SiEUGreen
Sino-European innovative green and smart cities

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Spotlight on SiEUGreen Results and Learnings

Final Project Conference, 17 November 2022

Ski, Norway

by seecon international gmbh

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Final project conference

On 17 November 2022, Mr. Wafler and Mr. Heeb of seecon international gmbgh (Switzerland) participated in the hybrid SiEUGreen Final Project Conference in Ski, Norway, which was attended by more than 40 people in person and virtually. The aim of the conference was to present, discuss and promote the cross-country results and learnings of the SiEUGreen project.

About SiEUGreen

The Sino-European Innovative Green and Smart Cities (SiEUGreen) project, which runs from early 2018 to the end of 2022, aims to strengthen the EU-China cooperation in promoting urban agriculture (UA) for food security, resource efficiency, and smart and resilient cities. In the general context of zero-waste circular economy, the project leveraged existing technological tools and develops innovative resource-efficient agricultural techniques and integrated concepts to demonstrate how technological and societal innovation in UA can positively impact the economy, society and environment in China, Europe and elsewhere beyond the project period.

SiEUGreen brings together a multidisciplinary consortium of European and Chinese researchers, technology providers, Small and Medium Enterprises (SMEs), financiers, local and regional authorities and resident communities to facilitate the development and deployment of state-of-the-art urban agriculture models. Building on the zero-waste and circular economy model, SiEUGreen combines technological and societal innovation in promoting urban agriculture for food security, resource efficiency, and smart, resilient cities.

Showcases

The project prepares, deploys and evaluates five ground-breaking multidisciplinary showcases in urban and peri-urban areas in Europe and China that contribute to the future development of urban agriculture (Figure 1).

Figure 1: Map with SiEUGreen Showcases

Campus Ås is home to Norway's largest interdisciplinary academic environment in the field of life sciences. The full-scale implementation of a GREENergy concept demonstrate that an innovative combination of known and emerging technologies, actions and planning can contribute to resilient, climate-, environment- and people-friendly urban development.

Aarhus is located in the Central Denmark Region (Midtjylland) and is an ethnically diverse city where 15% (about 50 000 people) of the population is made up of immigrants and direct

descendants of immigrants. The municipality of Aarhus is known for its bottom-up initiatives that show how cities can create more socially inclusive places and communities by focusing on edible nature and urban agriculture.

Hatay province is located in the southern part of Turkey. Its proximity to the Syrian border has had a strong influence on population development in recent years, leading to a sharp increase in the number of inhabitants, especially in the border municipalities. The project supports the Hatay Municipality on how local authorities can ensure food security and self-sufficiency for Syrian refugees and socially disadvantaged members of the local community.

Beijing is home to more than 20 million people. People living in the Chinese megacity find it difficult to connect with nature. The Sanyuan Farm within the Citizen Farm Project tries to meet the city dwellers' aspirations for greenery, nature and environmental protection and to support the first step from traditional agriculture to urban farming as a leisure activity.

Changsha is the capital of Hunan province and one of the most densely populated provinces in China. As such, it faces a huge environmental problem in terms of food supply via long transport routes. Changsha also has to deal with water shortages, as it has limited water resources. The Changsha showcase supports the use of waste and wastewater reuse and recycling technologies in a housing project to create green neighbourhoods and develop circular systems where waste recycling and wastewater management go hand in hand with resource-efficient, smart and sustainable urban agriculture.

Green cities

In his presentation, Prof. Petter Jensson, retired professor from the Norwegian University of Life Sciences (NMBU), articulated the vision of sustainable green cities that promote human well-being, reduce water and energy consumption, eliminate or reduce emissions, and produce food in the city based on local waste resources. Havana, Cuba, where 60% of the vegetables consumed are produced within city limits, his own experience growing 35 kg of potatoes per square meter in raised beds and an annual production of 150 kg of tomatoes per square meter in Norwegian greenhouses served as examples of how urban agriculture can contribute to food security. Prof. Jensson shared examples of urine-diverting flush toilets and vacuum toilets to enable collection of concentrated black- and yellow-water (i.e. urine) streams that are a prerequisite for struvite production and ammonia stripping and on-site greywater treatment that enables reduction of potable water consumption by up to 90%. Prof. Jenssen concluded that a holistic system analysis including Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA) and economic assessments in monetary and non-monetary terms (MCA) are needed to optimise systems and system combinations in a shift towards circular economy. In conclusion, Prof. Jenssen said "Above all we need good examples to learn from as in SiEUGreen, Helsingborg, Fjordbyen, etc.".

Feasibility and challenges

Dr. Trond Mæhlum from the Norwegian Institute for Bioeconomy Research (NIBIO) gave a brief overview of traditional and innovative agricultural cultivation techniques, waste management and wastewater systems studied and deployed in the SiEUGreen project, including feasibility issues and potential challenges. Amongst others, he touched upon traditional soil-based cropping systems, aquaponics and hydroponics, the use of compost from organic waste and faeces as a substitute for peat, the use of new urban cropping systems such as self-watering boxes, the use of insects bred on organic waste (e.g. black soldier fly, etc.) as fish feed, household-level microgreens production and large-scale industrial application, alternative toilet systems such as vacuum toilets and urine-diverting toilet systems, anaerobic digestion for the treatment of blackwater from vacuum toilets treatment and energy production in the form of methane. Dr. Mæhlum concluded that "Circular urban cultivation using local resources (i.e. soil media, nutrients, water, energy, etc.) is possible, plays a role in urban circular economy and makes cities more climate resilient provided proper technology and management is applied. Many technologies/techniques are readily available and can be used now, while some are still at a development stage. Energy prices, food security and new technology in combination with changing attitudes to resources in waste can cause rapid changes in circular UA."

Figure 2: Dr. Trond Mæhlum showing produce from SiEUGreen research (source: presentation by Dr. Trond Mæhlum on 17 November 2022)

Sewage-based compost

Prof. Trine Hvoslef-Eide from NMBU, in her presentation "Sewage-based compost in a semi-hydroponic culture system", cited sources that Canada's consumption, transport and processing of peat (mainly for the greenhouse industry) had increased by 66% in the period from 1990 to 2000 and that it would take 2000 years to restore the land naturally. Prof. Hvoslef-Eide presented results from scientific research using various growing media (i.e. commercially available sewage-based compost, peat, a 50:50 mixture of peat and wood chips, and manure-based compost), using various fertilizers such as Struvite and Bløme (a slow-release plant fertilizer made from

insect droppings that is approved by the Norwegian Food Safety Authority for organic cultivation) when growing tomatoes and cucumbers. One of the findings is that in the 50:50 mixture of peat and wood chips, the microorganisms that break down the wood chips win the competition with the plants for the nitrogen, and therefore the plants yield less.

Blackwater in circular UA

Dr Melesse Eshetu Mogens from NMBU elaborated on unlocking the potential of blackwater in urban circular economy. As the world's population increases, so does the global demand for water and phosphorus for food security. On the one hand, domestic wastewater is an important source of nitrogen and phosphorus; on the other hand, its management remains a major social, environmental and economic challenge. There is a paradoxical situation that nitrogen (N) and phosphorus (P) are removed at high cost in tertiary wastewater treatment, while the demand for artificial fertilizers is continuously increasing. This paradox opens a new perspective on domestic wastewater management as part of the circular economy, which takes a resource-oriented and holistic approach to ecologically and economically sound wastewater management. Rethinking resource utilisation within a circular economy and zero-waste approach to sustainable development may include source separation, on-site wastewater treatment, as well as a resource recovery approach to handling domestic wastewater streams to nutrient and energy recovery.

Figure 3: Dr Melesse Eshetu Mogens standing in front of aperture for producing algal biomass from the blackwater digestate (source: presentation by Dr. Trond Mæhlum on 17 November 2022)

The results show that in addition to nutrient and energy recovery, more than 100 kg of carbon dioxide (CO_2) equivalent per person per year can be sequestered in a process that includes anaerobic digestion of blackwater from vacuum toilets, filtration and UV treatment of the liquid digestate for biogas production, disinfection and removal of pharmaceutical residues, phosphorus recovery in the form of Struvite and production of algal biomass from the digestate (Figure 3) to produce dry organic fertilizers, and sludge dewatering and drying for biochar production.

Nutrient recycling

Dr. Bente Føreid (NIBIO), in her presentation "Nutrient recycling at the local level", gave a retrospective of the time when most nutrients were recycled in agriculture. However, when people moved to cities, this circular system changed. In her research, Dr. Føreid examined and compared the main sources of nutrients in urban environments/households and compared treatment methods such as composting, vermi-composting, storage of source-separated urine, etc., as well as looked into whether the amount of nutrients available matches the demand. Her research indicates that in urban agriculture people often do not accurately determinate the optimal nutrient dose, but rather use the fertiliser they have. Kitchen waste can be recycled at household level both, by either composting or anaerobic digestion. According to Dr. Føreid, both processes (if done properly) produce stable, good quality products. Composting is easier to be done on small-scale at the local level compared to biogas digestion. But the later one avoids nutrient losses as happens in the composting. Urine is a very suitable liquid fertiliser for many reasons: it has a high N:P ration and therefore supplements compost well, all nutrients are readily plant available, it has less hygiene issues than faces, it can be used throughout the growing season (split application), nitrification produces a smell-free and stable product. Urban systems have both supply and demand for nutrients, but amounts do not always match. Dr Føreid made an appeal that people practising urban agriculture should get advice like other farmers.

Figure 4: Growth tests (source: presentation by Dr. Bente Føreid on 17 November 2022)

SiEUGreen in China

Today, urban planning restricts the development space of urban agriculture in China and community agriculture is subject to various restrictions. At the same time, the supply of UA technology is insufficient and only few market players are

engaged in UA research and extension. The importance of urban agriculture is underestimated, and the development of UA needs more support from the aspects of policy, finance and urban planning. Against this backdrop, Dr. Qiang Li from the Institute of Vegetable and Flowers at the Chinese Academy of Agricultural Sciences (CAAS), provided an overview on the SiEUGreen activities in China and an Impact Assessment of UA. For example, Chinese partners developed urban farming equipment such as fruit vegetable planters suitable for cultivation of e.g. tomatoes, cucumbers, etc., mushroom planters, planters for succulent plants that automatically manage watering and artificial lighting and microgreens planting shelves (Figure 5). Furthermore, different growing media for potted balcony vegetables such as Coriander, Celery, Green onion, Nepeta, Pepper and Tomatoes were developed and tested with more than 300 households in Beijing, Changsha and Urumqi. For the recycling of kitchen waste, a Kitchen Waste Composting Machine was development and tested that can produce about 3 kg of organic fertilizer every week. Low-flush toilets were installed in 18 newly constructed flats for the collection of blackwater for Struvite precipitation. A total of 2.650 kg of Struvite, a slow-release ecological fertilizer, was produced for Hunan Hongyu Property Management company to carry out 13.000 m^2 community landscaping. A small-scale aquaponics system was constructed in Beijing's Sanyuan Farm and a larger-scale one in Pinggu district. With an area of ca. 1.300 m^2, the larger aquaponics system yields about 12.000 kg fish per year and 7.500 kg of vegetables per year. According to an impact assessment, UA in China fulfils ecological, economic and social functions. From the point of view of ecological function, urban agriculture brings a healthy, green and low-carbon lifestyle to urban residents by adopting a lifestyle of recycling urban resources. From an economic standpoint, UA lowers food costs for residents and increases household income for low-income people. In its social function, urban agriculture promotes community harmony and enriches the lives of residents.

Figure 5: Fruit vegetable planter, mushroom planter and microgreens planting shelf (from left to right) (source: presentation by Dr. Qiang Li on 17 November 2022)

Deployment plans

Ms. Vasiliki Moumtzi, co-founder of ViLabs, a Greek SME that acts as both a private Research & Innovation Laboratory and an Innovation Hub for startups, presented the deployment plans for the transition of the SiEUGreen Showcases Campus Ås, which hosts Norway's largest interdisciplinary academic environment in the field of life sciences, the community gardens in Aarhus (Denmark), previously unused urban land with high refugee density in Hatay (Turkey), large urban community farms in Beijing (China), and a new green urban development in Changsha (China) to circular economy.

Efficiency & resilience

Dr. Luciane Aguiar Borges (Nordregio) spoke on "Broader conceptual framework for resource efficient and resilient cities with UA". She explained the definition of resilience as the ability of a city or urban system to cope with shocks and threats, survive stresses, and adapt to social, political, economic, and environmental changes. In a rapidly changing world, resilience and resource efficiency offer useful ideas for understanding and managing uncertainty and risk. Inspired by natural ecosystems, the circular economy is a pathway to resilient and resource-efficient cities. The concept promotes a shift away from the "linear" paradigm of extraction, production, distribution, consumption, and disposal toward a sustainable regenerative economy that focuses on cycles of reuse, restoration, and renewability and encompasses the entire value chain. SiEUGreen uses five showcases to demonstrate that UA can contribute to resource-efficient food production through the application of circular strategies and circular resource flows, making cities better equipped to manage risk while improving human well-being and ecological functioning.

Knowledge exchange

Dr Jihong Liu Clarke (NIBIO) addressed in her presentation the successes and challenges regarding knowledge exchange between Europe and China in Horizon 2020 projects. With a total number of 590 organisations (Figure 6) involved in EU Horizon 2020 projects, China ranks second behind the USA (more than 1.800 organisations). This fact reinforces the importance of the (international) knowledge transfer between the EU and China both, between academic partners, between academic and industrial partners, between industrial partners, and the dissemination to all stakeholders.

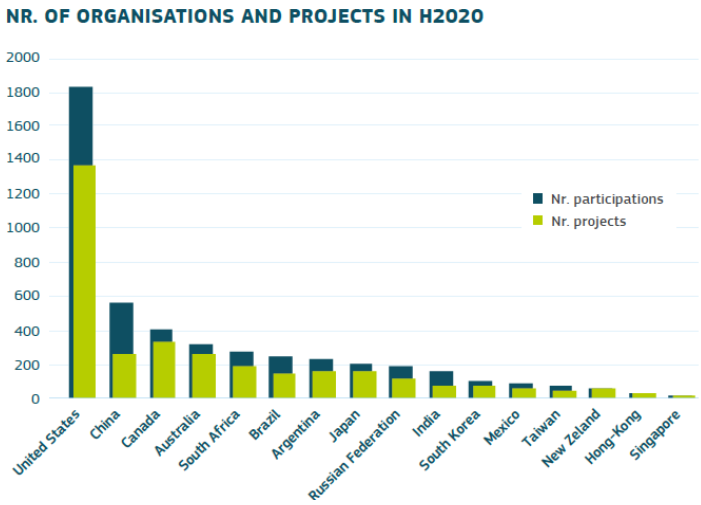

Figure 6: Number of organisations and projects in EU Horizon 2020 projects (source: European Commission, 2021, A Practical Guide for China - 2021-2027)

In the past, China attracted the attention of scholars, police makers and company executives mainly because of its growing power as a competitor in knowledge intensive activities, but little attention was devoted to the issue of international technology transfer from and to China. But it is a natural step that China will become an important producer of technology demanded by other countries on the one hand, and that China will increase its demand for technology developed abroad, on the other hand. In this context it is important to consider that

Chinese Intellectual Property Rights (IPR) and regulations different from those in the EU. The most important part of IPR laws and regulations, is that the consortium partners share their knowledge and protect IP in a way that ensures the best possible outcomes to society (internationally) – and according to the project goals.

One examples of successful EU-China knowledge transfer and sharing with the scope of SiEUGreen is about paper-based microgreen production technology. Developed by Beijing Green Valley Sprout (BGVS) Ltd., this technology was introduced to NIBIO that verified and optimized the production protocol for European countries. For example, NIBIO used ordinary kitchen paper instead of special paper provided by BGVS to achieve the same results. In return, NIBIO shared this improvement with BGVS to achieve a two-way knowledge and experience sharing and transfer. The optimized paper-based microgreen production protocol is now available in 4 languages (CN, EN, NO and TR). Beyond the SiEUGreen project, trust and a friendly working relationship and regular communication and updates between partners is essential for a two-way knowledge transfer and learning.

New market entry points

On 15 November 2022 the next global billionth milestone was reached: the world's population surpassed the 8 billion mark and population is projected to reach a peak of more than 10 billion in 2080. For most of human history, the majority of people lived in small communities, but this has changed dramatically in recent times. According to UN estimates, the year 2007 marked the point when the number of people living in cities exceeded those living in rural areas. With the massive migration of people to urban areas, also food demand in these areas increases. It is predicted that by 2050, 80% of all food will be consumed in cities. In his presentation "Linking SiEUGreen Technologies to New Market Entry Points", Mr. Martin Wafler from seecon international gmbh (Switzerland), highlighted that with a growing consumer demand for diverse food products, transportation has emerged as a key link in food supply chains and that food travels long distances – sometimes hundreds or thousands of kilometres – across the globe, connecting faraway fields, factories, distribution centres, and store shelves before it reaches our plates.

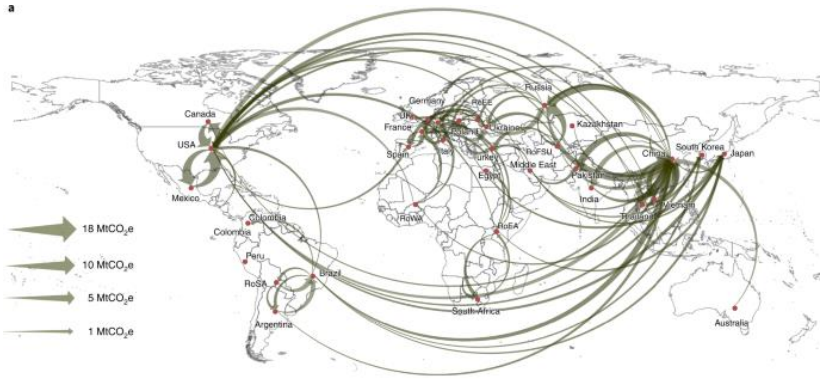

Figure 7: Top 100 bilateral flows of international food-miles emissions (source: MENGGYU, L., 2022, Global food-miles account for nearly 20% of total food-systems emissions)

For example, in the USA, average travel distance of agricultural produce is ca. 2.400 km. Global food-miles accounts for 3 Gt of CO_2 equivalents in greenhouse gas emissions and global freight transport associated with vegetable and fruit

consumption contributes 36% of food-miles emissions. The SiEUGreen Showcase Aarhus demonstrates market entry points for UA such as social inclusion, waste recycling, extension of the growing season. Education and communication, employment generation, nutrient recycling is demonstrated in the Hatay Showcase and innovation, resource efficiency, water saving, waste and nutrient recycling are cornerstones of the Showcase As. Physical and mental wellbeing, leisure, improved food security are demonstrated in the Beijing Showcase. In the 2023 Food Report, the German Zukunftsinstitut, provides a perspective on the most recent food trends. Transparency, local food, quality, sustainability, local exotics, fair food and zero-waste are identified as specific market entry points for SiEUGreen technologies.

Sociocultural adaptation

The production of chemical fertilizers is a highly energy intensive process. Energy is expensive, and its generation can harm the environment and the climate. Potential substitutes are fertilizers produced from human excreta and fertilizers from fish sludge. In his presentation on "Sociocultural Adaptation in European Urban Agriculture", Dr Atle Wehn Hegnes (NIBIO) shared findings on the questions whether consumers are willing to eat food produced by these alternative fertilizers (assuming that the food is approved by the health authorities and taste as good as other food and is as healthy and nutritious as other food). Dr Wehn Hegnes' research shows, that while most of the personality traits (i.e. openness, conscientiousness, extraversion, agreeableness and neuroticism) have effects on both food types, openness to experience has the largest effect. Generally speaking, younger individuals are more willing to try than older people, and men are more willing to try than women. Individuals who care about the environment are more willing to try than individuals who don't care about the environment. Furthermore, vegetarians, individuals negative to fish farming and individuals caring about animal welfare are less willing to try food produced with fish sludge.

Policy recommendations

In addition to researching, optimising and deploying urban agriculture technologies and practices, another key objective of the SiEUGreen project is to derive policy recommendations targeting local, national and European policy makers and regulators for improving the framework conditions that will enable the flourishing and expansion of UA, through the lens of overall goals about circular and adaptive planning. Ms. Eleftheria Ntonou from EMETRIS (a Greek business consulting company specializing in Strategic planning & foresight, Financial planning and Marketing studies), shared key learnings from the planning, implementation and monitoring of the SiEUGreen Showcases Campus Ås (Norway), Aarhus (Denmark), Hatay (Turkey), Beijing and Changsha (China). For example, recommendations shall provide support instruments for UA applying innovative circular approaches such as reuse of black and grey water, human excreta, etc.) in the framework of the EU's new Common Agricultural Policy (CAP) 2023-27 that is key to securing the future of agriculture and forestry, as well as achieving the objectives of the European Green Deal, to increase public funding to further boost research, development and implementation activities for human excreta treatment and

use in urban farming activities through pilot projects, promote the dissemination between European Member States, integrate UA activities and technologies as an institutionalized land use in urban regeneration plans and plans for new urban blocks, support the creation and reinforcement of Urban Farmers' Cooperatives to boost strategic mass and capacity building in circularity-oriented UA projects, etc.

Partners

Norwegian University of Life Sciences (NMBU)

Norwegian Institute of Bioeconomy Research (NIBIO)

The Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences (CAAS)

Nordregio

Emetris S.A.

Aarhus Kommune (AAKS)

ViLabs (CY) Ltd.

Okys Ltd.

Beijing Eco-Creative Agricultural Service Alliance (BAEISU)

Scandinavian Water Technology AS (ScanWater)

Hatay Metropolitan Municipality

Chinese Academy of Social Science (CASS)

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seecon international gmbh

Leibniz Institute of Vegetable and Ornamental Crops (IGZ)

Beijing Photon Science & Technology Co. Ltd. (PHOTON)

Beijing Green Valley Sprouts Co. Ltd. (BGVS)

DRAXIS Environmental S.A.