental degradation on top of the existing negative trends, China and EU will push for strict implementation of laws and regulation concerning food waste. Waste companies are projected to thrive under such circumstances.

	Similar actions have been already taken in the EU to reduce the ecological damage.	
Legal	China has issued a series of regulations obliging food operators to meet specific requirements concerning food waste (collection, classification, etc.) and establishing sanctions for non-compliance. In 2019, Shanghai introduced a new municipal regulation that requires households and enterprises (e.g., hotels, restaurants, and contract catering) to sort their trash correctly imposing fines for non-compliance.	The EU commission will define the legal food waste targets and revise its date marking rules by 2023. It is projected that the legal framework both in Europe and China will become more stringent offering great opportunity of growth to the food waste market.
Institutional	Global partnership of FAO with the UN to reduce food waste through "Think Eat Save" initiative. International Day of Awareness of Food Loss and Waste, recognizing the need to transform the way we produce and consume food. The EU Platform on Food Losses and Food Waste to better identify, measure, understand and find solutions to deal with food waste.	Institutions at a global, national and local level are expected to toughen their position concerning food waste.

Political

In view of existing world hunger and current estimates showing that nearly 690 million people (8.9 % of the world population) are hungry, food waste is something that has got the attention of policy makers in the last years. This issue has become even more critical with the outbreak of coronavirus pandemic that has likely brought about more hunger in the world and more food waste disrupting supply chains and increasing food insecurity.

This has sparked the political reaction and generated food waste management initiatives across the world with the aim to increase awareness about negative implications of wasting food. Some of the initiatives include, "Love Food, Hate Waste" in the UK and the "Stop Wasting Food" movement in Denmark as well as the "Think Eat Save" initiative created by FAO and the UN Environment Program.

The Chinese government has put forward food waste initiatives such as the "Clean Plate" campaign. The government calls upon general public not to over order in restaurants and cut down "shameful" food waste amidst food security concerns that are in part triggered by the

coronavirus. Moreover, in 2015 in the context of 13th Five-Year Plan for Economic and Social Development the central committee proposed the anti-food waste action.

In Europe the problem of food taste is taken also very seriously. The EU countries are committed to meet the "Sustainable Development Goal 12" target to reduce at least by 50% the per capita food waste by 2030 (United Nations, 2021). Moreover, the European Green Deal and more specifically the new Farm to Fork strategy seeks to implement series of actions in order to ensure food security and prevent food waste and food loss on a European scale. Furthermore, the EU Commission will integrate food waste prevention in other EU policies, aiming to preventing food waste and loss across the entire supply chain process, and continue to encourage the implementation of EU Platform on Food Losses and Food Waste for food waste prevention.[91]

More political action taken against food waste in the near future can be translated to better growth opportunities for companies that handle food waste in Europe, China but also on a global scale. For example, if food businesses, industries or households are required to dispose food waste according to some specific standards set by a government this effectively creates new clientele for food waste management market.

Economic

After the unexpected outbreak of coronavirus in 2020, the world experienced deep recession with food consumption remaining at the same levels if not increasing. The global economic activity is expected to rebound in 2021 and more specifically, the World Bank predicts 7.9% and 3.6% growth in China and the EU, respectively.[28] The positive macroeconomic projections are expected to reinforce the food consumption and probably increase the amount of wasted food worldwide.[92] This can provide enormous opportunities for the food waste management companies active in China and Europe but also around the world.

[91] EU Platform on Food Losses and Food Waste, available at: <https://ec.europa.eu/food/safety/food_waste/eu_actions/eu-platform_en>.
[92] In general, an economic expansion has the potential through increasing the disposable income of an average consumer to reinforce the trend of over-shopping food and hence generate more food waste (see also the Social section below).

Social

According to China's National Bureau of Statistics the economic growth in the country has increased the purchasing power of the average consumer more than 5 times over the last two decades.[93] This has increased affordability and availability of food and in turn has developed the habit of buying and throwing away food in larger quantities (already existed in Western countries), increasing food waste in the country. On top of this, higher disposable income and busier lifestyle has created the trend of dinning out and ordering in huge quantities (sign of wealth) resulting in even higher food waste. What is more, in Chinese culture it is central to treat guests well by providing more dishes than can be consumed as a sign of wealth or risk being perceived as cheap. Similarly, when dining out many are embarrassed to ask for take-away boxes fearing it suggests an inability to afford food at home (Zhang and Zhang, 2018).

However, it is also true that during the last years we have been observing the awakening of public environmental consciousness around the world. For example, currently, the social trend and attitude of many people in Europe and NA is to recycle more and move to more sustainable diets, reducing food waste both in and out of home in order to support a more sustainable and eco-friendly development. This means that a rapidly growing number of people in Europe are using services and devices to dispose their food waste in a manner that it can be recycled into energy, fertilizers, compost, etc. It is projected that sooner or later the less developed countries are going to adopt similar attitude and behavior towards the environment, making the food waste management market to thrive. Furthermore, it is expected that the current pandemic will reinforce the positive social behavior towards the environment and will reduce food waste amidst of rising food insecurity around the globe.

Technological

Waste management companies are striving to develop intelligent and innovative recycling technologies to make the best use of food waste and achieve a "zero-waste" economy. The R&D&I efforts in AD have made it possible to convert food waste to biogas that can be used as a source of renewable energy. Moreover, AD is resulted in OFs, BFs and compost that can be used by farmers, residents etc. Considering the existing trends, we can project that the food waste management market will be dominated by innovative recycling and energy

[93] Source: National Bureau of Statistics of China 2021, viewed on 20 January 2021, available at: <http://www.stats.gov.cn/english/Statisticaldata/AnnualData/>.

recovery systems. Besides the innovative technologies in handing food waste, companies can invest in AI technologies to automate tasks required to measure, monitor and sort food waste achieving significant reduction of food waste in restaurants, households and other food operating businesses.

Environmental

As we have mentioned before food waste is a common problem for the majority of countries around the world. On a global scale, significant proportions of food waste end-up in landfills or incinerators without undergoing appropriate treatment. This is an issue because when organic matter decomposes in an oxygen-free environment, it releases landfill gases such as CH_4 which is many times more potent than CO_2 and can cause environmental, hygiene, and safety problems. Food waste alone generates about 8% of global Greenhouse gas emissions.[94]

The UK produces 20 million tons a year of food waste. In Australia more than 30% of the food that is purchased is wasted and this accounts for more than 5% of Australia's greenhouse gas emissions. In the EU approximately 88 million tons of food waste are generated annually with 70% of EU food waste arising in the household, food service and retail sectors, and the remaining 30% in production and processing sectors (Fusions, 2016). China is the world's second largest producer of municipal solid waste, the majority of which is food waste (35 million tons annually).

The local authorities of major Chinese cities - that face the most significant problems regarding the amount of food waste - have responded by investing in safer and more sophisticated incinerators and landfills in recent years. Moreover, in 2019 Shanghai with the support of the Chinese government launched China's first program requiring residents to sort recyclables from trash in order to mitigate the food waste problem. In addition, according to the Ministry of Housing and Urban-Rural Development, China plans to set up domestic waste classification systems in most of its major cities by the end of 2021.[95]

Food waste possess a serious problem in Europe contributing to the environmental degradation that we have been experiencing over the last decades. The negative implications

[94] Source: European Commission Website , Food Waste, available at: <https://ec.europa.eu/food/safety/food_waste_en>.
[95] Source: Ministry of Housing and Urban-Rural Development , 2021, viewed on 20 January 2021 available at: <http://english.www.gov.cn/state_council/2014/09/09/content_281474986284089.htm>.

for the environment, human and animal health, has prompted various political, legal and institutional interventions that we describe in other parts of the analysis. Overall, it is expected that EU will push for reduction of food waste implementing stringent regulation, laws and rules on food operating business, food industries and even households.

Given the already existed environmental burden coupled with the negative environmental trends due to food waste, governments in the EU and China will have to act sooner than later. It is expected that in their effort to reverse the current environmental degradation they will create tremendous opportunities for the food waste management companies. For example, instead of burying food waste in landfills or burning them in incinerators, waste companies can collect this food waste and convert into green (renewable) energy (or even fertilizers) saving-up enormous costs and reducing the ecological footprint.

Legal

In the past China has issued regulation on food waste obliging food operators to meet specific requirements concerning collection and transportation of food waste, establishing waste management register and sanctions for non-compliance ("Opinions on Strengthening the Improvement of Waste Oil and the Management of Kitchen Wastes"). Another regulation known as the "Transparent Kitchen Program" urges catering service units to establish a management system for the disposal, classification and placement of kitchen waste; to record in detail the types, quantities, destinations and uses of kitchen waste and finally to calculate the production of kitchen waste in catering service units. More recently in 2018, the Food Safety Operational Regulations for Catering Service provided detailed regulations on the management of food waste, including containers, facilities and signs for waste storage, classified disposal of waste and waste management registers. In 2019, Shanghai introduced a new municipal regulation on food waste-management that requires households and enterprises (e.g., hotels, restaurants, and contract catering) to sort their trash correctly imposing fines for non-compliance. As it is obvious, China has quite some laws and regulations to tackle food waste but meanwhile enforcement of current regulations should be improved.

As a part of its Action Plan strategy the EU Commission is going to propose regulation (by end of 2023) to reduce food waste by legally binding the food waste targets that are defined against a baseline levels set by the EU (European Union Commission, 2020a). Moreover, the EU intends to revise its date marking rules ("use by" and "best before" dates) by the end of

2022.[96] Finally, the Revised EU Waste Legislation calls on the EU countries to take action at each stage of the food supply chain, monitor and report food waste levels in order to reduce food waste (European Parliament, 2018).

In view of current negative trends that cause serious economic and environmental damage it is projected that the legal framework both in Europe and China will become more stringent over time providing enormous opportunities for growth in the food waste management market. Moreover, with the development of new technologies in food waste management (i.e., AD) there is a need to create a regulatory framework for the byproducts from these processes (composting, OFs and BFs) in order to allow their legitimate trade in the market.

Institutional

In 2019, the 74th UN General Assembly designated 29 September as the International Day of Awareness of Food Loss and Waste, recognizing the need to transform and rebalance the way our food is produced and consumed.

The European Commission and the UN have set as a target to halve the amount of food waste by 2025. A global partnership between FAO and the UN Environment Program is seeking to galvanize action on global, regional and national level, catalyze awareness of food waste and more importantly generate some action at different levels and sectors of the society through the "Think Eat Save" which is part of Save Food Initiative contributing to UN's Sustainable Food Systems Programme.

Furthermore, the EU Commission has funded research projects such as REFRESH (2015-2021) to take action against food waste. More specifically, this project aimed at understanding better through evidence based research the main drivers of food waste and went as far as provide guidance to policymakers and legislators in order to support proper governance and tackle food waste (Refresh 2021).[97] In addition, the EU Platform on Food Losses and Food Waste was established in 2016 with the aim to bring together the relevant EU institutions, experts and stakeholders in order to better identify, measure, understand and find solutions to deal with food waste, share the best practices and evaluate progress over-time.

[96] Source: European Commission Website, The EU actions against food waste, available at: <https://ec.europa.eu/food/safety/food_waste/eu_actions_en>.
[97] Source: Refresh 2021, available at: <https://eu-refresh.org/about-refresh>.

Institutions at global, national and local level are expected to toughen their positions regarding food waste. This can potentially generate more opportunities for the companies working in food waste management sector.

4.5.5 SWOT Analysis

In this section we present the SWOT analysis for the SiEUGreen food waste management solutions summarized in Figure 12 below.

Internal Strengths & Weaknesses

Urban Composting Hub

Strengths: Urban Composting Hub offers locally produced OFs and soil amendments (compost) that can be used directly by residents for balcony gardening or in urban community gardens. This constitutes an improvement upon the standard practice of companies in this field to collect organic waste and then treat it in a remote plant usually outside the urban area. This decentralized closed loop production of OFs made possible by the Urban Composting Hub reduces the cost of collecting and transporting organic waste and the time that residents have to wait in order to use the products of the organic waste for urban farming (home/rooftop or community gardens). What is more, this decentralized system is of a particular usefulness especially under the current situation and restrictions due to the coronavirus pandemic.

What is more, since residents benefit directly from the results of AD that takes place in the Urban Composting Hub it is easier to engage and convince them in recycling and promote the idea of sustainable development to local communities. Hence, achieving important social, economic and ecological goal.

Another strength for this food waste solution is the SiEUGreen project itself and more specifically, the partnership between the EU and China that can potentially provide a great opportunity for Urban Composting Hub to obtain an easier access to the Chinese market.

Weaknesses: The major weakness over its competitors is the high cost of installing the hub in the urban district. This fixed cost can prove to be quite important burden for its market expansion. Moreover, the Urban Composting Hub is not designed to produce biogas - that can be used as a source of renewable energy - which is a common practice among its competitors in the market and something that can generate great revenue.

Garbage Processor

Strengths: The unique selling point of this device is its capacity to produce OFs out of household or kitchen waste at home. As we can understand this is extremely useful especially in circumstances that we are currently experiencing with the COVID-19 pandemic.

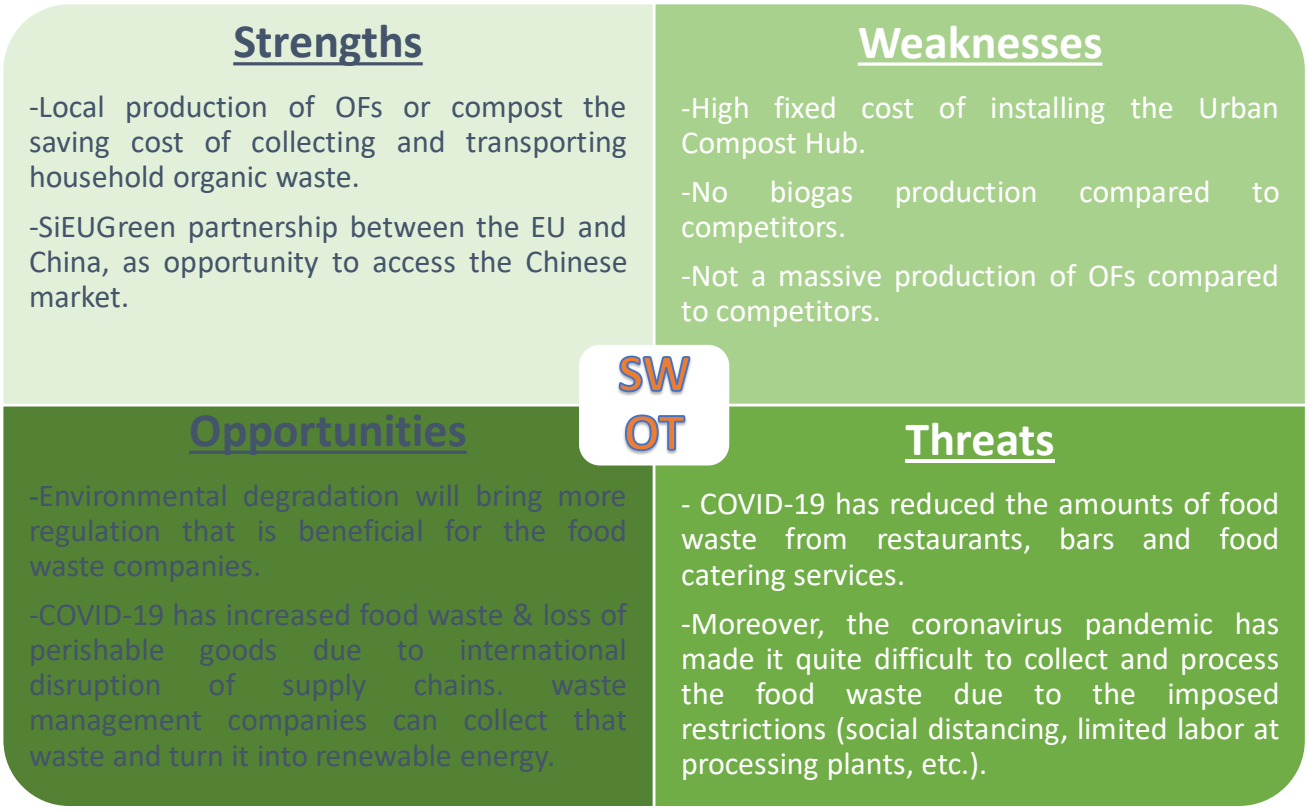
Furthermore, the SiEUGreen partnership constitutes an excellent opportunity for Garbage Processor and the designer company Photon to enter European markets and to expand its domestic position in the Chinese market.

Weaknesses: Obviously the production of OFs is not massive or it cannot be done on a large scale. Instead these OFs are produced to cover the needs of a single balcony or a rooftop garden. Hence, the commercial exploitation of OFs would not be possible.

External Opportunities

Environmental degradation, stringent regulatory framework to be adopted and the current COVID-19 pandemic are among the most important drivers and external opportunities for food waste management market.

Figure 12: SWOT Analysis for SiEUGreen food waste management solutions.



As we saw in the previous section food waste is still a growing problem across the developed and developing world. The COVID-19 pandemic has only further aggravated this situation. The supply chain disruption caused by lockdowns and movement restrictions among countries and even among regions within countries have resulted in significant increases in food waste and loss. Perishable products such as fruits and vegetables, fish, meat and dairy products have been wasted even before they reach the consumers. The food waste companies by collecting, processing and converting the food waste into biogas can make a great use of the waste and turn it into renewable energy that will benefit at the same time the environment, human health and will save high energy costs.

Furthermore, the rapidly increasing environmental damage caused by overproduction and extreme use of natural resources can be only tackled with more stringent regulation and stricter laws over proper recycling of waste. More stringent and comprehensive laws on waste disposal creates a window of opportunity for the food waste management companies. As more food industries, companies and households will be required to dispose properly their food waste more business will be generated for waste management enterprises. Hence, more regulation can be translated to an excellent opportunity for them to enlarge their market by acquiring new clientele.

External Threats

One of the major threats to the food waste management is the coronavirus pandemic. The closure of much of the catering and food service industry has resulted in less food wasted in restaurants and bars hence reducing the volumes that companies can collect and process. Furthermore, the global pandemic has restricted the functioning of the waste management companies and their plants. Just as in the case of all other businesses that are disrupted by coronavirus pandemic, waste companies have also suffered significant consequences regarding their operations due to limited working staff allowed at the plants and offices.

5 Way forward and the next steps for SiEUGreen technologies

In the current deliverable, we identified and analyzed 5 markets where SiEUGreen marketable outputs/results can be placed. More specifically, we provided a thorough analysis on the state of each market and their main features, trends, opportunities as well as threats and barriers on the European, Chinese but also Global level. Moreover, we identified and studied the external macro factors that can affect the market development of SiEUGreen technologies, and determined the internal strong points and shortcomings of the marketable outputs/results. In addition, throughout the deliverable particular focus was placed on the competitive landscape, in order to assess the level of competition and determine the key market players on the European, Chinese but also Global level.

Overall, the analysis conducted in this deliverable contributes directly to the *D5.5-Business Plan* and further market exploitation of the SiEUGreen technologies. More specifically, the results of *D5.3-Market Analysis III* provide a better understanding of the larger landscape that SiEUGreen commercially exploitable outputs will compete in and can serve as a solid base for the next Deliverable *5.5-Business Plan.* Moreover, the competition analysis of *D5.3* is crucial for assessing which geographical locations offer great market opportunities for the SiEUGreen marketable outputs and will feed directly into *D5.5-Business Plan*.

D5.5 will focus on creating sustainable business plans for the exploitable outputs of the SiEUGreen project and especially those with a clear commercial perspective. Furthermore, in *D5.5* we can go one step further and narrow down our competition analysis to the country-specific level. We can examine competition within our partner countries or those countries with developed markets in the area of the SiEUGreen technologies like for example, Germany, Switzerland, the Benelux, Nordic and Mediterranean countries, as well as developing markets in Asia and Latin America.

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