SiEUGreen
Sino-European innovative green and smart cities

Sino-European Innovative Green and Smart Cities

Deliverable 4.2

Transnational board meeting report and issue of white paper

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

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

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

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

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

Technical References

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[1] **PU** = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
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Executive Summary

This D4.2 reports the outcomes of the transnational board meeting (TBM), including the presentations of various technologies and a basic outline for the white paper. Active knowledge transfer and experience sharing between European and Chinese partners from the project start to month 36 are also presented by the consortium partners. Both European and Chinese partners have been involved in knowledge transfer and technology sharing, even during the covid-19 pandemic, by using online communication platforms, e.g. Zoom. The TBM, which was held in October 2020, permitted all partners to receive an update of the EU-China knowledge transfer and active collaboration through the 2-day presentations and highlighted several milestones: 1) Active technology sharing and knowledge transfer between the European and Chinese partners has been achieved as shown through the Greenergy (the blue technology sharing) from Europe to China, and the implementation of the paper-based microgreen production from China to Europe (Norway, the green technology transfer). 2) Two-way traffic (EU↔China) for knowledge transfer and technology sharing was established for the green and blue technologies. This effective sharing culture across the EU and China shall benefit EU-China collaboration in the future beyond SiEUGreen. 3) Understanding of European and Chinese IPR, IPR law and regulations were significantly improved among the SiEuGreen partners through active knowledge transfer, meetings and communication between the European and Chinese partners. 4) Promoting knowledge transfer and sharing at the individual participant level. Totally, thirty-three participants attended the 2-day TBM. This D4.2 deliverable presents the TBM meeting report issues and the white paper based on the outcome of the meeting.

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1. Introduction

Global production of food is growing rapidly. At the same time, large quantities of organic waste from farms and greenhouses, such as livestock manure, crop stalks, and rotten vegetables, accumulate and pollute aquatic ecosystems and the atmosphere (Woodward et al., Science, 2012. **336**: pp. 1438-1440). Furthermore, mineable rock phosphate is a limited and non-renewable resource, and mineral P should be replaced with recycled P from secondary resources like organic waste. The reuse of waste fractions might reduce the environmental impact of the food production industry (Martínez-Alcántara et al., PLOS ONE, 2016. **11**(10): e0161619; Favoino and Hogg, Waste Management & Research, 2008. **26**(1): pp. 61-69). The covid-19 pandemic has shown once again the importance of food security and safety, and of the UN Sustainable Development Goals (SDGs). To contribute to food security, urban agriculture (urban food production) is developing rapidly around the world, including in China, the EU and Norway. Paris is building the world's largest urban rooftop farm (www.bbc.com, news August 24, 2020). Moreover, waste to value (zero waste) is the key to a circular economy and can benefit urban food production in the future.

The SiEUGreen project, in line with the rapid development in urban agriculture worldwide, aims to share and transfer knowledge and experience between China and European countries to achieve a successful urban agricultural food production with zero waste, minimum transport, reuse, recycling and reduced environmental and energy burdens, to contribute to a circular economy. The knowledge and technologies shall be shared and transferred through the project period, including the green technology with important crop cultivation techniques, the blue technology including wastewater treatment and reuse technology, waste composting and biogas production. The social acceptance by and impact to urban citizens and their involvement are essential to achieve the ultimate sustainable urban agriculture contributing to the UN SDGs, especially SDG2- Zero hunger.

With the support of the signed Grant Agreement, the Partner Agreement on IPR, and the MoU (D4.1), the SiEUGreen project partners have achieved effective knowledge sharing and technology transfer between China and Europe in the green and blue technologies reported in this D4.2. A white paper is included in this document (cf. deliverable D4.2).

2. Transnational board meeting report

2.1 Introduction

The Sustainable Development Goals Report (2019) issued by the United Nations stresses that progress is slow, and many areas require our urgent attention, including climate change and the inequality among countries mainly due to poverty, hunger and disease. Actions promoting sustainable agriculture are essential to gradually improve this situation.

The Horizon 2020 Framework Programme promotes cooperation between the EU and China for sustainable urbanisation, following the Joint Declaration on the EU-China Partnership on urbanisation signed in 2012, as well as the conclusions of the EU-China Innovation Cooperation Dialogue of 2013.

The transnational board meeting intended to present the methods and results of the H2020 project SiEUGreen and to share and transfer "know-how" between China and European partner countries. The project brings together European and Chinese scientists, technology providers, and authorities at a local and national level. The knowledge transfer aspires to promote novel urban agriculture and integrated waste handling concepts, social engagement methods, and business models that can be adopted in urban and peri-urban areas, in order to improve the local environment, economy, society, health and food quality and security.

2.2 Objectives

The core objective of the meeting has been to share and transfer "know-how" between China and European countries. Therefore, the topics have been based upon the exchange of experience among partners and including information about:

- Views of urban agriculture in Europe and China and corresponding policies.
- Examples, results and practices from SiEUGreen, as well as knowledge exchange between the showcases regarding:
  - ✓ Adaptation of technologies
  - ✓ Social inclusion
  - ✓ Environmental impact
  - ✓ Sustainability
  - ✓ Potential and challenges

2.3 Audience

The meeting participants have been two policy makers of the European Commission RTD, DG AGRI, the SiEUGreen external Expert Advisory Board members, and the members of the SiEUGreen consortium, including stakeholders of the five EU and Chinese showcases.

Thirty-three (33) persons in total participated in the meeting. The participant list is not presented for GDPR protection purposes, since the dissemination nature of this report is Public.

2.4 Date and Location

The meeting took place on 15 & 16 October 2020. Due to the fact that in this period, Europe was still affected by covid-19 and possibilities for travelling were very limited, the meeting was conducted online through the Zoom platform.

2.5 Organizing committee

The organizer of the meeting was the leader of Task 4.3 *Transnational Board meeting to exchange knowledge and issue MoU*, the beneficiary Vilabs Ltd. It received advice from the leader of WP4 *International knowledge transfer,* the beneficiary NIBIO and the project coordinator.

2.6 Agenda

The agenda is included in Annex I of this report.

2.7 Summary of the meeting

A virtual transnational board meeting on the transfer of know-how between China and Europe was held, to share the methods and tools that the SiEUGreen project 'Sino-European Innovative Green and Smart Cities' applied to exchange knowledge among its European and Chinese project partners. The principal aim of the meeting was to introduce the policies for the collaboration between Europe and China in the domain of urban agriculture and highlight examples from the SiEUGreen showcases towards the adaptation of technologies, social inclusion, environmental impact and sustainability.

The Horizon 2020 Framework Programme promotes cooperation between Europe and China for sustainable urbanisation. In this context, the SiEUGreen project, which is co-funded by the H2020 programme of the EU and the Chinese Ministry of Science and Technology (MOST), identified that there is a wide range of available innovative resource-efficient agricultural techniques both in Europe and China. With the financial support from the EU and MOST, several of these are deployed and evaluated in five showcases; three European (Norway, Denmark, Turkey) and two Chinese (Beijing, Changsha).

The research group of ViLabs Ltd, supervised by NIBIO, the Norwegian Institute of Bioeconomy Research, seized the opportunity to organise this meeting. The goal has been to gather all partners and discuss the knowledge transfer between the European and Chinese showcases and then develop the White Paper with the results that will be widely published on both continents. The knowledge exchange discussed in this meeting touches upon different disciplines of the project including the policy scene, technologies, sustainability and social inclusion.

In welcome remarks, Prof. Petter Jenssen from the Norwegian University of Life Sciences (NMBU) and SiEUGreen project coordinator, highlighted that urban agriculture practices have been applied in China for many years.

Ms Alexia Rouby, the Policy Officer of the European Commission's Directorate-General for Agriculture and Rural Development (EU DG AGRI), opened the session on policy and research. She focused her presentation on the current H2020 Framework policy on urban agriculture and introduced the upcoming Horizon Europe Framework. She emphasised the relevant active projects and the need for a more comprehensive vision of urban farming. Turning to Horizon Europe, she announced that 8.9 billion € are expected to fund projects under Cluster 6 on food, bioeconomy, natural resources, agriculture and environment. Supplementarily, Mr Iuri Aganetto, the Policy Officer from DG AGRI of the European Commission, presented the vision of Horizon Europe for the international cooperation between the EU and China. He explained the whole pathway behind the cooperation that started in 1991 and concluded with the upcoming challenge of upgrading the conditions for EU-China cooperation that the Horizon Europe Framework is expected to prioritise. Dr Jihong Liu Clarke, Research Professor and Coordinator for China Relations at the Norwegian Institute of Bioeconomy Research, and Professor Jiang from the Institute of Vegetables and Flowers (IVF) at the Chinese Academy of Agricultural Sciences (CAAS) closed the session on research and policy. Both speakers focused their presentations on the SiEUGreen project knowledge exchange and sharing between

Europe and China, and strategy experience and lessons learnt. They highlighted the meaning of knowledge exchange and the method to achieve it, along with the good practices of the project on knowledge sharing between the European and Chinese showcases in the different technologies and also social sciences.

The session on the scientific advantages was moderated by the Advisory Board Member Mr Thore Vestby, a former member of the Norwegian Parliament, Vice President of Mayors for Peace and Honorary Mayor with experience in computing and politics. Mr Vestby and Ms Liu Jian from Beijing co-founded Ichi Foundation, a Norwegian non-profit organization that focuses on cultural and educational cooperation projects between China and Europe. It links students from China with other cultures by making arenas or bringing into other arenas talented young people with a forward-leaning thinking about technology and sustainability.

The first topic of the session he moderated was the 'GREENenerg' concept from Europe to China that was analysed by Prof. Petter Jenssen (NMBU) and Mr Georg Finsrud, Chief Technical Officer, ScanWater. They highlighted the benefits of water management technologies, along with examples of SiEUGreen technologies that will be implemented in showcases in China and Europe. Turning to innovations introduced, Dr Jihong Liu Clarke, (NIBIO) with the CEO of Green Valley Sprout Ltd, Guiqin Zhang, presented the 'paper-based microgreen production technology'. This presentation of the novel method and its results included a video from the Green Valley greenhouse, that is located in Beijing. This knowledge transfer from China to Europe and knowledge sharing at the current stage is an excellent example of EU-China R&D collaboration under the SiEUGreen project. The session closed with another impactful technology, kitchen composting. Dr Xin Mei, Beijing Photon Science & Technology Co. Ltd., presented how this method is implemented in China, focusing on the biological kitchen waste disposal that is already deployed in fifty apartments in Beijing.

The sustainability of urban agriculture has also been a key priority for SiEUGreen. The session on the knowledge transfer across EU and China for this topic was moderated by the advisory board member Prof. Dr. Grietje Zeeman, who is emeritus professor of environmental technology at Wageningen University, and also works with the LeAF company. Having great experience in the field, having been involved in the Run4Life project and the EU-Cost project Circular City, an interesting conversation followed. The discussion related to the presentation of the methods and tools applied in SiEUGreen to design business models was held by Mr Martin Wafler and co-authored with Dr Johannes Heeb, both from Seecon International GmbH. They talked about highlights, lessons learned and recommendations from a business model webinar they organised successfully bringing together EU and Chinese partners. It is worth mentioning a comment by Mr. Heeb, that if we compare this webinar with a physical meeting, quality-wise, better input has been provided. All the consortium agreed and congratulated them for this outstanding achievement.

The meeting ended with a session about the knowledge transfer on social inclusion across the EU and China. Dr Luciane Aguiar Borges and MSc Sandra Oliveira e Costa from Nordregio, a leading Nordic and European research centre for regional development and planning, presented efficient strategies to engage communities in urban agriculture, along with the best practices of the Taste Aarhus initiative. They explained interesting theories on community engagement, the governance cases of the SiEUGreen Showcase at Aarhus, Denmark, and their possible impact on the city, the value chain of actors in green space management and the urban agriculture governance model.

2.8 Dissemination

All the information and materials (agenda, presentations) about the meeting are publicly available on the project website.

A press release has been published at the EIP-AGRI network.

3. White Paper: Technology and knowledge transfer between Europe and China to achieve sustainable urban agriculture during and beyond SiEUGreen

Summary

The SiEUGreen-project brings together European and Chinese scientists, technology providers and authorities to share knowledge and best practices in urban agriculture within science, commerce and industry. SiEUGreen aspires to promote novel urban agriculture and integrated waste handling concepts, social engagement methods, and business models that can be adopted in urban and peri-urban areas, to improve the local environment, economy, society, health and food quality and security.

Introduction

In the United Nations' Sustainable Development Goals Report sustainable agriculture plays an important role of in alleviating poverty, hunger and disease caused by climate change and inequality. And although global food production is growing rapidly, large quantities of organic waste from farms and greenhouses – such as livestock manure, crop stalks, and rotten vegetables – accumulate and pollute aquatic ecosystems and the atmosphere. In addition, mineable rock phosphate is a limited and non-renewable resource that is better replaced with recycled phosphate from secondary resources, such as organic waste. Also, reuse of waste fractions might reduce the environmental impact of the food production industry.

Urban food production is one way to increase food security. Urban agriculture is developing rapidly in many countries; one example is the city of Paris, host to the world's largest urban rooftop farm. Tantamount to a successful urban food production is that it contributes to a circular economy. This entails zero waste, minimum transport, reuse & recycling, lower energy use, and reduced burdens on the environment.

The following are some highlights of urban agriculture showcasing the adaptation of technologies, social inclusion, environmental impact and sustainability from the SiEUGreen-project.

SiEUGreen urban agriculture highlights

Beijing, China: Recycling of restaurant and kitchen waste – from kitchen waste to plant fertilizer

Li Mojun, Mei Xin, Yin Wen and Zhao Yuping, Beijing Photon Science & Technology

Introduction

Green cities play an important role in sustainable urban development, where waste reduction is vital and reuse of restaurant and kitchen waste is key. Reduced amounts of restaurant and kitchen waste will lessen contamination of municipal waste, improve the ecological situation of municipalities and promote green urban agriculture. Reduction of restaurant and kitchen waste is a small, but important, example of how to help improve the development of a more cyclic and sustainable world economy.

Restaurant and kitchen waste includes the restaurant waste and kitchen waste, which refers to the refuse produced in the activities of food processing, restaurant services and cafeterias, excluding citizen's domestic garbage. Here, restaurant waste is defined as leftover food and the refuse produced during the production of fruits, vegetables, meat, oil and pastries in restaurants, while kitchen waste is the perishable organic waste – especially the solid waste produced by the skin of fruits and vegetables and the uneaten food – in a person's daily life.

Awash in moisture and organic matter, kitchen waste easily rots and smells, making it difficult to keep, collect, clean and transport. There's a lot of it, and it is important to find efficient ways to treat it and get rid of potential pollution problems. Ideally, kitchen waste should be delivered, collected, and transported separately according to their characters.

In addition, kitchen waste may ferment and rot if not treated timely and properly. Toxic, noxious, and smelly gases produced during fermentation and rotting may pollute water and air and damage the city's appearance and environmental sanitation and spread diseases that can threaten the health and daily life of citizens.

Economic development and population growth has led to a marked increase in kitchen waste. Globally, the amount of residential trash generated in urban areas has surpassed fifty billion tons annually, with 10-20 percent stemming from kitchen waste. So, it is important to minimize, decontaminate and recycle the kitchen waste.

Current situation

China generated more than one billion tons of urban household garbage in 2015, with 350-500 million tons coming from kitchen waste. Between 2014 to 2015 China's garbage production increased by 186 million tons, and 97 percent of this – over 180 million tons – was disposed of in landfills. In the same period, Shanghai's inhabitants of generated 365-438 thousand tons of kitchen waste. From Beijing we know that 65 percent of the municipal waste is organic, and that 30 percent originates from residents' kitchens. For lack of a suitable system, adequate regulations, and proper technologies, most of China's kitchen waste is still discarded in landfills or pigsties. China is, however, taking steps to solve these challenges; first and foremost, by implementing relevant rules and regulations, renewing treatment technologies and by reusing kitchen waste.

In the **United States** more than twenty million tons of kitchen waste is produced each year, accounting for over ten percent of the total municipal waste. Only 2.6 percent of USA's kitchen waste is recycled, far below the thirty percent recycling rate for municipal waste. While restaurants producing large amounts of kitchen waste have their own garbage crushers that discharge crushed garbage directly into sewers, and oil-fat separators that separate and deliver the oil to nearby processing facilities, household kitchen waste can be ground by the residents themselves, and then discharged or collected or delivered to a central processing facility. In addition, kitchen waste can be turned into fodder, soil conditioner, compost, biodiesel and methane at separate processing plants, and the fractions that cannot be reused are deposited on landfills or burned. In the US, food waste legislation is decided at the state level, and each state government has their own way to treat kitchen waste – including how to minimize food waste, whether to donate food to the needy, feeding animals with leftover food, using it for industry, or whether it should be composted, buried and/or burned.

Japan produces about ten million tons kitchen waste every year. Due to the prohibitive cost of transporting kitchen waste (up to 250-600 dollars per ton), many companies and communities use trash crushers in order to dispose of the kitchen waste. This is supported by the Japanese government, which also promotes the development of crasher manufactures.[1] In order to minimize kitchen waste, protect the environment and recycle useful products from kitchen waste, the Japanese government passed a law on kitchen waste recycling in 2000 requiring all food processing units, restaurants, and cafeterias to recycle their kitchen waste into fodder and fertilizer. According to the law, kitchen waste should be treated in order of importance, to: 1.) curb production; 2.) reuse useful materials (fertilizer > fodder > oil and fat); and 3.) minimize waste.

The **EU** countries generate about fifty million tons of kitchen waste every year. Each member country has their own kitchen waste collection- and treatment system. For example, Denmark began recycling kitchen waste in 1987. In the Netherlands, kitchen waste on landfills became illegal in 1996, and the garbage treatment companies have used aerobic fermentation to dispose of kitchen waste since then. In all, twenty-three compost plants and two fermenting plants were constructed by the end of 1999. In Germany, colored storage bins are used to sort kitchen waste from other household trash, making composting easier. In Ireland and many other EU countries, kitchen waste is collected together with other organic waste products, and then sorted at a central composting station.

Beijing field study

Of the dry fraction of kitchen waste, our analysis of the materials collected at the eight sampling sites in Beijing showed that it consisted mainly of food leftovers (88.6 percent) and discarded bones (10.6 percent). We also found some glass, ceramic, plastic, and wood pieces, but we did not find any metal.

We also measured moisture, total oils and fats, amount of protein and salt, ash content, and the specific heat value (energy content) of the kitchen waste (Table 1). Average moisture content was 78.5 percent, proteins 22.8 percent, and the total oils and fats 4.1 percent.

Table 1. The content of kitchen waste collected at eight sampling sites in Beijing.

Moisture content	Total oils and fats	Protein	Salt	Ash	Energy content
78.5 %	4.1 %	22.8 %	1.9 %	1.8 %	2948 MJ

[1] Over five hundred companies manufacture kitchen waste crashers for restaurants, food processing companies, cafeterias, and private households.

Anaerobic digestion of kitchen waste

In some countries kitchens are equipped with garbage grinders that discharge the kitchen waste directly into the sewer system. However, the resulting wastewater can be smelly, and function as a breeding ground for pathogenic bacteria, flies and disease-spreading mosquitoes. In addition, oil, and fat block drainpipes, reducing municipal sever drainage – causing secondary pollution.

In China, kitchen waste is usually deposited onto landfills, and the organic fraction left to rot. Due to its high moisture content, however, kitchen waste requires high standard landfills, something that tends to increase cost. In addition, anaerobic processes produce methane and polluted percolate. Because of the increased amounts of kitchen waste, many countries do not allow it to be deposited onto landfills.

However, kitchen waste can also be turned into valuable plant fertilizer. There are two ways of performing this organic alchemy – with or without oxygen. With oxygen, solid organic matter is turned into fertilizer compost using aerobic bacteria and micro-organisms that thrive on the otherwise smelly wastewater. Without oxygen, anaerobic microorganisms break down the organic materials, producing energy-rich methane and byproducts that are easily absorbed by both plants and animals.

For the oxygen-free, anaerobic, process, specific fermenting bacteria can be used to degrade and transform the kitchen waste macromolecules – oils and fats, starch and proteins – into valuable high-quality products. A wide selection of bacteria strains, including *Bacillus subtilis*, *Polymyxa betae* and Nocard's bacillus, and *Bacillus amyloliquefaciens* could help produce a liquid fermenting material containing more than ten billion living organisms.

Many anaerobic bacteria thrive in conditions like those found in kitchen waste, with a neutral pH, about 6.0-7.5, and with temperatures around 45-55°C.

There are several advantages to anaerobic digestion of kitchen waste. The solid organic fraction of the anaerobic system can reach 10-25 percent, similar to the solid content rate of kitchen waste. This way, there is no need to add water or drying the trash before fermentation, simplifying the pre-process flows, and reducing energy use. Also, with a C:N-ratio of 20-25, kitchen waste is suitable for anaerobic digestion, something that has little impact on the environment.[2]

Microbial fermentation technology

Microbial fermentation turns trash into organic fertilizer, and with complete recycling of all nutrients. This process can be automated. By the push of a button kitchen garbage is added automatically, the waste is stirred, and, after temperature increases, waste gases are emitted and the resulting organic compost sanitized and deodorized using UV light[3] and active carbon,

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[2] According to our tests, employing anaerobic bacteria, and under suitable conditions, it would take 12-24 hours to turn the organic fraction of kitchen garbage into an organic fertilizer. Turnover is 20 percent and 10-25 kg per day.

[3] Energy-rich ultraviolet light (185-253 nm) splits the oxygen molecule, creating ozone that can be used to sanitize (degrade) the waste gases, with water and some toxic micro-molecules as byproducts.

before drying. The resulting organic compost can then provide nutrition to flowers and vegetables grown in balconies and community gardens.

In the EU it is not allowed to dump kitchen waste on landfills. It is prohibited to use animal fodder based on proteins derived from the same species, and kitchen waste can only be used for feeding farm animals.[4] Most EU restaurants therefor employ the anaerobic method of processing their organic waste. The method is similar to the one employed for biological kitchen waste disposal.

In **Sweden**, waste management companies provide households with special brown paper bags that are placed in dedicated trash cans, and all the kitchen waste is recycled into biofuel or organic fertilizer.

France has implemented mandatory sorting of kitchen waste, sorting it as either harmless, neutral, or dangerous and either recycled, burned or deposited at a landfill. An example of how this system works is the treatment of food oils. In 1992, it was illegal to pour waste oil into the sewage or to throw it together with the normal garbage. If the sewer pipes were clogged, due to improper treatment of fats and waste oil, the restaurants would face heavy penalties, and in some cases even ordered to close.

Conclusion

Household microbial treatment devices can bring considerable social and economic benefits and minimize the quantity of kitchen waste. By recycling municipal waste and reducing kitchen waste compost, we protect our environment, lessen the amount of garbage dumped on landfill sites, decontaminate municipal waste, and improve the urban ecological conditions. This way we form a virtuous and ecological circle in our cities contributing to energy-saving and emission reductions both in China and in the EU.

Urban agriculture for food security, resource efficiency and smart, resilient cities – methods and tools to design business models

Senior Project Manager Martin Wafler and Senior Partner Johannes Heeb, seecon Switzerland (https://seecon.ch/)

SiEUGreen aspires to enhance the EU-China cooperation in promoting UA for food security, resource efficiency and smart, resilient cities. The overall goal has been to initiate a change in the ability of consortium partners to ideate, describe, evaluate and discuss business models using the BMC, a strategic management template for describing, analyzing, and designing new or documenting existing business models.[5]

Degrading material and layers of active carbon adsorb the water and filter the toxic gases produced during UV-irradiation. Any left-over ozone is converted into oxygen, using a honeycomb ceramic.

[4] Excluding fur animals.

[5] BMC stands for Osterwalder and Pigneur Business Model Canvas. The term business model is described as "the rational of how an organization creates, delivers and captures value." Osterwalder

The first example of this EU-China cooperation is the retrofitting and transformation of a twenty-four students student flat at Campus Ås for testing and demonstration. Campus Ås is a part of the SiEUGreen project, where we have conducted testing of innovative urban agriculture-related technologies in various business models, such as:

- *GREENERGY concept*: Builds upon the development and demonstration of the integrated solid and liquid waste management system applied at the Campus Ås and (partially) Changsha showcase.
- *Fruit & vegetable planter*: Tailored to the continued development of balcony vegetable/mushroom/succulent planting equipment that allows urban residents to eat their own organic vegetables and reduce – in part – the demand for market supply.
- *Garbage processor*: Describes the reduction of household kitchen waste and production of organic fertilizer, which can be used by urban residents to grow healthy, green organic vegetables.
- *Urban composting hub*: Production of organic fertilizer from anaerobic digestion of organic household waste streams, creating a composting hub where residents can provide their organic waste and obtain locally produced compost.
- *Urine-based fertilizer*: Treatment and further processing of source-separated urine to a traditional but modern, locally produced, high-quality, hygienic, quick-release, liquid fertilizer for commercial applications.
- *Paper-based microgreen production*: Residents grow vegetables at home and sell them to a company, which processes these vegetables into soap, nutritious food and other products and sells them to the market.

The second case study is from the Danish town Aarhus. Aarhus is known for its bottom-up initiatives involving urban agriculture. An example is the "Taste Aarhus" program, where more than three hundred urban agricultural initiatives have been implemented. The Taste Aarhus program addresses the question "How can cities create more socially inclusive places and communities, when focusing on edible nature and urban farming?" Taste Aarhus uses urban gardening as a tool to bring people together, activating underutilized spaces around the city and engaging people in the practice of growing their own food. SiEUGreen sustains and enriches the UA activities by implementing moving mobile gardens, dry toilets and polytunnels.

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and Pigneur translated these three core tasks into concrete building blocks when they created BMC. With the help of the BMC, an organization or individual can refine, reflect, or define its business model and take strategic decisions on how to proceed and implement its developed ideas. The goal of the BMC is to assist people in understanding their business idea and how the business operates, to encourage discussions, foster analysis, and leverage creativity to design a business model that works. BMC is not only designed to frame for-profit companies, but also to analyze those organizations that "have strong non-financial missions focused on ecology, social causes and public service mandates." To adapt the original model of the business canvas to the organizational settings of such organizations, two additional building blocks are introduced to include the social and environmental costs of a business model (i.e., its negative impact), and the social and environmental benefits of a business model (i.e. its positive impact).

- *Integrated multiscale analysis framework*: Using the Taste Aarhus showcase to help policy makers assess benefits and drawbacks of urban agriculture in city development integrated urban planning.

A third example is from Hatay, Turkey's seventh most densely populated province. Hatay is close to the Syrian border, and has experienced a sharp population increase, particularly in border municipalities. The rapidly increasing population places a burden on Hatay's economy, which largely depends on agriculture. SiEUGreen supports Hatay in accessing innovative technologies and knowledge related to how urban agriculture can create new jobs and increase food production and resource efficiency.

Hatay Showcase: Helping disadvantaged communities to produce fresh, local, pesticide free, organic food through innovative urban agriculture systems and renewable energy sources.

Our fourth example comes from Changsha, the capital of the South-Central Hunan province – one of China's most densely populated provinces. Due to long transport distances, Changsha faces an enormous environmental challenge when it comes to food supply. Urban agriculture could ameliorate this by producing food locally in an environmentally friendly manner with zero transport required.

The fifth example comes from Sanyuan Urban Farm, located in Beijing's metropolitan area. Beijing's metropolitan area consists of two parts – the East District and the West District. While the East District has had urban agriculture-projects running for decades, the West District is in the planning phase. Sanyuan Urban Farm combines urban agriculture with tourism, technology, and education.

Beijing Showcase: Promotion of a high-efficiency aquaponic system for the integrated ecological fish-vegetable production with zero pollution and zero emissions in water shortage area or around the big city.

Taste Aarhus – strategies for social engagement for a sustainable urban agriculture

Senior Research Fellow Luciane Aguiar Borges and Research Fellow Sandra Oliveira e Costa, Nordregio https://nordregio.org/

Urban agriculture can be seen as a tool to achieve urban sustainability goals by revitalizing urban spaces, foster innovation and create new jobs in the green sector and reduce waste and stimulate community education and development. It is imperative, however, to engage people in the practical urban agriculture. As simple it may seem, this can be complex and challenging, as people may lack time, resources like land to grow food, financial mean, or interest. In addition, urban agriculture is mainly based on volunteer work which means inconsistencies in practice. Strategies to involve people in urban agriculture should aim to overcome these obstacles and need to be adapted to each context.

For more than five years Aarhus Municipality in Denmark has supported urban agriculture through the "Taste Aarhus" program. Building on a model of zero-waste and circular economy, Taste Aarhus demonstrates how technological and societal innovation in urban agriculture can have a positive impact on society and the economy. Its main contribution is the successful strategy employed to involve people in urban agriculture. In addition, the formation of partnerships and coalitions is key to engage communities and bring about environmental and behavior change.

Taste Aarhus uses different strategies to engage people with eatable resources found in the city, as well as with urban gardening. Ensuring societal inclusion has been the cornerstone of Taste Aarhus program, promoting urban agriculture "for all" – i.e., for people with different interests and backgrounds, ambition levels, physical and economic possibilities. In addition, urban agriculture is used as a tool to strengthen the community spirit and engagement. And lastly, Taste Aarhus plays a key role in promoting knowledge of the food system among the urban population.

Taste Aarhus adopts a broad definition of health, including both physical and mental health. Urban agriculture can generate benefits for physical health via contributions to bodily activity and access to organic food. Both physical and mental health benefits can be achieved by the simple act of spending time outdoors in connection to greenspace and engaging with nature. In addition, urban agriculture can generate benefits for mental health via contributions to social interaction and community building among participants, hence counteracting social isolation and loneliness.

The program supports several urban agriculture-activities in the city today, either initiated by Taste Aarhus or by residents. Any person in the city is eligible to start up a garden. Only two requirements are necessary: i) a democratic structure consisting of a chairperson, treasurer and three other decision-makers, and ii) organizing two events per year that are open to the public. The latter is a means of giving back to the community for the privilege of using public land.

Alongside the project manager, the Taste Aarhus employs a gardener, a chef and a communications specialist who are responsible for supporting the community to set-up and get the most out of their gardens. The program is managed by Aarhus Municipality – in part through self-funding (€1 million), and between the years 2015-2018 in part by Nordea Bank (€1 million) – and fully financed by the municipality.

Approximately three out of four gardens in Aarhus have been initiated by the public sector via Taste Aarhus, and one quarter are initiated and managed by civil society. One quarter of them are managed by Taste Aarhus Program and on half by another government body, such as schools and hospitals, in collaboration with Taste Aarhus. Approximately one quarter of the gardens account for public information on edible resources in the city. The partnership between Taste Aarhus and other local actors, such as health and educational institutions and civil society organizations, sustain more than half of the gardens in the city.

When the public sector informs the community, the flow of communication is unilateral and the outcome is the establishment of communication and outreach channels, as well as informed citizens. Consulting activities develop connections between the public sector and the community. Still, the communication flows between them are divided. Surveys are good example of tools for consultation, in which the public sector asks questions and the community replies. Interactions become more intense when both the public sector and the community share the same means of communication. When both the public sector and community collaborate, the means of interaction between them is more robust, and partnership and trust between both increases. This is a kind of shared leadership, where agency and power are evenly distributed between the public sector and the community, and the partnership delivers services that are of use for the community.

Now, how to implement – *plan*, *design*, *manage* and *maintain* – urban greenspaces? A simplistic framework of the relationship between the public sector and community – which is at the center of the process of any engagement strategy – and *planning* and *design*, relate to spatial planning and the creation of new structures and spatial planning of greenspace. *Management* deals with the existing physical structures, and thus concerns the management of the physical space. In addition, management refers to the organizing of people and organizations included in the work. While physical planning "plans space", management "plans processes". The responsibility of management can be shared between various public departments and often also outsourced to private actors. While *maintenance* concerns operational matters, it can also be argued that park organizations need to be strategic in order to survive in competition with other departments and should therefore be strategic and future oriented. Lastly, *maintenance* is a responsibility of the management and regards operational and technical issues concerning the practical upkeep of greenspace.

Three types of governance were identified in the gardens in Aarhus:

1. Top-down, coordinated within the local government corresponds to the initiatives that are solely managed by the Taste Aarhus Program.
2. Top-down, coordinated by the local government and other actors (other public actors, civil society organizations): corresponds to initiatives when Taste Aarhus program partners with other public actors (e.g., school, health services) and/or formalized civil society organizations.
3. Bottom-up, with support of the local government includes the urban agriculture practices that were initiated by citizens with the support of Taste Aarhus program.

From the scientific literature we know that, via formal or informal agreements, the urban agriculture-practitioners can take such far-reaching responsibility over the planning, design, and maintenance of the urban open space that they practically take on the role of "managers". Nevertheless, the public sector does not completely abandon its' responsibilities, and while users can take on management and maintenance tasks, the task of physical planning still lies within the public sector.

One of the cornerstones of Taste Aarhus is raising awareness about the city's edible resources in the city. In order to achieve this, the Taste Aarhus team at the municipality make themselves available to the public primarily, through the Green embassy located in the town square. At the Green embassy maps point to the location of the city's edible foodstuffs, and its citizens are invited to taste locally grown foods and drinks. They also get advice on gardening on a drop-in basis, and information about upcoming events run by gardening groups. Visitors to the Green Embassy can taste the products coming out of the city's gardening projects, and at the same time meet key persons in the organization, making it an important meeting place for Aarhusians to learn about the efforts made by the municipality. The sheer physicality of the Green embassy also represents other possibilities than for example an official website, and it is more engaging than a post on social media.

Aarhus municipality also raises awareness about edible resources by placing signposts around the city, identifying herbs and vegetables, such as rams and different types of fruit, which are found in forests, public spaces and beaches, and that can be incorporated in daily diets. An example is the use of the expression “Fyld hatten” in promotional materials. “Fyld hatten”, which means fill up your hat, originates from an old Danish law from the year 1241, stating that one can take from nature as much as one can fit in one’s hat. “Fyld hatten” signposts encourage citizens to harvest crops in the city to use at home, and tailor-made recipes can be found on the project’s web site. More harvesting of edible plants takes place in areas where the signs were put up.

Taste Aarhus also partner with other public actors and civil organizations to promote urban agriculture, breaking silos and connecting different departments of the municipality. For example, a farm owned by the municipality is a living lab for pupils from different schools and kindergartens across the city who can visit and experience growing vegetables. Every year, different groups of children have their own plot and learn how to cultivate. This is a useful strategy to make children realize where food comes from and to nurture care and respect for nature. In this respect, the program offers an opportunity to strengthen the relationship between people, nature, and food – a connection that is often lost in the urban context. In this case, the land ownership is public, and the initiative comes from the municipality. The farm is managed by the public administration, while children are involved as users of the farm facilities.

In addition, Taste Aarhus supports a multitude of gardens of varying size and number of members. One example is *Pier 2*. Formed in 2017 by a group of enthusiastic citizens, the Pier 2 garden consists of forty-five smaller gardens built on pallet frames, set up at a construction site in the harbor, following a workshop promoting the use of underutilized spaces for gardens. It’s central location and relatively large size attracts a wide variety of people, mostly inner-city apartments dwellers. For some, Pier 2 is a chance to strengthen bonds with family or friends, like between grandparents and grandchildren; for others, it is a chance to meet new people.

In case of Pier 2, civil persons took the initiative, and were also the ones using and managing the garden – with some support from the public sector, via Taste Aarhus. The land is privately owned, belonging to a real estate developer. However, there are strong elements of involvement between the civil society, the public sectors, and the private landowner, as the residents are doing parts of the maintenance of the urban open space. The members of Pier 2 are taking care of an underutilized space where new residential houses will be built. While this garden offers an opportunity to people who live in high density parts of the city to grow food and reconnect with nature, it is also an example of how an area under construction can be transformed into a place for social interaction.

Another example is *Skovvejen orchard*, one of the earliest Taste Aarhus projects. Skovvejen orchard began in 2015, when a group of neighbors sought a common space where they could come together. They approached the municipality about clearing an overgrown area behind their houses and planting fruit trees there; because, even if all their houses had gardens, they were too small for fruit trees. In contrast to the area around Pier 2, Skovvejen is a relatively wealthy area, with average house prices around €800,000; and people already knew each other. Given this background, one might expect negligible social capital benefits from this project. However, the Skovvejen residents were pleasantly surprised by how much the shared garden space meant for bringing them together. The children play together in the orchard, instead of in their own backyards. The orchard and the fruits are also available to the public, and several public workshops have been held in the garden about how to plant and care for fruit trees. In the case of Skovvejen orchard, the initiative to use public land for common activities came from the residents, and clearly shows the benefits of a shared leadership over the garden and the activities taking place there.

Conclusions and recommendations

Sorting out the different actors, roles and variations in initiation and management are important steps to be able to evaluate the social impacts of the initiatives in Aarhus – both for individuals, for the communities and for the city.

The results show that Taste Aarhus initiated the majority of Aarhus' urban agriculture, and that these publicly initiated spaces for urban agriculture offers other types of social impact than the bottom-up initiatives do. While the urban agriculture initiated by Taste Aarhus also involves the public via raising awareness of what the city offers in terms of edible resources, the bottom-up initiatives offer more room (literally!) for social interaction and community building since their governance structure motivates the users to take responsibility over tasks related to the management and maintenance of the urban open spaces. When successful, such collaborations can lead to empowerment of the local individuals and a closer connection with nature.

Since the bottom-up initiatives often are in intra-urban spaces, they harbor a potential to reactivate underutilized spaces in the city while at the same time contributing to safer and livelier public spaces.

From a social perspective, urban agriculture is clearly a valuable tool in enhancing social capital, though the way this happens appears to vary from garden to garden. In some cases, bonds between acquaintances are strengthened through participation, and in other cases, new bonds are created between people who were previously strangers. Larger gardens appear to bring less people together.

From a political perspective, urban agriculture appears to present at least some opportunities for the new forms of engagement with the political ecology of the city. The democratic structure required by the Taste Aarhus project is instrumental here; however, the opportunity to use public land also appears to elicit a degree of ownership. In at least two cases, this ownership has led participants to take action in seeking to secure permanent changes to the urban structure following engagement with temporary initiatives.

However, the urban agriculture located within education and health institutions does not influence the quality of public spaces in Aarhus quite as much, as many of these gardens are not entirely open and accessible to the public. The restricted access is due to several aspects, such as being located on private land, inside hospitals and schools, or designed for preserving the privacy of vulnerable groups involved in urban agriculture. But the gardens that *are* open to the public, offer another potential to activate passers-by, and for the urban agriculture-practitioners to contribute to inclusive activities in public space.

The top-down urban agriculture should not be seen as less important for the social life in the city. While perhaps being more superficial in the way the city residents are engaged, activities such as signposting of eatable plants are quite inclusive, since they offer knowledge and (literally) low-hanging-fruits for individuals who might otherwise have less time or interest to engage in a more profound and long-term manner.

Taste Aarhus is a top-down initiative supporting bottom-up initiatives in urban agriculture. By supporting bottom-up initiatives, the municipality shows appreciation for the activities that are conducted, and they also support a self-organized management of urban greenspace that includes a wide array of initiatives. With an ambition to create socially inclusive places and communities, focusing on edible nature and urban farming as an overall goal, Taste Aarhus has the potential to reach a wide variety of residents. More demographic knowledge about participants would be useful in shedding light on the economic dimension of societal inclusion.

From Europe to China – circular systems for water and waste coupled to urban agriculture – the Greenergy concept

Petter D. Jenssen, Melesse M. Eshethu and Georg Finsrud, NMBU, and Trond Mæhlum, NIBIO

Domestic wastewater and organic household waste is a valuable resource. Aiming at the circularity of resources, the SiEUGreen approach implements decentralized and source separation of waste streams. Blue (water and waste) and yellow (energy) technologies are used to demonstrate how source-separated domestic urban waste resources can be turned into fertilizer, growth media and bioenergy primarily for local urban and periurban use.

In the following section we show how these blue and yellow technological options can achieve a zero-waste system at household and community levels. Sanitized liquid fertilizers, struvite, algae biomass (as biofertilizer), biochar and clean water are produced from source-separated urine and blackwater stream of the domestic wastewater. These fertilizer products can be safely used in a local food production. In addition, source separated greywater can be treated so as to achieve drinking water quality. Although the use of greywater as a source of drinking water is not yet practiced, returning the treated greywater to the household non-potable use (e.g., for laundry, toilet flush) can reduce the total water consumption by up to 90 percent.

Why source separation? 20-40 percent of the water consumption in sewered cities is used for flushing toilets, and often this is potable water – brought to the cities at a high cost.

In industrialized countries, each person uses 150-250 liter water per day, while the volume of what comes out (undiluted urine and feces) is about 1.5 liter. This means that the discharged waste matter constitutes less than one hundredth of the wastewater volume. At the same time, this one percent contributes to around 90 percent of all the nitrogen and phosphorus in wastewater, to about half of the organic matter, and the majority of all the pathogens – and constitute a major concern regarding health problems and water pollution from sewage. Through source separation, by diverting the dry and wet fractions, or with water saving toilets, such as vacuum toilets, valuable waste resources can be recaptured with minimal dilution. Altogether, this constitutes a nutrient and energy loop where the excreta and organic household waste are co-processed into fertilizers, soil amendment and growth media, and biogas.

Circular systems

First, water consumption can be minimized by water saving technologies in the area of household appliances and toilets, and greywater recycling. By reclaiming the nutrients in excreta, and recycling them to plant production, water discharge is minimized or near eliminated. Blackwater and organic household waste can also be treated anaerobically in order to produce biogas, thus reducing emission of greenhouse gases. The History of NMBU's Cooperation with China in Water and Wastewater Projects NMBU started the cooperation with the University CFSU in Changsha in 1995. The goal was to create "blue sky, clean water, green land and healthy people" for Zhuzhou City, one of China's most polluted cities.

Drinking water

In 2006, China introduced new standards for drinking water quality, and big cities like Zhuzhou City had to improve their purification process. Since the main technical method was almost the same as the one used in the pilot plant established in Zhuzhou it became a successful showcase, giving valuable input for the improvement of other cities' waterworks. An example is membrane filter technology. This was rarely used prior to the Zhuzhou pilot plant was put into operation, and it completely changed the ways water treatment plants were designed. Today, membrane filtration is used to produce barreled and bottled water in both cities and some rural areas, and China is the world's biggest market membrane processed drinking water.

Sewage treatment

Before 2008, sewage treatment was almost absent in Chinese cities; and there were less than ten existing sewage treatment plants in the entire country. However, a huge change took place after 2008, when China started to invest heavily in sewage treatment facilities, with about 80 percent coverage today.

With improved knowledge and experience, several advanced processes were introduced, such as modified anaerobic, anoxic, and aerobic treatment (AAO), moving bed biofilm reactors (MBBR).

In most Chinese cities, sewage treatment plants built before 2010, were located downtown. Today it is therefore both difficult and hugely costly to improve or enlarge, or even maintain, some of these plants. Decentralized systems could help alleviate the need for upgrading the existing sewerage treatments facilities.

In rural areas sewers and sewage treatment plants are often absent. Thus, small rivers, lakes, ponds are polluted by wastewater from households and livestock. Implementation of decentralized circular water and wastewater systems, as exemplified by the SIEUGreen project, can solve many of these challenges in a sustainable way. One good Chinese showcase is in Changsha, and there are several more examples in Europe.

In summary: there is a huge opportunity in China for the technologies demonstrated through the SiEUGreen project.

Greenergy and zero-waste – a new concept for domestic water management

The Greenergy and Zero-waste concept demonstrates the value of domestic wastewater as a source of alternative local nutrient-energy-water resources at the household and community level. The concept builds upon the development and demonstration of an integrated solid and liquid waste management system. The development of an integrated treatment and resource recovery facility, based on a source-separated sanitation system, can provide a healthy local environment, social and economic payback for households and communities, and contribute to green development and food security. In contrast to a linear resource flow, a circular resource flow of water, nutrients and energy promotes the reduction of water consumption, reuse of water and recovery of resources from wastewater. It also increases resilience to sabotage, disasters, such as earthquakes, and to climate change, and reduces the emissions of greenhouse gases from the provision of water and wastewater-related services.

Using the circular water concept, source-separated greywater can be treated locally, yielding water of drinking quality for non-potable domestic uses. Nature-based solutions, such as infiltration, constructed wetland, biofilters, compact/package treatment systems and membrane supported solutions are also in use. In addition, a lab scale compacted biological aerated filtration (BAF) system has also been tested as an efficient small footprint local greywater treatment system. By combining the compacted BAF greywater treatment, a green wall filtration system, or a constructed wetland system with sequential activated carbon and nano filtration, followed by reverse osmosis and ultraviolet disinfection as post treatment, all the greywater can be converted into a drinking water quality, and be used as an alternative local water source. Similarly, source-separated blackwater, and the urine fraction of the domestic wastewater, can be locally treated to produce nutrients, energy, in the form of heat and electricity, and water. This can then be safely used in local food production, achieving a near zero-waste system. CO2, heat and power from biogas combustion, together with the nutrient rich retentate, can then be reused locally for year-round plant production in super-insulated greenhouses. This way environmental pollution is reduced while preserving a healthy ecosystem and society.

The blue technology

The blue technology is one of the SiEUGreen innovation principles, and at the core of the Greenergy concept. Blue technology highlights an efficient resource use, recovery and recycling, water and waste management and the concomitant production of fertilizer and soil amendment from waste. Blue technology consists of technologies for source separation of wastewater, i.e. alternative toilet systems, technologies for processing of waste and wastewater, for resource recovery and recycling, and technologies for storm water handling. Yellow technology includes biogas production from waste resources, seasonal solar storage, combined heat and power, and photovoltaic generation of electricity.

Source separating technologies in wastewater treatment

In the early 20th century, it was common to collect excreta, termed night soil, sometimes mixed with peat and/or lime, and using it as fertilizer. In China, for example, there are long traditions of collecting night soil for use in agriculture. With the invention of the water toilet in the late 19th century, and with the development and installation of subterranean gravity sewer systems, these resources began being discharged to water, causing pollution. With the coming “green shift” and circular economy, the interest in source separation of wastewater has grown, and source separation can be sees as a new sanitation – reusing nutrients. A combined treatment and resource recovery facility, based on source separation and on-site treatment, has been developed and tested at laboratory scale at NMBU, which also explores source separation technology. This laboratory scale resource recovery facility demonstrates an alternative strategy for improving the recovery of resources from wastewaters, using a decentralized approach, where black water (toilet wastewater), grey water (other domestic wastewaters) and organic kitchen waste are collected separately.

Source separation as base for circular systems will change both the logistics of wastewater handling and of organic waste –depending on the toilet type.

Transportation of blackwater, urine or composted fecal matter by truck is energy consuming, and this must be considered in a sustainability analysis of a decentralized source separating wastewater treatment system in urban areas. How far it is feasible to truck the material?

Our analyses show that it may be feasible to truck blackwater up to 30 km, urine up to 50 km and the compost material up to 1400 km. 25-30 km is sufficient to reach agricultural areas from the center of many mid-size cities with 100.000-500-000 inhabitants. [6]

The large difference in transport distance is mainly due to how concentrated the material is. Blackwater is normally more dilute than urine, and since the end product from the composting toilet is relatively dry, it can thus tolerate a much longer transport distance before the energy used for transportation equals the energy used for production of an equivalent amount of mineral fertilizer. However, for composting toilets the transport distance is very much dependent upon how much nitrogen that is reclaimed in the compost.

Urine Treatment Options

Foul smell is a challenge when using urine in urban agriculture. In one SiEUGreen project, we attempt to nitrify urine on-site to achieve a socially and hygienically acceptable chemically stable, concentrated and odor-free liquid fertilizer product. Nitrate is stable, does not smell and is more available as a nitrogen source than ammonium for most plants. Our results show that both a moving bed bioreactor (MBBR) and the multipass packed-bed biofilter appear to be suitable for urine nitrification – making it an attractive fertilizer for urban greening and gardens. However, the methods need more laboratory testing to optimize the various factors influencing the nitrification process and make the reactors more robust and suitable for concentrated urine.

Blackwater treatment and resource recovery

Anaerobic treatment of blackwater and organic household waste

In the SiEUGreen project we also use anaerobic technology to treat and recover energy, nutrients and water from blackwater and organic household waste. Blackwater collected from vacuum or other low flush toilets and the organic household waste, mainly kitchen food waste, is transported via vacuum to an anaerobic digestion biogas reactor. The anaerobic digestion reactor employs different groups of microorganisms to decompose and convert organic matter into biogas.

Handling of anaerobic digestate

Although the anaerobically digested blackwater is rich in plant nutrients, a major concern is the associated health risk from pathogens. The SiEUGreen system, however, promotes a

[6] This calculation is based on several assumptions, some of which have large inherent uncertainties. There are also many other aspects that need to be considered in a more complete system analysis.

completely closed loop flow of resources and nutrients. This way, more than 75 percent of the nitrogen from ammonium and more than 85 percent of the phosphate can be recovered as liquid fertilizer. Similarly, a substantial amount of soluble potassium can be recovered in the liquid phase. The liquid fertilizer can subsequently be used in hydroponic cultures in greenhouses, or as a slow-release fertilizer (struvite) used in the balcony gardens and garden plots outside the apartment buildings that are part of the project. In addition, the microalgae can be used as biofertilizer, as livestock/fish farm fodder and, if produced at a large scale and in significant amounts, used as a feedstock for production of biodiesel.

The SiEUGreen project demonstrates the potential of such a production system. Recovery of valuable nutrients as liquid or solid fertilizer adds value to the circular economy and reduces environmental pollution.

Greywater as a source of drinking water

Norway

One of the goals of SiEUGreen project has been to demonstrate that it is possible to reduce total water consumption by 90 percent, through improved water use efficiency, on-site treatment, recycling, and local reuse of the light greywater stream of the domestic wastewater. Although greywater is currently not used for drinking water, the technology is available. Through the SiEUGreen project, we processed the effluent from a constructed wetland/filter-bed to drinking water of a better quality than many raw water sources, especially on a global scale. [7] If the water is then run through reverse osmosis and disinfected with UV-light, a pure and safe drinking water can be provided. And by returning the treated greywater to the household for non-potable use, such as laundry or toilet flushing, the water footprint can be reduced by 90 percent.

Changsha

In the Changsha showcase 17 houses are connected to the greywater treatment facilities located in an underground parking lot. The wastewater from kitchen is first treated in an oil separation tank. Then, the wastewater from washing machines, shower/bathing water and the oil separated kitchen water is mixed evenly through the regulation tank. Considering that the greywater contains a large number of surfactants and organic pollutants [8] the greywater treatment process adopted in this project is thus:

Regulation tank + Flotation tank + Integrated biological processing equipment + UV + Reverse osmosis

After UV processing, the discharged water quality shall meet the class A standard of "Cities Sewage treatment plant Pollutant discharge Standard" (GB18918-2002), and the final recycled water quality shall meet the standard for drinking water.

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[7] Using *E. coli* as an indicator bacterium the concentration was reduced from 1.56 X 103 MPN/100 mL to < 1 (i. e. not detected) and the turbidity reduced from 27 to < 1 NTU.
[8] It is imperative that the effluent quality meets the discharge standards.

ANNEX I – Agenda of the Transnational board meeting

15 October 2020 | 9:00 – 13:00 CEST / 15:00 – 19:00 CST	
9:15 – 9:25 CEST	**Welcome** Prof. Petter D. Jenssen (Project Coordinator), Norwegian University of Life Sciences, NMBU
	Session 1: Setting the scene on Policy and Research
Session moderated by Vicky Moumtzi (ViLabs Ltd)- Each presentation includes 10' Q&A with the audience	
9:30 – 10:00	**Urban agriculture in Horizon 2020 - SIEUGreen in relation to other projects in the sector – Urban agriculture in Horizon Europe (2021-2027)** Speaker: Alexia Rouby, Policy officer, DG AGRI
10:00- 10:30	**The Horizon Europe vision for the international Cooperation between EU and China. State of play of EU china cooperation** Speaker: Iuri Aganetto, Policy officer, DG AGRI
10:30 - 11:00	**SiEUGreen - knowledge exchange between Europe and China and strategy experience and lessons learnt** Speakers: Dr Jihong Liu Clarke, Research Professor & Coordinator for China Relations, NIBIO W.J. Jiang, Ph.D, Professor Institute of Vegetables &Flowers Chinese Academy of Agricultural Sciences
11:00-11:30	**Coffee break**
	Session 2: Results and lessons learnt from exchange of knowledge on technologies between the SiEUGreen showcases
Session moderated by: Thore Vestby (advisory board member) - Each presentation includes 10' Q&A with the audience	
11:30-12:00	**From Europe to China – the "Greenergy" concept** Speakers: Prof. Petter D. Jenssen NMBU and Georg Finsrud, Chief technical officer, Scanwater
12:00-12:30	**From China to Europe: Paper based growing technology** Speaker: Dr Jihong Liu Clarke, Research Professor & Coordinator for China Relations, NIBIO
12:30-13:00	**From China to Europe: Kitchen composting** Speaker: Dr. Xin Mei, Beijing PHOTON SCIENCE&TECHNOLOGY Co., LTD
	End of Day 1

16 October 2020 | 9:00 – 10:45 CEST / 15:00 – 14:45 CST	
9:00 – 9:25 CEST	Login to the online meeting room
9:25 – 9:30	**Welcome** Prof. Petter D. Jenssen (Project Coordinator), Norwegian University of Life Sciences, NMBU
	Session 3: Knowledge transfer sustaining urban agriculture across EU and China
Session moderated by: Grietje Zeeman (advisory board member) -Each presentation includes 10' Q&A with the audience	
9:30-09:50	**Methods and tools to design business models** Speakers: Mr Martin Wafler and Dr Johannes Heeb, SEECON
09:50-10:00	**Q&A with the audience**
	Session 4: Knowledge transfer on social inclusion across EU and China
Session moderated by Vicky Moumtzi (ViLabs Ltd) - Each presentation includes 10' Q&A with the audience	
10:00-10:20	**Strategies to engage communities into UA: best practices of Taste Aarhus.'** Speaker: Dr. Luciane Aguiar Borges and Dr. Sandra Oliveira e Costa,NORDREGIO
10:20-10:30	**Q&A with the audience**
10:30 – 10:45	**Closing remarks and End of Day 2** *Vicky Moumtzi (ViLabs Ltd)*

ANNEX II – Papers Presented in the Transnational board meeting

During the two-day transnational board meeting with main focuses on "setting the scene on Policy and Research: *SiEUGreen - knowledge exchange between Europe and China and strategy experience and lessons"* and *"Results and lessons learnt from the exchange of knowledge on technologies between the SiEUGreen showcases*", the SiEuGreen project consortium has demonstrated the benefits and successful examples of knowledge sharing and two-way transfer between China and Europe. Moreover, the basic outline of the white paper was discussed and following papers were presented.

Paper I: The Actuality and Processing Technologies of Kitchen Waste

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Li Mojun, Mei Xin, Yin Wen, Zhao Yuping

BEI JING PHOTON SCIENCE&TECHNOLOGY CO., LTD

Abstract This paper explains the concept and composition of kitchen waste and the difficulties to treat them. We analyze the actuality and the processing way of kitchen waste in China, the United States, Japan and the European Union and pay the most attention to the biological disposal of kitchen waste. We research the technical flows and technological methods of disposal and find the best way to use them to minimize the source and quantity of kitchen waste. This way we can realize decontaminated treatment of municipal waste, improve the municipal ecological situation and promote green urban agriculture, which will benefit the cooperation between China and the European Union in the building of Smart Cities and the cyclic development of the world economy.

Keywords.

Kitchen Waste; Processing Technologies; Biological Kitchen Waste Disposal; Green Cities

1. Introduction

As its name goes, the restaurant-kitchen waste includes the restaurant waste and kitchen waste, which refers to the refuse produced in the activities of food processing, restaurant services and unit canteens excluding citizens' domestic garbage[1]. The restaurant waste here means the food leftovers and the refuse produced during the procession of fruits, vegetables, meat, oil and pastries in restaurants; While the kitchen waste means the perishable organic wastes, especially the solid waste produced by the skin of fruits and vegetables and the uneaten food in our daily life.

Kitchen waste may ferment and rot if not treated timely and properly. And the toxic matters and smelly gas produced during the fermentation and rot may pollute water and air, damage the city appearance and environmental sanitation, spread diseases and threaten the health and daily life of citizens. [2] In recent years, due to population growth and economic development, the amount of kitchen waste has increased apparently. Now, the total amount of residential trash generated in urban areas in the world can reach 50 billion tonnes every year, among them 10-20%[3] from the kitchen. So, it’s important to minimize, decontaminate and recycle kitchen waste.

2. **The Actuality of Kitchen Waste in China and Other Major Countries**

2.1 China

According to statistical data, China generated more than 1 billion tonnes of urban household garbage in 2015, and 35%~60% of them from the kitchen. Compared to last year (2014), the garbage produced in China increased by 186 million tonnes, with 97.3% of them (about 181 million tonnes) disposed of [4]. In Beijing, 65% of the municipal waste is organic, and 30% of them from residents’ kitchens [5]. While in Shanghai, residents generate 1000 to 1200 tonnes of kitchen waste every day [6].

In a word, China now still has no sound and suitable systems, law and technologies to manage and dispose of kitchen waste. And most of them is discarded in landfills or pigsties [7]. Meanwhile, China is taking steps to solve the problems by implementing related laws, renewing treatment technologies and reusing kitchen waste.

2.2 The United States

The United States produces more than 20 million tonnes of kitchen waste every year on average, accounting for 11.2% of the total municipal waste. The recycling rate of kitchen waste in the US is only 2.6%, far below 30.1% of municipal waste [8]. Now, the US has two different ways to treat kitchen waste. For the units producing large amount of kitchen waste, they should have their own garbage crusher and oil-fat separators. The crushed garbage can be discharged directly into sewers and the oil separated can deliver to the processing factories. While the household kitchen waste can be ground by the residents themselves then discharged or be collected and delivered to the uniform processing center. In order to reuse kitchen waste, the federal government takes effort to develop the processing technologies by turning the garbage into fodder, soil conditioner, compost, biodiesel and methane. The matters in the garbage that cannot be reused shall be buried and burned away. At the same time, every state government has formulated their own way to treat kitchen waste, which includes minimizing food waste, donating food to the needy, feeding the animals with wasted food, using the waste in industrial sectors, composting, burying and burning away [9].

2.3 Japan

Japan produces about 10 million tonnes of kitchen waste every year and it is expensive to transport kitchen waste in Japan, which can reach 250~600 dollars per tonne. So, many companies and communities use trash crushers to dispose the kitchen waste under the support of the government, which also promote the development of crasher manufacturers. Statistics show in Japan there are 270 companies manufacturing kitchen waste crashers for restaurants, food processing companies and units' canteens and 250 for household use [10]. In order to minimize the amount of kitchen waste, protect the environment and reuse the useful matters from kitchen waste, Japan government passed the Law on Reusing Kitchen Waste in 2000 which requires the food processing, restaurants and units' canteen to reuse the useful matters in their kitchen waste as qualified fodder and fertilizer. And according to the law, kitchen waste should be treated in the order of curbing production, reusing matters (fertilizer>fodder>oil and fat) and minimizing waste [11].

2.4 European Union

The European Union generates about 50 million tonnes of kitchen waste every year. All member countries of the EU have their determination and comprehensive system to collect and treat kitchen waste. For example, Denmark began to recycle its kitchen waste in 1987. While in the Netherlands, landfill of kitchen waste has become illegal since 1996, and the trash treatment companies have used aerobic fermentation to dispose of the kitchen waste since then. The Netherlands has constructed two fermenting plants and 23 compost plants at the end of 1999. Germany uses colored devices to sort kitchen waste from other household trash when collecting them, which can make the composting process easier. In Ireland and some other countries, kitchen waste and other organic waste are collected together and then sorted by their characters to compost [12].

3. The Difficulties to Dispose Kitchen Waste

Kitchen waste is a kind of waste resource which contains plenty of moisture and organic matter. It's difficult to keep, collect, clean and transport kitchen waste because they are easy to get smelly and rotted [13]. Due to a large amount of kitchen waste, we must find efficient processing systems to treat them and get rid of the potential pollution caused by them. Through these systems, the kitchen waste should be delivered, collected, transported separately according to their characters [14]. China is a later starter in kitchen waste treatment and we have no advanced technologies and enough planet to processing kitchen waste. What's worse, we also face a lot of challenges in processing programs and costs, which need us taking much more effort to perfect our kitchen trash treatment system.

4 The Meaning of This Research

Green City is a new concept and mode of urban development nowadays and also the domestic need for the sustainable development of urban areas. It enjoys the greatest and newest achievements of information technologies and social-economic development. In order to coordinate with the sustainable development of green cities in the world, we need to protect our environment and reuse kitchen waste fully for its large amount.

5 Research Content

5.1 The Composition of Kitchen Waste

5.1.1 The Component of Kitchen Waste

Table 1 shows the component of kitchen waste collected in the sampling sites in Beijing. From the table, we know the main dry materials of kitchen waste here are food leftovers and discarded bones, accounting for 88.6% and 1.6%. Apart from these main materials, there are also some glass, ceramic, plastic and wood pieces, but we do not find metal matters in our investigation.

Table 1 The Component of Kitchen Waste (based on dry materials)

Sampling Sites	Food leftovers	Bones	Glass	Ceramic	Plastic	Wood	Metal
1	83.4	15.5	0	0	0.7	0.4	0
2	85.6	13.7	0	0.1	0.4	0.2	0
3	97.3	2.1	0	0	0	0.6	0
4	91.4	8.2	0	0	0.2	0.2	0
5	71.9	27.6	0	0	0	0.5	0
6	90.2	8.9	0	0	0	0.9	0
7	94.0	4.5	0.7	0.6	0	0.2	0
8	95.0	3.9	0	0.6	0	0.2	0
average	88.6	10.6	0.7	0.4	0.4	0.4	0

5.1.2 The Constituent of Kitchen Waste

According to the utilizing technical at home and abroad, we measured the moisture, total oils and fats, protein, salt, ash content and heat value of kitchen waste. From table 2, we can know the kitchen waste has high moisture content with an average number of 78.5%, then the protein and the total oils and fats accounting 22.8% and 4.1%.

Table 2 The constituent of kitchen waste

Sampling Sites	Moisture	Total oils and fats	Protein (based on dry materials)	salt	Ash (based on dry materials)	heal value
1	66.3	4.6	32.6	3	1.1	3020
2	82	5.3	18.9	1	2.3	3043
3	79	5.7	12.4	2.7	5.4	3050
4	81	3	31.8	3	1.5	2810
5	84	4.1	2.1	2	0.8	2980
6	82	4.3	29.8	0.75	1.6	3010
7	73.4	3	31.5	1.2	1	2890
8	80	2.7	23.6	1.8	0.9	2780
average	78.5	4.1	22.8	1.9	1.8	2947.9

5.2 Treatment of Kitchen Waste

5.2.1 Discharged Directly into Sewers after Crushed

It's a basic standpoint that we need to dispose of the kitchen waste on the spot for the limited area of our kitchens. Nowadays, some developed countries have installed garbage disposal in the kitchen of their residents which can crush the garbage from coking and discharge them into the municipal sewers. But this way of disposal tends to produce waste water and smelly gas, germinate illness-causing bacterium and attract flies and mosquitoes which spread illness. And the oils and fats from the kitchen waste cannot be crushed but discharged into the sewers, which would block drain pipes after condensate, damage the drainage ability of the municipal severs systems and cause secondary pollution [15].

5.2.2 Landfill

A landfill is a common way to dispose of the kitchen waste and other kinds of trash in most areas in China. The kitchen waste contains much degradable composition which can rot in the landfills and help the landfills to restore [16]. But for its high moisture, the kitchen waste requires high standard landfills to dispose of which increase the cost. And the anaerobic digestion of the kitchen garbage can produce methane and percolate which would cause secondary pollution. With the increasing utilization of kitchen waste, the landfill rate of kitchen waste is decreasing and some countries even forbid the landfill of kitchen waste.

5.2.3 Utilization as Fertilizer

There are two different ways to turn kitchen waste into fertilizers. One is aerobic composting and the other one is anaerobic digestion. Aerobic composting is the creation of fertilizing compost that relies on bacteria that thrive in an oxygen-rich environment [17]. During this process, organic solid matter is turned into compost by micro-organisms living in the composting material and the waste water and smelly gas would produce. So, we need to consider carefully before using this way to compost. Anaerobic digestion is a process in which microorganism break down organic materials in closed space where there is no oxygen. The products of the anaerobic digestion can be absorbed easily by animals and plants [18]. And the advantage of the process is its high efficiency and the reuse of organic materials and methane gas.

5.3 Biological Kitchen Waste Disposal

It's hard to treat household kitchen waste in the way of collective disposal for its high frequency and low quantity. But if we can collect the household kitchen waste of a whole community together, we can have high reuse value from them. So, we need to take the proper way to collect and dispose of the kitchen waste uniformly and make use of them fully.

5.3.1 The Technical Flows

The biological treatment device is controlled by just one button and can finish all the processes automatically. The technical flows of the devices go as follow: put the kitchen garbage in →add zymogen automatically →stir →increase temperature →emit waste gas →decompose through UV technology and deodorize with activated carbon → drying→ organic fertilizer. Then, through all the process, the trash has turned into organic fertilizer, which completes the recycling of resources.

5.3.2 The Technological Methods

5.3.2.1 The Selection of Fermenting Bacterium

We should select the fermenting bacterium that can degrade the macromolecular materials in the kitchen waste such as oils and fats, starch and protein. Then we also need to select bacterium that can provide high-quality amylase, protease, lipase and cellulose from more than 70 kinds of bacterium, which includes bacillus subtilis, polymyxa betae and Nocard's bacillus. The result is that we decide to use bacillus subtilis, polymyxa betae, Nocard's bacillus and bacillus amyloliquefaciens to produce liquid fermenting material which contains more than 10 billion viable organisms.

5.3.2.2 The Fermenting Capacity of the Bacterium

The bacterium used to dispose of the kitchen waste is mainly the anaerobium whose pH belong to 6.0-7.5 and react efficiently at the temperature of 45-55℃. The anaerobium can keep alive in the trash and process in four states: hydrolyzation, fermentation(acidification), hydrogen-and-acetic acid-producing and methane-producing [19]. At last, the kitchen garbage is degraded into CH4, H2 and CO2.

The advantages of anaerobic digestion: (1) the organic solid content rate of the anaerobic system can reach to 10%-25%, which is similar to the solid content rate of kitchen waste. So there is no need to add water and drying the trash before fermentation, simplifying the pre-process flows and reduce the energy consumption. (2) The kitchen waste is suitable to take anaerobic digestion for its carbon nitrogen ratio as 20-25, which is similar to the ratio the anaerobium needed. (3) the anaerobic digestion has little impact on the environment [20].

According to our tests, we can know at the suitable situation, it would take 12-24 hours for anaerobium to turn the garbage into organic fertilizer with the turning rate of 20% and the per day processing amount of 10-25kg.

5.3.2.3 The Purification of Waste Gas

We take the UV degrading technology to deal with the waste gas produced by kitchen waste. The spectrum of 185nm and 253.7nm from the UV lamp can turn the oxygen molecule in the waste gas into ozone and the ozone can degrade the waste gas once more to produce water and some micro-molecule toxic gas.

There is degrading material and layers of activated carbon in the bottom of the device which can adsorb the water and filter the toxic gas of micro molecule producing during the decomposition of the UV. And the ozone not reacted can be transformed into oxygen by honeycomb ceramic.

6. Discussion

It is prohibited to dump kitchen waste on any EU landfill. According to Regulation (EC) No 1774/2002 implemented in 2003, the practice of feeding an animal species with proteins derived from the bodies, or parts of bodies, of the same species should be prohibited. At the same time, kitchen waste produced within the Community should not be used for the feeding of farmed animals other than fur animals. So, most of the restaurants in the EU countries chose the anaerobic digestion way to process kitchen waste. This way is similar to the biological kitchen waste disposal to break the organic compound such as carbohydrate, fat, protein, starch into low-molocular weight compounds such as amino acid, fatty acid and sugar under the microorganism degradation. These low-molocular weight compounds can be transformed into water, carbon dioxide, organic fertilizer by aerobe and the gas production can be discharged directly after the peculiar smell control system.

In Sweden, waste disposal companies provide brown paper bags with strip seal for residents to collect kitchen waste. The sealed paper bags full of kitchen waste would be collected in brown trash cans or the dedicated kitchen waste collectors. All this kitchen waste can be recycled as biofuel or organic fertilizer.

Mandatory kitchen waste garbage sorting has been implanted in France, and the kitchen waste is classified into 3 different levels which included harmless, neutral and dangerous. And every level has different categories which can determine whether the waste is recycled, landfill or burned. Take waste food oil as an example. Early in 1992, it was illegal in France to dump the waste oil into the sewer pipes or throw them directly as normal garbage. If the sewer pipes were stuck for the improper treatment of waste oil, the restaurants will face heavy penalties or even been ordered to be closed. For the restaurants that have a number of violation records, the government will investigate the owner's criminal responsibility[21].

7. Conclusion

It is a great challenge for the world to deal with the rapid growth of the urban population and their increasing product and consumption demands with limited environmental resources. In order to meet the challenge, we should take a green development way by building resource-saving, environment-friendly, secure, livable and vigorous green cities. But the green cities cannot be built overnight, and we should minimize, decontaminate and reuse the municipal waste at first. And it' s a development trend for the world to turn municipal waste into useful agricultural resources because kitchen waste contains microelement of nitrogen, phosphorus, potassium and calcium.

The household microbial treatment devices of kitchen waste can bring considerable social and economic benefits and minimize the quantity of kitchen waste. By recycling municipal waste and reduce kitchen waste compost, we can protect our environment, reduce the landfill rate of trash, decontaminate the municipal waste and improve the urban ecological conditions. The microbial fermentation technology mentioned above can turn kitchen garbage into organic fertilizer, which can provide nutrition to the flowers and vegetables grow on balcony. Through all this work, we can form a virtuous and ecological circle in our cities and contribute to the emission-reduction and energy-saving programs in China and the EU.

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Paper II: Methods and Tools to Design Business Models

M. Wafler und J. Heeb

seecon international gmbh, Switzerland, Mueligass 7, 6130 Willisau

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Abstract

This paper aspires to contribute to the international knowledge exchange and enhancing the EU-China cooperation in promoting Urban Agriculture for food security, resource efficiency and smart, resilient cities. We present highlights, lessons learned and recommendations derived from a virtual business model development training and coaching programme for European and Chinese SiEUGreen project partners. These activities constitute a core element in sustaining exploitation of project results for scientific, commercial and non-commercial purposes or in public policymaking.

Keywords. Business Model, Business Model Canvas, Webinar, Coaching, Lessons Learned

List of Notations and Abbreviations

H2020 ....European Union's Programme for Research and Innovation Horizon 2020

BM ....Business Model

BMC ....Business Model Canvas

COVID-19 ....Coronavirus disease 2019

EU ....European Union

HCD............Human Centred Design

KCF.............Key Competitive Factor

PDF.............Portable Document Format

SiEUGreen...Sino-European innovative green and smart cities (Horizon 2020 Innovation Action)

UA ....Urban Agriculture

1. Introduction

Dissemination and exploitation of H2020 project results

Under the European Union's (EU) Programme for Research and Innovation Horizon 2020 (H2020) beneficiaries shall engage in dissemination[9] and exploitation[10] activities to benefit the largest number and the fruits of research to reach society as a whole (European Union, n.y.). Identifying and assessing the exploitation potentials of their research results enables H2020 consortium partners to create a vision for and put the basis for exploitation planning.

From scientific and technological exchange to the exchange of business models

The H2020 Innovation Action SiEUGreen (Sino-European innovative green and smart cities) strives to take EU-Chinese cooperation to the next level: from scientific and technological exchange to the exchange of business models. This is achieved by creating new value chains and developing innovative and sustainable business models for Urban Agriculture (UA) initiatives that target economic and social benefits and are replicable across regions and countries.

SiEUGreen Urban Agriculture Showcases

[9] Sharing research results with potential users (that is peers in the research field, industry, other commercial players and policymakers). Sharing research results with the rest of the scientific community contributes to the progress of science in general.
[10] Use of project results for commercial purposes or in public policymaking

SiEUGreen aspires to enhance the EU-China cooperation in promoting UA for food security, resource efficiency and smart, resilient cities. Throughout SiEUGreen's implementation, the EU and China share technologies and experiences, thus contributing to the future developments of UA and urban resilience in both continents. The project contributes to the development, implementation and evaluation of UA showcases in 5 selected European and Chinese cities (adapted from SiEUGreen 2018):

Canpus Ås (Norway demonstrate that an innovative combination of known and emerging technologies, actions and planning can contribute to achieve a more resilient, climate, environment and human friendly urban development with near zero emissions, circular economy, low climate and water footprint as well as economic and health benefits.Situated in the Central Denmark Region (Midtjylland), **Aarhus** is known for its bottom-up initiatives involving UA. The 'Taste Aarhus' program has been a key driver for the implementation of more than 300 UA initiatives around the city. The program addresses the question of 'How can cities create more socially inclusive places and communities when focusing on edible nature and urban farming?'. Taste Aarhus uses urban gardening as a tool to bring people together, activates underutilised spaces around the city and engages people in the practice of growing their own food. SiEUGreen sustains and enriches the UA activities by implementing moving mobile gardens, dry toilets and polytunnels.

Hatay is Turkey's seventh-most densely populated province and located in the southern part of the country. The proximity of Hatay Province to the Syrian border had a strong influence on population development in recent years, leading to a sharp increase in the number of inhabitants, particularly in border municipalities. The rapidly increasing population places a burden on Hatay's economy which largely depends on agriculture. SiEUGreen supports Hatay in accessing new UA-related technologies and knowledge, with the aim of creating job opportunities, increasing food production and resource efficiency.

Changsha is the capital of Hunan province - one of the most densely populated provinces in China. As such, it faces an enormous environmental challenge regarding food supply with long transport distance. UA will ameliorate the situation by producing food locally in an environmentally friendly manner with zero transport required. The target of the SiEUGreen project is to go beyond traditional farming, highlighting green ecology, leisure environment and quality of life.

Sanyuan Farm, the showcase situated in the metropolitan area of **Beijing**, China, consists of two parts – East District and West District. While the East District is running for decades, the

West District is in the planning phase. In recent years, the urban farm adopted a concept combining UA with tourism, technology, and education. Sanyuan Farm aims to demonstrate resource-efficient UA and a healthy, happy lifestyle.

What is a business model and why is it important?

The term business model is widely used in theory and practice and reflects core aspects of a business or organisation. Osterwalder and Pigneur describe it as "[…] the rational of how an organization creates, delivers and captures value" (2010, p. 14).

The Business Model Canvas

To translate these three core tasks into concrete building blocks Osterwalder and Pigneur (2010) developed the Business Model Canvas (BMC). With the help of the BMC, an organisation or individual can refine, reflect or define its business model and take strategic decisions on how to proceed and implement its developed ideas. The goal of the BMC is to assist people in understanding their business idea and how the business operates, to encourage discussions, foster analysis and leverage creativity to design a business model that works.

The nine-building blocks of the original BMC (adapted from Osterwalder and Pigneur, 2010):

1. *Customer Segments:* The different groups of people or organizations an enterprise aims to reach and serve.
2. *Value Proposition:* The bundle of products and services that create value for a specific Customer Segment. The value may be quantitative (e.g. price, speed of service) or qualitative (e.g. design, customer experience).
3. *Channels:* How a company communicates with and reaches its Customer Segments to deliver a Value Proposition. Communication, distribution and sales Channels comprise a company's interface with customers. Channels can be direct or indirect, owned or partner channels.
4. *Customer Relationships:* The types of relationships a company establishes with specific Customer Segments.
5. *Revenue Streams:* The cash a company generates from each Customer Segment.
6. *Key Resources:* The most important assets required to make a business model work. These resources allow an enterprise to create and offer a Value Proposition, reach markets, maintain relationships with Customer Segments, and earn revenues. Key

resources can be physical, financial, intellectual, or human. They can be owned or leased by the enterprise or acquired from key partners.

7. *Key Activities:* The most important things a company must do to make its business model work. They are the actions that are required to create and offer a Value Proposition, reach markets, maintain Customer Relationships and earn revenues.
8. *Key Partnerships:* The network of suppliers and partners that make the business model work.
9. *Cost Structure:* All costs incurred to operate a business model.

According to Osterwalder and Pigneur (2010, p. 264), the BMC is not only designed to frame for-profit companies but also to analyse those organizations that "have strong non-financial missions focused on ecology, social causes and public service mandates". To adapt the original model of the business canvas to the organizational settings of such organizations, two additional building blocks are introduced to include the *social and environmental costs* of a business model (i.e. its negative impact), and the *social and environmental benefits* of a business model (i.e. its positive impact) (Osterwalder and Pigneur, 2010, p. 265).

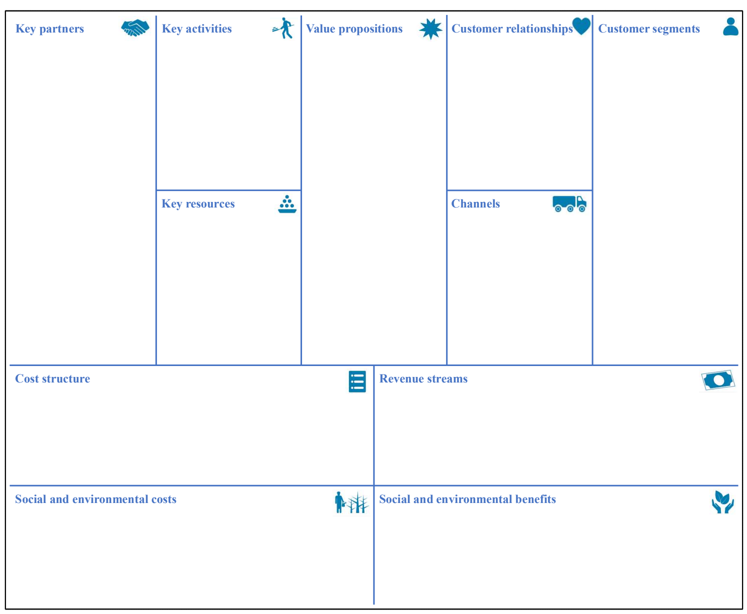


Figure 1: The "extended" Business Model Canvas featuring a total number of 11 building blocks. Including two additional building blocks to also address the social and environmental costs (i.e. its negative impact) and the social and environmental benefits (i.e. its positive impact) of a business model. The Business Model Canvas is a visual template for identifying, describing, designing, challenging, pivoting and organizing different elements of a business model. It is a great strategic management tool to help you quickly and easily understand, define and communicate a business model in a straightforward, structured way (own graphic, adapted from Osterwalder and Pigneur, 2010).

2. Methods and Tools

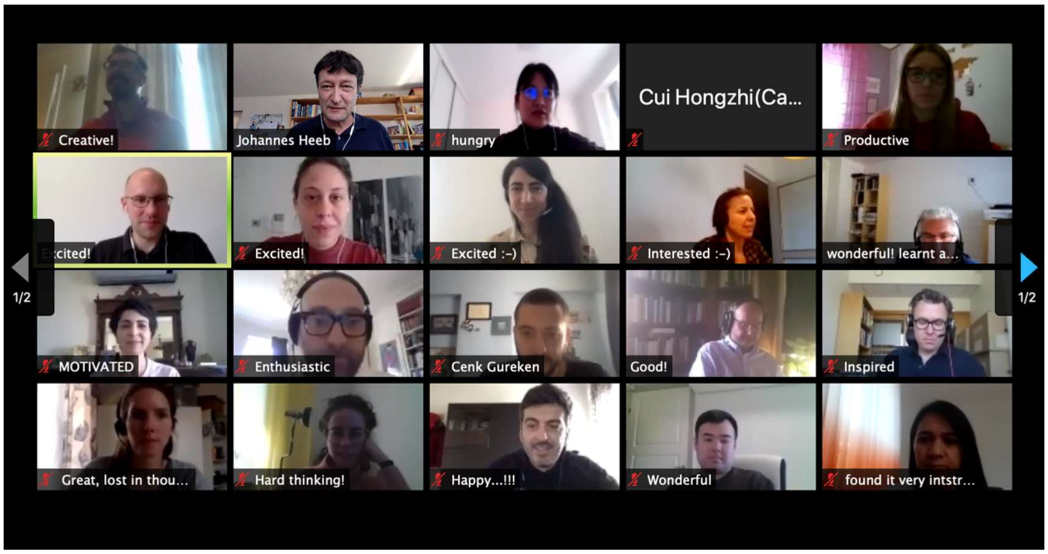
SiEUGreen aims to create a “bridge” of shared knowledge and best practices between Europe and China and aspires to facilitate the strengthening of durable connections, not only at the scientific level but also at the commercial and industrial level through the exchange of best practices and business models. Furthermore, novel agricultural techniques are expected to become an example for the agricultural communities already existing at each of the involved showcases, which strongly benefit from an international knowledge transfer resulting in developing technology packages that boost the production of healthy, economic vegetables in urban and peri-urban communities.

The project team, seized upon the long-term perspective of partners to ensure the sustainability of the SiEUGreen legacy across the EU and China, and organised capacity development and coaching activities for European and Chinese project partners in the development of business models. To support the exploitation of project results for scientific, commercial and non-commercial purposes or in public policymaking to maximize impact, SiEUGreen project partner seecon international gmbh (from Switzerland) led the organisation, implementation and follow-up to these activities.

First, it was planned to organise a 2,5-day *Business Model and Lean Business Plan Development Seminar for SiEUGreen Technologies, Concepts and Showcases*, in Willisau (Switzerland) in mid-March 2020. Later, the plan was revised and a two half-day seminar to be held in Norway in end-April 2020. In response to the global Coronavirus disease 2019 (COVID-19) pandemic, a two half-day virtual event was held instead in end-April 2020. In preparation for the event, a test session was organised the day before. During this session project partners could check 1) if their computer had everything required to successfully join the webinar and 2) familiarize themselves with the conferencing application used in facilitating the event. Two Follow-up Coaching Sessions were organized to support and coach project partners in the further development of business models for SiEUGreen showcases and other exploitable project results developed during the webinar and/or development of new business models.

The planning of and preparation for the webinar considered the six-hour time difference between Europe and China, selecting an appropriate video conferencing software that works and can be used in both, EU and China and allows to create of multiple breakout rooms for group works, collaboration and discussions, registration of participants and detailed information/instructions on the successful use of the video conferencing software, etc.

The overall goal of these activities was to initiate a change in the ability of consortium partners to substantially ideate, describe, evaluate and discuss business models using the BMC, a strategic management template for describing, analysing, and designing new or documenting existing business models. This approach has been in line with the vision to support the sustainability of the SiEUGreen, by the project partner that will be in a position to conceptualise and elaborate additional business models they can conceive.



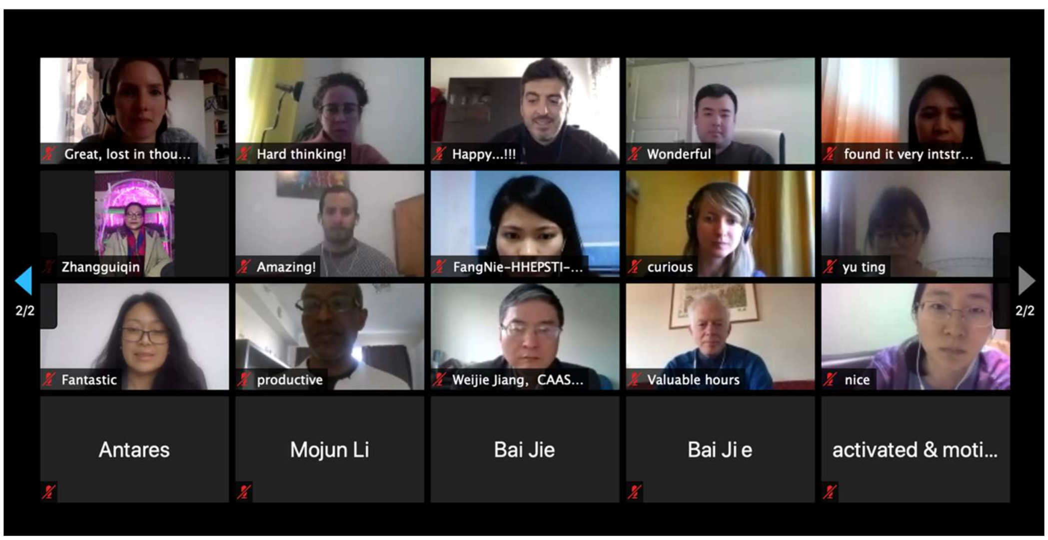


Figure 2: Group picture taken during 1st day of SiEUGreen Business Modelling Webinar (23. April 2020).

3. Results

Results from the webinar and related activities directly and immediately fed into the development of sustainability and exploitation plans for SiEUGreen showcases and exploitable project results. Thus, offering the right context for industry players and investors to understand business opportunities of the emerging "smart, green, inclusive" city model and contributing to ensuring the sustainability of SiEUGreen beyond the end of the project term and promoting the expansion and adoption of suggested solutions by key actors in the field.

So far, a total number of 9 business models were developed, which vary between socially- and commercially-driven ones and reflect how partners consider exploiting project results:

Integrated multiscale analysis framework: This business model draws from the Aarhus showcase and addresses the issue of policy makers lacking instruments to assess the benefits and drawbacks of urban agriculture for the development of cities and integrated urban planning.

Beijing Showcase: The business model is for the promotion of a high-efficiency aquaponic system for integrated ecological fish-vegetable production with zero pollution and zero emissions in a water shortage area or around the big city.

Hatay Showcase: Business model for empowering disadvantaged communities towards continuous production of fresh, local, pesticide-free, organic food by using innovative urban agriculture systems and renewable energy sources.

GREENERGY concept: The concept builds upon the development and demonstration of the integrated solid and liquid waste management system applied at the Campus Ås and (partially) Changsha showcase.

Fruit & Vegetable Planter: The business model is tailored to the continued development of balcony vegetable/mushroom/succulent planting equipment that allows urban residents to eat their own organic vegetables and reduce - in part - the demand for market supply.

Garbage Processor: The business model describes the reduction of household kitchen waste and production of organic fertilizer, which can be used by urban residents to grow healthy, green organic vegetables.

Urban Composting Hub: The business model values households' organic wastes to green the circular city in a sustainable way by promoting the production of organic fertilizer from anaerobic digestion of organic household waste streams. It focuses on creating a composting hub, where residents can provide their organic waste and obtain locally produced compost.

Urine-based fertiliser: The business model involves the treatment and further processing of source-separated urine to a traditional but modern, locally produced, high-quality, hygienic, quick-release, liquid fertilizer for commercial applications.

Paper-based microgreen production: This business model involves residents in growing vegetables at home and sells them to a company, which processes these vegetables into soap, nutritious food and other products and sells them to the market.

4. Highlights, Lessons Learned and Recommendations

What really matters in the successful preparation, implementation and follow-up of a virtual business model development training and coaching programme:

1. ***Provide detailed information, instruction and training materials in advance***

   Mailing a "Save the Date" notice for the event two months ahead of the tentative event dates proofed to be timely. This communication was followed by an Announcement document providing relevant information on why the business model development training and coaching are organised, the webinar times, the overall goal, the training and coaching methodology, key benefits to participants, the expected outputs and contributions to project deliverables, the tentative programme, registration and contact details, etc. A few days prior to the event a detailed user manual was sent to all registered participants to assist them in the successful use of Zoom, the application used in facilitating the webinar. The day before the event, copies of the input presentation and templates of the BMC were mailed to all participants.

2. ***Quick and effortless registration***

   To give project partners a quick, effortless and positive registration experience, a lean online registration procedure using Google Forms was used. We designed and build a quick-to-fill, painless, user-friendly and easy to understand registration form asking clear questions to extract the exact information needed: attendee's details, full names of all colleagues working on the same exploitable result/business model and a brief description of the SiEUGreen project result or Showcase that a business model is developed for.

   As the use of Google Forms is blocked in mainland China, Chinese project partners were asked to fill in a PDF (Portable Document Format) version of the form.

3. ***Have a plan B***

   Have a backup plan, including a mailing list with all the participants and a drafted email in case software stops working and an email with a link from a different software is sent to participates. Also, have the presentation slides ready to send to participants if having technical issues.

4. ***Keep it simple and stupid!***

   Since participants were new to the subject of business model development, their focus should be on applying the BMC to their business idea and not be distracted by having to use unknown software applications. Therefore, we decided to use applications that participants are familiar with and frequent or casual users of Microsoft Word (a word processing program to create text-based documents) and PowerPoint (a presentation software.

5. ***Keep webinar days short***

   Virtual events must not be designed as online replications of physical events. That's because attentive participation in virtual events is even more challenging/demanding than in traditional face-to-face ones. An all-day virtual training is exhausting to both, trainers and participants and therefore not recommended. Separating the event in two half-days also allows participants to reflect on the results of the first day and hence improve overall training outputs. To not lose momentum and important information, it is advisable to use two consecutive days.

6. ***Know your application well***

   If the software application used in the facilitation of virtual event is new and the team has little experience with organizing webinars, calculate enough time for preparation and organize an internal simulation with the moderator(s), trainer(s) and coach(es). Make sure all people know who to contact should they have any issues and things they can do to improve connection (such as turning video off and just have voice). Add, check and test special features / functionalities if required (chat function with emojis, prepare polls, surveys, screensharing or uploading videos).

7. ***A well-coordinated team***

   Distribute roles (depending on the scope of the webinar and the available resources, different roles can be covered by the same person as well):

   (1) moderator

   (2) co-moderator or assistant (if required)

   (3) person responsible for technical issues / features / connectivity

   (4) person responsible for the chat function, replying to questions in the chat

(5) person responsible for protocol and documentation (in case that the automatic recording function does not work)

(6) contact person for "emergencies" – available via phone/ Skype / WhatsApp, depending on the scope of the webinar (and available resources)

4. Conclusion

In view of the continuation of the global COVID-19 pandemic and related travel restrictions, it was the right decision and at the same time a great experience to organise an online business model development training for European and Chinese consortium partners.

Participants benefited from the training and coaching as they acquired knowledge and tools readily applicable to current challenges in the exploitation of project results. The webinar facilitated and contributed to the EU-China knowledge exchange, built and increased the ability of consortium partners to ideate, describe, evaluate and discuss business models and contributed to maximising exploitation of SiEUGreen results for scientific and (non-)commercial purposes or in public policy- making.

Having a systematic approach to and sequences of short input presentations followed by the immediate transfer and application of learning contents to their own business model (in breakout sessions) created an active and activating environment, helped participants to better understand the development of business models, fill in the various building blocks of the BMC step-by-step and realise that "creating a business model is not rocket science" (anonymous feedback from webinar participant).

Acknowledgement

We thank Mr. Dimitrios Petalios', Work Package 5 leader, for useful discussions and support in the preparation of the webinar.

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Paper IV: From Europe to China – circular systems for water and waste coupled to urban agriculture - the “Greenergy” concept

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Petter D. Jenssen (NMBU), Melesse M. Eshethu (NMBU) Georg Finsrud and Trond Mæhlum (NIBIO)

Abstract. This paper presents the “Greenergy” concept in promoting Urban Agriculture for food security, resource efficiency and smart, resilient cities. The concept builds upon the development of an integrated treatment and resource recovery system for solid and liquid waste management. Aiming at the circularity of resources, the SiEUGreen approach implements decentralized and source separation of waste streams. Blue (water and waste) and yellow (energy) technologies are used to demonstrate how we can turn source-separated domestic urban waste resources into fertilizer, growth media and bioenergy primarily for local urban and periurban use.

Keywords. Greenergy, decentralized, resource efficiency.

1. Introduction

The project, 'Sino-European Innovative Green and Smart Cities' (SiEUGreen) promotes cooperation between the EU and China for sustainable urbanization. Its principal aim is to share and transfer "know-how" on novel agricultural techniques coupled with circular urban solutions for minimizing pollution and climate gas emissions. Its vision is to provide examples for future urban environments of both continents and to demonstrate this in Europe (Norway, Denmark, Turkey) and China (Beijing, Changsha). To achieve sustainability and the circularity of mass flows a system or holistic approach is necessary (Mitch and Jørgensen 1989). Thus, SiEUGreen is a multidisciplinary project (Fig 1.) where water, energy and waste experts (blue and yellow technology) cooperate with agricultural and social science expertise (green and red circles).

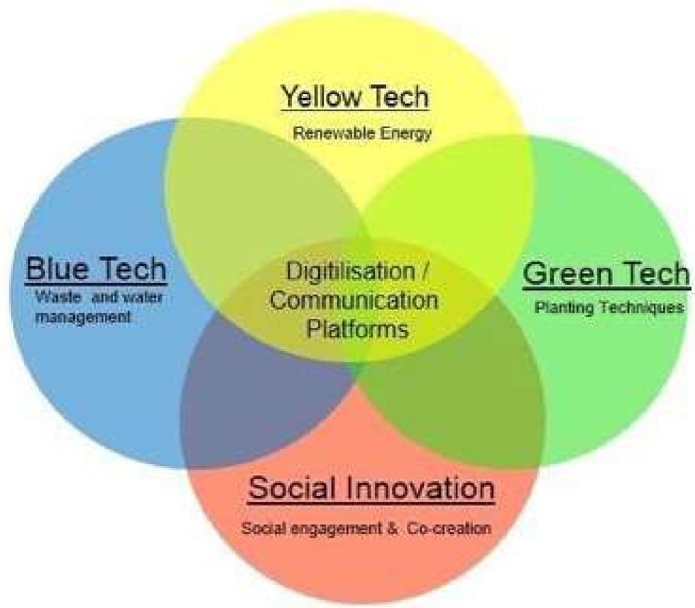

Figure 3 The multidisciplinarity of SiEUGreen.

This chapter deals with the blue and yellow technologies and how we can turn domestic urban waste resources into fertilizer, growth media and bioenergy primarily for local urban use, but we also see a potential for the export of fertilizer products, especially, to ex-urban agriculture. Circularity regarding water and nutrients can be achieved through different approaches. The SiEUGreen approach is decentralized and based on source separation of wastewater.

Why source separation? Twenty to forty per cent of the water consumption in sewered cities is used for flushing toilets (Gardner 1994). This is often potable water brought to the cities at a high cost. The daily water use in industrialized countries ranges from 150 to 250 liters per capita. The volume of our excreta (urine and faeces undiluted) amounts to 1.5 liters per capita per day, hence, our excreta constitute less than 1% of the wastewater volume. But this 1% excreta contributes about 90% of the nitrogen and phosphorus (Todt et al. 2015), about 50% of the organic matter and the majority of the pathogens in wastewater. These substances are of major concern regarding health problems and water pollution from sewage. By source separation and the use of dry-, urine diverting- or extremely water saving toilets, as vacuum toilets, we can capture the resources from excreta with minimal dilution. This facilitates co-processing of the excreta and organic household waste into fertilizers, soil amendment/growth media and biogas as exemplified in the nutrient and energy loop (Fig. 2.).

Figure 2. The principle of source separation and circular wastewater handling.

Dual flush vacuum toilets are emerging in the market. They use an average of about 0.5 liters per flush or 2-3 liters/person/day. The proposed new Swedish design values suggest a greywater production of 100 liters/person/day. This means that greywater constitutes more than 90% of the household wastewater when vacuum or other low flush toilets are used. With the majority of nutrients and pathogens removed in the blackwater, greywater constitutes a raw water source better than many surface water sources currently used for processing of drinking water. In SiEUGreen the processing of greywater to drinking water is demonstrated. If greywater is processed to potable standards and recycled more than 90% water saving is achievable.

2. Circular Systems

The vision of SiEUGreen is expressed in Fig. 3. The water consumption is minimized by water saving technology (household appliances and toilets) and greywater recycling. The nutrients in excreta are reclaimed and recycled to plant production, thus discharge to water is minimized or near eliminated. Blackwater and organic household waste are treated anaerobically to produce biogas and thus reduce greenhouse gas (GHG) emissions. Jönsson (2019) points out that recycling of plant-available nitrogen and organic material from wastewater has a great potential to reduce the climate impact of wastewater management. It takes 39 MJ of energy to produce one kg of Nitrogen fertilizer (Refsgaard et al. 1998). If nitrogen can be brought to the fields at a lower energy cost it will cut GHG emissions and most likely be more sustainable.

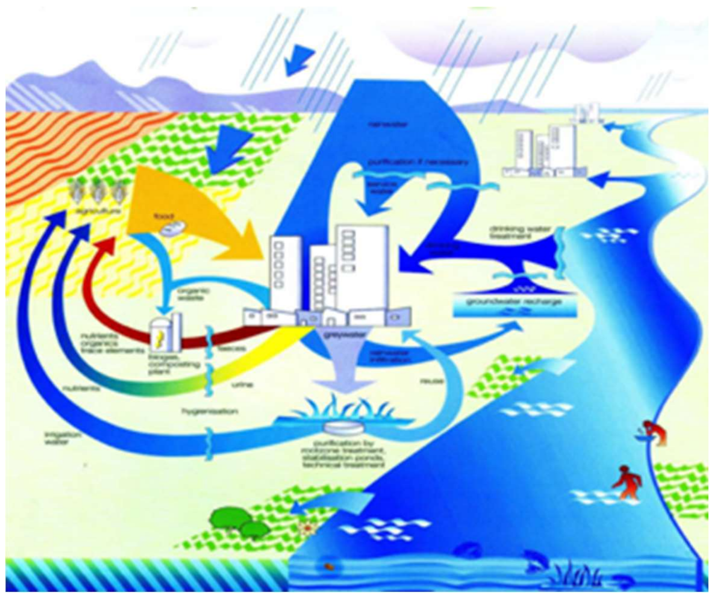

Figure 4. The vision of SiEUGreen

The remaining commercially viable phosphorus ores are mainly found in West Africa, China and USA. This uneven geographical distribution may cause geopolitical tension (Rosemarin and Ekane 2016). Recycling of resources already in the biosphere can reduce the risks for conflict. Thus, there are several incentives to turn to circular systems within wastewater and waste management.

3. The History of NMBU's Cooperation with China in Water and Wastewater Projects

NMBU started the cooperation with the University CFSU in Changsha in 1995. The first project was initiated with financial support from NORAD (The Norwegian Agency for Development Cooperation) aiming to create "blue sky, clean water, green land and healthy people" for

Zhuzhou City, one of the top 10 polluted cities in China. The first project in Zhuzhou city included: Cleaner production plans for more than 100 industries in Zhuzhou City

Drinking water treatment technology introducing:

- Coagulation and filtration through Filtralite and Sand followed by filtration through Activated Carbon
- Membrane filtration

Wastewater treatment with technologies:

- SBR (sequenced batch reactors)
- AAO (Anaerobic, Anoxic and Aerobe treatment)
- Chemical precipitation and P-removal
- Organic P-and N-removal
- MBBR technology
- Remote control used to secure the water supply

Several visits between the two Universities (NMBU and CSFU) and the cities Zhuzhou and Fredrikstad.

4. Drinking Water

During the period 1995-1998 Norad supported the buildup of a pilot plant of drinking water and sewage treatment in Zhuzhou City of Hunan Province. The design and engineering of these plants were done by several Norwegian Engineering Companies, where Scanwater still is active in the cooperation that was established back in 1995.

New advanced processes for drinking water treatment was implemented using activated carbon together with ozone and membrane filtration. At that time, only conventional processes (coagulation + sand filtration) were applied in almost all the existing purification plants of China. Only 35 indices should be monitored according to Chinese drinking water standard. In 2006, the New Standard for Drinking Water Quality was enacted, meaning that most of the big cities like Zhuzhou City had to make improvements of their purification process. The main technical route was almost the same as the one used in the pilot plant established in Zhuzhou city through the cooperation with Norway.

This means that the pilot plant has been a successful showcase and giving valuable input for the improvement of these waterworks. The introduction of membrane filter technology in the pilot plant also changed the ways of designing treatment plants. Prior to the pilot plant was put into operation, membrane filter systems were rarely used. This was completely new for Zhuzhou city and even the whole China, but nowadays barreled and bottled water made by membrane filtration has become very popular both in cities and even in some rural areas. Currently, China is the absolutely biggest market in the world of the membrane industry for processing of drinking water.

5. Sewage Treatment

A pilot plant for sewage treatment was introduced in Zhuzhou city in parallel to the drinking water pilot. The processes introduced were basically:

- AAO (Anaerobic, Anoxic and Aerobe treatment)
- MBBR (Moving Bed Biofilm Reactor)
- Chemical precipitation

Before 2008, sewage treatment was almost absent in Chinese cities, and there were less than 10 existing sewage treatment plants. Massive construction of sewage treatment facilities started after 2008, from that time, more and more investments have been allocated to this field. Now the coverage in most of the cities is approximately 80%. This is a huge change in China.

With the improvement of knowledge and experience, where the Norwegian input was significant, advanced processes like modified MBBR and modified AAO and improved biological treatment methods were introduced. Another issue that is worth mentioning is, that just two years after the pilot plant commenced operation, Kaldnes AS, a Norwegian company, received the project of Longquan sewage treatment which was the biggest sewage treatment plant in Zhuzhou city. This project was also financially supported by NORAD.

From these pilot projects, many students and engineers received their training. This was very helpful for the development of the sewage engineering industry. In the meantime, all such efforts from Norway have given significant help to the sewage industry in the Hunan Province especially.

When engineering/knowledge, technology, and experience from the implemented decentralized systems in Europe now are transferred to China, we see similarities to the earlier experiences and adoptions from Europe (where centralized systems were the only option). In 2019 China will reach an urbanization rate of 60 % and it is predicted to be at 65 % in 2025.

In most Chinese cities, sewage treatment plants built before 2010, were located in the center of the city. Today it is difficult to improve or enlarge and even maintain some of these plants without huge costs. This is due to the location in between housing complexes, offices, stores, and factories. If the authorities could regulate for implementation of the technology, and the philosophy, behind the decentralized system in these cities, much of the stress and need for support of the existing sewerage treatments plants could be reduced or eliminated.

In addition, in rural areas, sewers and sewage treatment plants are often absent. Thus, small rivers, lakes, ponds are polluted by wastewater from households and livestock. Implementation of decentralized circular water and wastewater systems, as exemplified by the SIEUGreen project, can solve many of these challenges in a sustainable way. Therefore, a good showcase is both necessary and important. The showcase in Changsha is one example in China, and there are several more examples in Europe. In total there is a huge upcoming opportunity in China for the technologies demonstrated by SiEUGreen.

The NMBU cooperation with China has continuously been under development since the upstart in 1995 and the SiEUGreen project is another example of the very strong bonds. Several engineers have graduated from both the Universities NMBU and CSFU often supported by the Norwegian "Norwegian Peace Corps Program". This education has been part of creating a common understanding for the source separation technologies – Greenergy^{TM}, which is the fundament of the SiEUGreen project and showcases in Campus Ås, Norway, and Changsha (Zhuzhou City).

5. Greenergy and Zero-Waste Concept in Domestic Water Management

The Greenergy and Zero-waste concept at the household and community level demonstrate the value of domestic wastewater as a source of alternative local nutrient-energy-water resources. The concept builds upon the development and demonstration of an integrated solid and liquid waste management system. The development of an integrated treatment and resource recovery facility based on a source-separated sanitation system can provide a healthy local environment, social and economic payback for households and communities, and contribute to green development and food security (Melesse E. 2019). In contrast to the linear resource flow, the circular resource (water, nutrient, and energy) flow promotes the reduction of water consumption, reuse of water, and recovery of resources from wastewater to not only increase resilience to sabotage, disasters (as earthquakes) and climate change but also to reduce the greenhouse gas emissions resulting from the provision of water and wastewater-related services.

Source-separated greywater, with the circular water concept, can be treated locally to a drinking water quality level for non-potable domestic uses. Nature-based (infiltration, constructed wetland, biofilter) solutions, compact/package treatment systems and membrane supported solutions are currently in use. A lab scale compacted biological aerated filtration (BAF) system tested in this SiEUGreen project demonstrated an efficient small footprint local greywater treatment system (Rummelhoff, 2019). By combining the compacted BAF greywater treatment or green wall filtration system or constructed wetland system with sequential activated carbon and nano filtration (0.28 µm) followed by reverse osmosis and ultraviolet disinfection as post treatment, all the greywater can be converted into a drinking water quality to be used as an alternative local water source. Similarly, source-separated blackwater and urine stream of the domestic wastewater can be locally treated to produce nutrients, energy (heat and electricity) and water that can be safely used in a local food production achieving a near zero-waste system (Figure 4). CO_2, heat and power from biogas combustion can be utilized together with the nutrient rich retentate in a super-insulated greenhouse for local resource reuse and year around plant production. This in turn prevents environmental pollution and preserve a healthy ecosystem and society with a direct or indirect effect on the Sustainable Development Goals (SDGs).

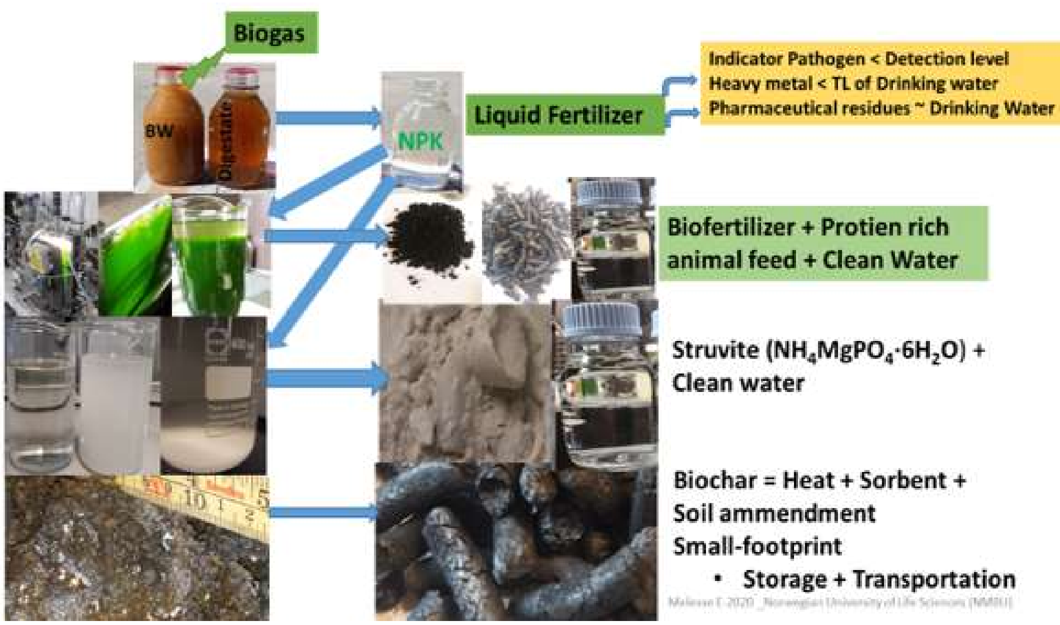

Figure 5. Zero-Waste value chain products of source-separated blackwater.

6. The Blue Technology

The blue technology is one of the SiEUGreen innovation principles (Figure 1.) and is the core of the Greenergy concept. It highlights efficient resource use, water and waste management, resource recovery and recycling, and production of fertilizer and soil amendment from waste. The blue technology consists of technologies for source separation of wastewater (alternative toilet systems), technologies for processing of waste(water) for resource recovery and recycling, and technologies for storm water handling. The yellow technology includes biogas production from waste resources, seasonal solar storage, combined heat and power, and photovoltaic generation of electricity.

Source-separated wastewater treatment systems involve the separate collection of greywater (GW) (from kitchen, shower, laundry and basin) and the toilet water (blackwater BW) from the source and treating them separately according to their properties. This is a new development strategy in the new sanitation concept aimed at efficient resource utilization, environmental protection, pollution prevention, and sustainable development. Increasing the overall sustainability of cities with novel circular and climate-friendly zero-waste concepts based on treatment, recycling, recovery and reuse of household organic wastes and wastewater is of prime importance. Source-separation sanitation systems provide opportunities for local recycling and utilization of resources and are appropriate alternatives to the conventional treatment of mixed wastewater in centralized treatment systems. Figure 5 presents a source separation system and a domestic wastewater flow by stream and volume. The amount of human excreta produced per person per day which is the major source of nutrients, organic matter and micro-pollutants is only about 1% by volume of the total wastewater generation per person per day. With the objective of maximizing resource efficiency and minimizing waste production, source separation and use of low flash technologies will reduce water consumption, facilitate recycling of nutrients and organic matter to urban and periurban agriculture. Moreover, the system reduces waste generation and reduces or almost eliminates risks of pollution of surface water. Decentralized and source-separation wastewater management, therefore, offers more opportunities for both economic and social sustainability.

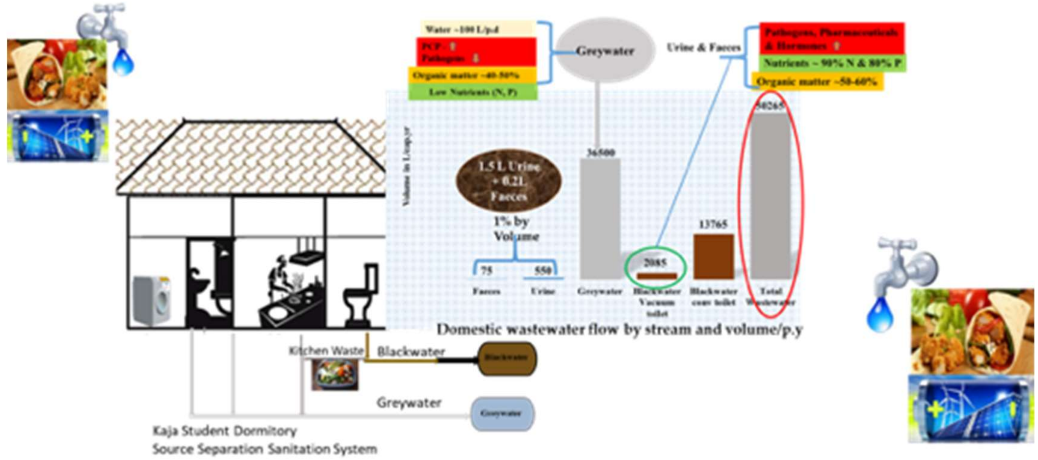

Figure 5. Source-separation for targeted on-site wastewater treatment & resource recovery (Melesse E. 2019)

7. Source Separating Technologies in Wastewater Treatment

A century ago our excreta, termed night soil, was often collected, sometimes mixed with peat and/or lime, and used as fertilizer. In China, especially there are long traditions of collecting "night soil" for use in agriculture. With the invention of the water toilet about 150 years ago and development and installation of subterranean gravity sewer systems, these resources began being discharged to water, causing pollution. With the current increase in focus on the "green shift" and circular economy, the interest in source separation of wastewater has grown. Rosanne Wielemaker (2019), in her PhD thesis "The fertile city", points to source separation as "new sanitation" when she outlines the reuse potential of nutrients from the population of Amsterdam. A combined treatment and resource recovery facility based on source separation and on-site treatment has been developed and tested at laboratory scale at the Norwegian University of Life Sciences (NMBU) (Melesse Eshetu, 2019). In a current EU-funded project «Run 4 life» source separation technology is also explored. Run4Life demonstrates an alternative strategy for improving the recovery of resources from wastewaters, using a decentralised approach where black water (toilet wastewater), grey water (other domestic wastewaters) and organic kitchen waste are collected separately.

SiEUGreen Conceptual Model Recycling of Resources is presented in Figure 6. The conceptual model shows an array of possible source separation technologies and a combination of technologies.

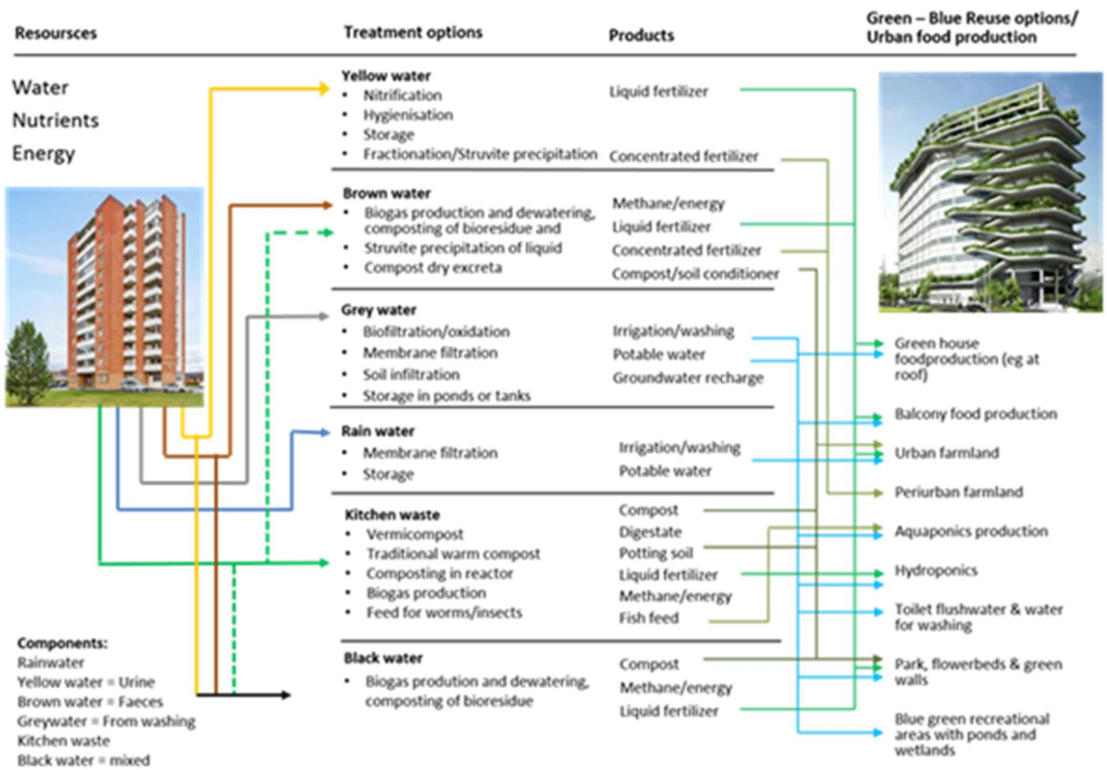

Figure 6. SiEUGreen Conceptual Model Recycling of Resources.

The SiEUGreen project does not pursue all the possible solutions in Fig. 6. Below a short overview of different source separating options are given. The SiEUGreen options are described in more detail and are presented in the table in Annex 1. Source separation as base for circular systems will change the logistics of wastewater handling, but also of organic waste. The system logistics depends on toilet type (Fig. 7).

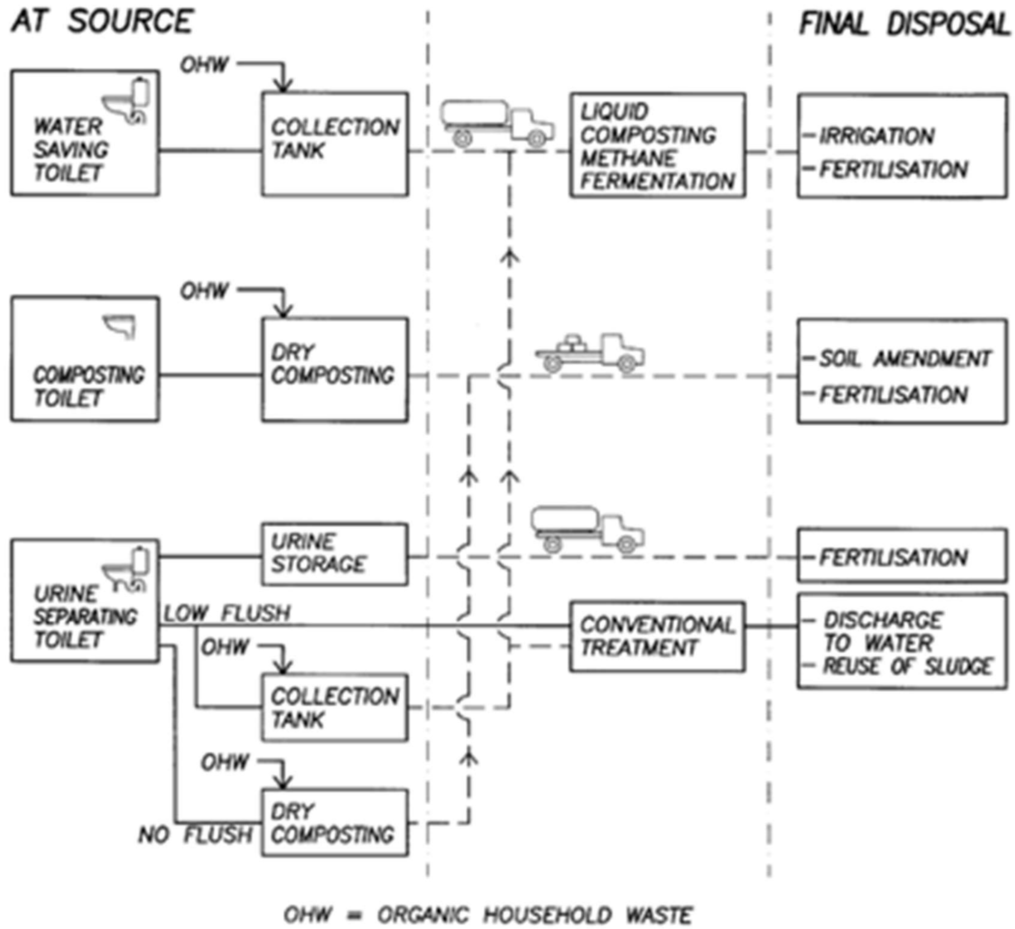

Figure 7. Logistics of blackwater and organic waste handling dependent of toilet type (Jenssen and Etnier 1997).

The use of a source separating system for wastewater treatment requires at least a dual plumbing system; one for blackwater and one for the greywater. If a urine separating toilet is used three handling lines may be needed one for urine, or yellow water, one for the faecal matter and one for the greywater. I Norway 110mm pipes are used for inhouse wastewater transport when using conventional systems. If a dual or triple system is used the diameter of the pipes can sometimes, but not always be reduced. If low flush gravity toilets are used normally 110mm pipes are used. For the faecal fraction of dual flush urine separating toilets normally 110mm pipes are used. The greywater and vacuum toilet pipes are normally from 50 – 75mm.

Figure 7 shows the different options at source separation where the blackwater, urine or composted faecal matter is collected and transported to agri- or silvicultural production. Transportation by truck is energy consuming and has to be taken into account in a sustainability analysis of a decentralized source separating wastewater treatment system in urban areas. One main question is how far it is feasible to truck the material. This is not an easy question to answer. The energy aspects of sewage treatment and fertilizer production are complex and a complete analysis is not available. One way to obtain data is to consider a truckload of blackwater, urine or compost toilet residue and look at the energy needed to produce an equivalent amount of mineral fertilizer. Then take this amount of energy and see how far the truck can run (Table 1).

Table 1. Transport distance for different organic fertilizers based on comparing energy content in an equivalent amount of mineral fertilizer to the energy needed for transportation (from Jenssen and Refsgaard 1998).

Organic fertilizer resource	Transport distance (km)
Blackwater	25 – 30
Urine	40 – 50
Compost	500 – 1400

Table 1 shows that it may be feasible to truck blackwater up to 30km, urine up to 50km and the compost material up to 1400km. 25 – 30 km is sufficient to reach agricultural areas from the center of many mid-size cities (100 000 – 500 000 inhabitants).

The reader should bear in mind that this calculation is based on several assumptions some of which have large inherent uncertainties. There are also many other aspects that need to be considered in a more complete system analysis.

The large difference in transport distance is mainly due to how concentrated the material is. The blackwater is normally more dilute than urine. The end product from the composting toilet is relatively dry and can tolerate a much longer transport distance before the energy used for transportation equals the energy used for production of an equivalent amount of mineral fertilizer. However, for composting toilets the transport distance is very much dependent upon how much nitrogen that is reclaimed in the compost.

8. Toilets and Treatment Options

One of the main objectives of source-separation is to collect a small but concentrated amount of urine and/or blackwater for effective treatment and resource (mainly nutrient and energy) recovery. Collection, treatment and resource recovery from urine and blackwater depends on the type of toilets used. Toilet systems in source separation sanitation include vacuum and/or low flush toilet systems, urine diverting toilets, composting toilet and solar dry toilet.

9. Vacuum and/or low flush toilet systems

The vacuum toilet technology is introduced to save water, but with the same comfort as a traditional flush toilet. Vacuum toilets are flush toilets based on a non-water transportation system and water is only used for cleaning the toilet bowl and pipes as well as noise reduction (WRS, 2001). Vacuum toilets are connected to vacuum sewers. Unlike typical gravity sewers, vacuum sewers use differential air pressure to transport the wastewater as all the sewer mains are under vacuum (negative pressure compared to atmospheric) (Dobrescu et al., 2011). It therefore removes faeces, urine and toilet paper with a minimal amount of water (0.5 to 1.2 litres). The high transport velocity of the air/water-mixture in the vacuum pipelines prevents deposits, odours and septic actions in the pipelines (GTZ, 2009). The vacuum toilet or low flush toilet system not only save water but also produces a small volume of blackwater as a raw material for resource recovery. The vacuum toilet technology has become the standard toilet technology in marine applications, trains, airplanes and busses. Vacuum toilets have also gained interest for apartments, hotels and offices as part of innovative source separating sanitation systems where water savings, and nutrient and energy recovery is important.

10. Urine diverting toilets -treatment options for recycling of resources

Urine is the most nutrient rich wastewater fraction (Jönsson et al. 1999) and contains all the necessary nutrients needed for plant growth – e.g. nitrogen, phosphorous and potassium – as well as a multitude of trace elements such as iron, zinc and boron (https://www.eawag.ch/en/department/eng/projects/aurin-fertilisers-from-urine/). Among the European countries Sweden has been pioneering the development of urine separating toilets as well as the use of urine in agriculture (Jønsson et al. 1999). Urine diversion toilets include urinals, urine-diversion flush toilets (UDFTs) (Figure 8) and urine-diverting dry toilets (UDDTs) (Münch and Winker, 2011, Rieck et al. 2012). Most urine-diverting toilets in Europe differ from ordinary toilets in that the bowls have two sections. A front bowl for urine collection and rear bowl for faeces and toilet paper. However, in a new model (Fig. 9) urine is collected by surface tension. In UDFT´s the faecal part is flushed to the sewer/local treatment system. In UDDT´s faeces goes to composting.

(a) (b) (c) (d)

Figure 8. In most urine diverting toilets the bowl is divided into two parts, a front one collecting urine and a rear one collecting fecal material: a and b two UDFT models; (c) urine diverting insert to a bucket toilet, and d, a UDDT model.

In Fig. 9 a new Swiss UDFT model that uses surface tension for urine separation is shown.

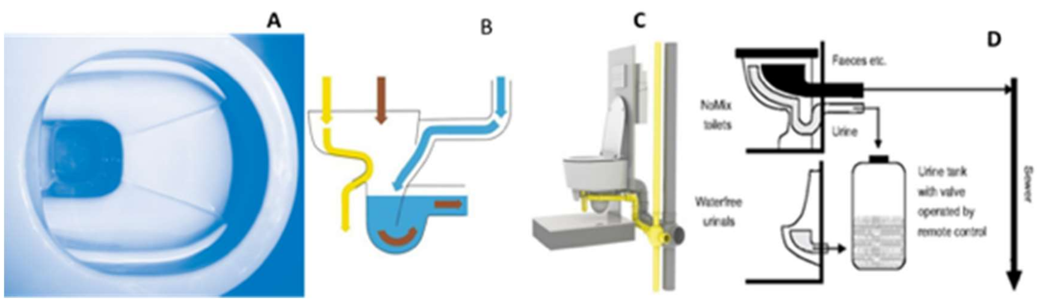

Figure 9. Laufen dual flush (no mix) urine diverting toilet - principle. (A) urine is diverted by surface tension (yellow), (B) faeces is flushed (blue) (C) connection to a dual piping system, www.eoos.com/cms/?id=413#;https://news.laufen.com/wp-content/uploads/2019/03/Laufen_ISH_save_EN_RZ_FINAL-1.pdf, and (D) system combined with waterless urinals (Larsen, T.A. 2009).

Urine separating toilets are implemented in some ecological housing projects, both for holiday residences, houses and apartments buildings. Urine diversion has not yet gained widespread use in housing developments. However, the easiest way to retrofit a source separating system in existing buildings is to install a UDFT. The use of waterless urinals are gaining popularity in Europe and there are many suppliers and models (Münch and Winker, 2011). Waterless urinals for men and women are available (https://www.shelby.no/uridan).

11. Urine Treatment Options

a) **Urine storage**

Despite that urine is sterile when leaving the body of healthy persons, some contamination will occur in the toilet bowl (Jönsson and Vinnerås 2007). Thus, urine need treatment before application in commercial agriculture (in Norway urine can be used without restrictions in private gardens). The most common treatment is storage. During storage the pH of urine increases as urea ($CO(NH_2)_2$) converts to ammonia (NH_3). Both the increased pH and ammonia concentrations contribute to reduction of unwanted microorganisms. Normally 6 months of storage is required to achieve sufficient reduction in microorganisms and corresponding risks (WHO 2006, Høglund et al. 2007).

b) Biofiltration of Urine

A challenge with utilization of urine in urban agriculture is the foul smell. In SiEUGreen project, trials are made to nitrify urine on-site to achieve a chemically stable, smell-free and concentrated liquid fertilizer product that is socially and hygienically acceptable. Nitrate is stable, does not smell and is a better nutrient than ammonium for most plants. Two types of reactors were tested in SiEUGreen at laboratory scale using stored human urine with a 5-75% dilution: 1) a moving bed bioreactor (MBBR) and 2) a multipass packed-bed biofilter using porous lightweight aggregates. Both the MBBR and biofilter appears to be suitable methods for urine nitrification making an attractive fertilizer for urban greening and gardens. The biofilter lab scale model worked well for up to 75% urine concentrations. The MBBR method has also been tested for biogas digestate with good results. However, the methods need longer testing in laboratory to optimise factors influencing the nitrification process and to make the reactors more robust and suitable for concentrated urine.

Use of urine in a liquid state can require large storage capacity limits transportation distance (Table 1 above). Several methods for concentration/solidification is therefore tried or under development. One of the recently developed concentrated urine fertilizer is "**Aurin".** It is a commercial concentrated liquid fertilizer produced from urine. The process is developed by EAWAG in Switzerland. The method reduces the volume significantly and can be stored and transported for long. (https://www.eawag.ch/en/department/eng/projects/aurin-fertilisers-from-urine/). The main prerequisite for this process of nitrogen extraction is the separated collection of urine. The production of the fertilizer occurs in two stages: first, a biological process stabilizes the urine, the nutrients are bound and the urine loses its unpleasant odor. An activated carbon filter ensures that all drug residues are removed from the urine. The liquid fertilizer with high nutrient content is vaporized, thus producing a high-quality fertiliser. "Aurin" has since 2018 also been approved by the Swiss Federal Office for Agriculture for the fertilization of edible plants. Another method may be a simpler one, that can be used to reduce the volume substantially while up concentrating the nutrient compounds in human urine is a freezing and thawing method (Zsofia Ganrot, 2005). With freezing and thawing method 80 % of the nutrients can be captured in 25% of the volume reducing the initial volume by up to 75% (Lind et al. 2000).

c) Struvite precipitation from Urine

Struvite ($MgNH_4PO_46H_2O$) precipitation where significant P and some N as (NH4) has been recovered is pursued by several authors (Udert et al. 2003, Ban and Dave 2004, Kemacheevakul et al. 2011). The process requires addition of a Mg source often MgO or $MgCl_2$ which elevates the pH and reduces the solubility of PO_4, that induces supersaturation and spontaneous precipitation (Simesh and Ganeapillai 2017). Struvite precipitation from urine was also tried by NMBU Richter (2018) using $MgCl_2$ and seawater as magnesium sources. Seawater is cheaper and available in all coastal areas. Richter found more precipitate produced using seawater than $MgCl_2$ (Fig. 10).

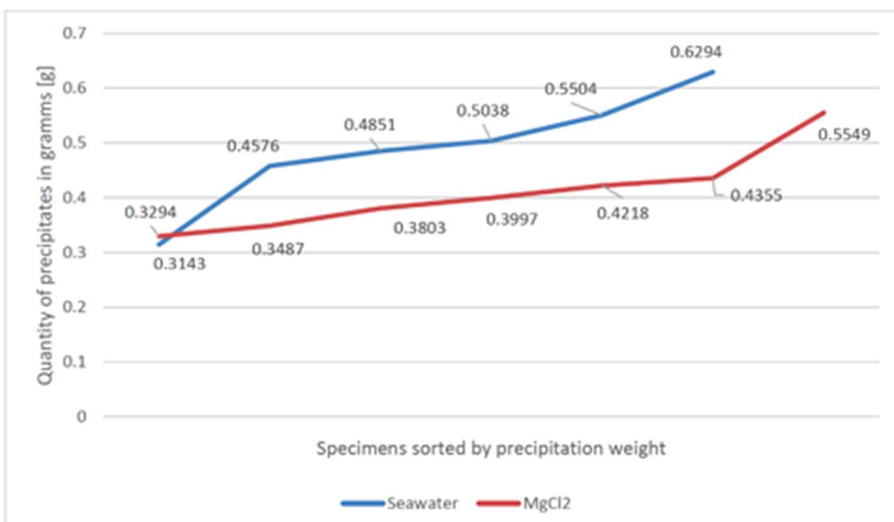

Figure 10. Struvite precipitation from urine by repeated trials using seawater and MgCl2. On the average seawater gave 0.49g of precipitate whereas MgCl2 gave 0.41g (Richter 2018).

d) Other technologies for urine treatment/recovery

A wide range of technologies for the treatment of source-separated human urine are tried in addition to the technologies mentioned above. Concentration by freezing and adsorption to zeolite and active carbon was tried by Ganrot et al. 2007. Bio-electrochemical technologies are environmentally friendly and recover energy along with the nutrients and forward osmosis is the considered the best available technology for water recovery and for concentrating the nutrients in urine, without or with minimal consumption of energy (Patel et al. 2020). Experimental work on this technology is at its primary stage. A single technology is still not sufficient to recover all nutrients, water and energy therefore, (Patel et al. 2020) suggests that integration of two or more technologies seems essential.

An obstacle using urine for fertilization are negative attitudes towards urine. For many urine is unclean and may contain pharmaceutical residues. Therefore, work must be done to improve the products with respect quality and user acceptance. This work will require quality assurance of the products regarding health effects, elimination of smell as well attitude changes.

Blackwater Treatment and Resource Recovery

a) Urea treatment of blackwater

A simple treatment for hygienization of blackwater is by adding urea ($CO(NH_2)_2$) to the collected blackwater and then leave the blackwater for storage (Vinnerås 2007). In initial laboratory trials Vinnerås added 3% urea and achieved a pH of 9 within 1 hour (Vinnerås op. cit.). Full scale trials of urea hygienization performed by the municipality of Uddevalla in Sweden in 2009. They use abandoned manure storage tanks at farms that have terminated animal production. The manure tanks are cheap to upgrade and provide an extra income to the farmers involved. After hygienization that takes two months of storage the treated blackwater can be used as fertilizer in nearby farms. The goal is to collect all blackwater from the 6500 homes not connected to the municipal sewer. Due to speculations around transfer of pharmaceuticals to farm crops the system popularity has declined lately. Investigations of the content of pharmaceutical residues are therefore underway.

b) Aerobic treatment of blackwater and organic waste

In Norway an aerobic system treating blackwater and organic household waste was developed more than two decades ago (Skjelhaugen, 1999). The system was based collecting blackwater and organic household waste from the surrounding community and converting this to a hygienic fertilizer by liquid composting. Figure 11 depicts the main features of the farmer operated bioreactor. The organic household waste is grinded prior to mixing with the blackwater. The wastes are stabilized in the reactor at temperatures between 55 and 60 ℃ with a hydraulic retention time of 7 days. Since considerable amounts of heat are generated by the aerobic bacteria no additional heat input is required to achieve thermophilic temperatures. The system is running with a net energy surplus considering the electricity used for operation and the output in form of heat. The heat can be used to warm up the incoming liquid or nearby buildings. Compared to the average cost for centralized sewage treatment in Norway in 1996 the source separated system with liquid composting and separate greywater treatment gave a theoretical saving to the householder of 1729 NOK (EURO 216) per year.

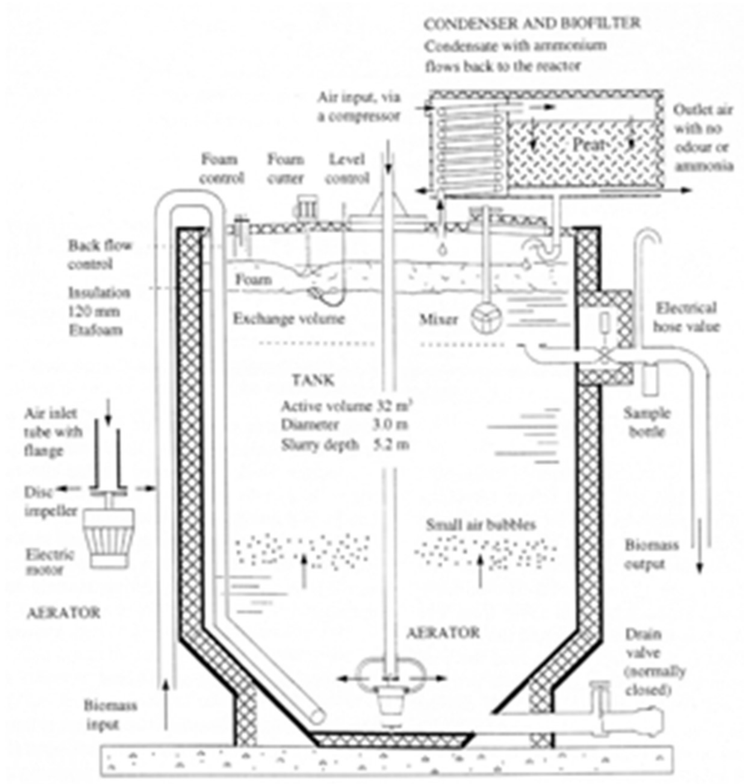

Figure 11. Thermophilic aerobic reactor for processing liquid organic waste, or a mixture of liquid and solid waste (Skjelhaugen, 1999).

c) Anaerobic Treatment of Blackwater and Organic Household Waste

In the SiEUGreen project, anaerobic technology is applied to treat and recover resource (energy (biogas), nutrient, and water) from blackwater (BW)and organic household waste (OHW). The BW collected from vacuum or other low flush toilets and OHW mainly food waste from kitchen is transported via vacuum to the biogas production unit (biogas reactor) called anaerobic digestion (AD) reactor. The anaerobic technology is a mature technology that involves different groups of microorganisms to decompose and convert organic matter into biogas (Rittmann and McCarty 2001). Anaerobic digestion process, governed by different groups of microorganisms, is a multi-step process consisting of four main stages in series: hydrolysis, acidogenesis, acetogenesis and methanogenesis (Batstone et al. 2002, De Mes et al. 2003). The digestates (both the liquid and solid) are further treated to produce sanitized by-products (Figure 12). CO_2, heat and power from biogas combustion can be utilized together with the nutrient rich retentate in a super-insulated greenhouse for local resource reuse and year around plant production.

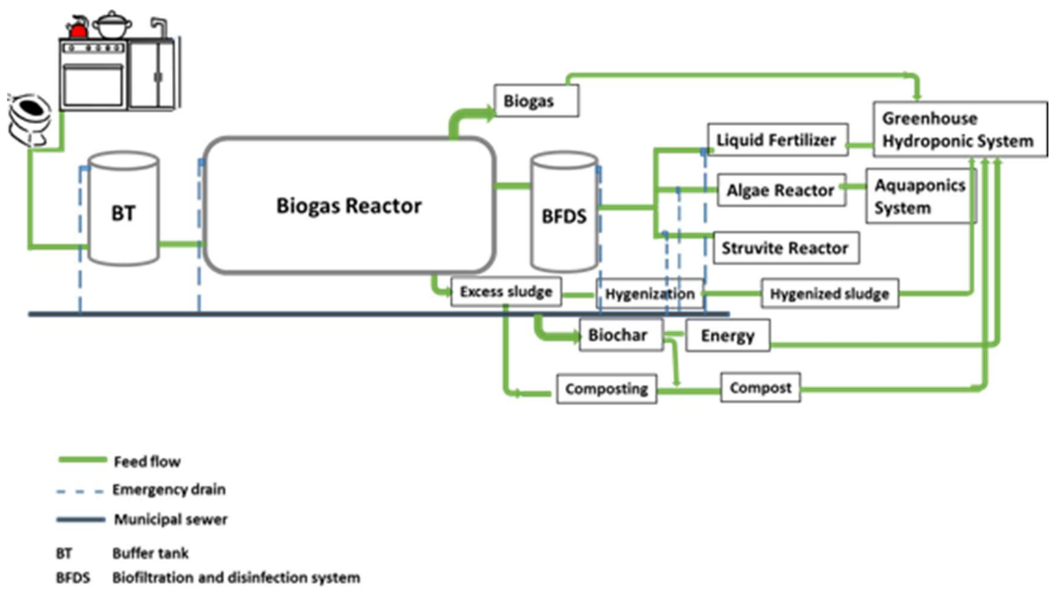

Figure 12. SiEUGreen schematic plan of blackwater and organic household waste collection, treatment and possible by-products.

The anaerobic treatment of the concentrated blackwater stream can yield net energy and the digestate be a source of nutrients for agriculture (Zeeman et al. 2008). The organic matter (CODt) content of blackwater from vacuum toilet may vary depending on different factors with an average of 5532 mg L^{-1} (Melesse, et al 2019), 8900-11400 mg L^{-1} (Todt 2015), 9500-19000 mg L^{-1} (de Graaff et al. 2010a, Zeeman et al. 2008) and 29520 mg L^{-1} (Gao et al. 2019). The theoretical potential energy from COD corresponds to energy densities of up to 103 kWh/m^3. If we consider an overall conversion to electricity efficiency of 25% (i.e. assuming 70% methane conversion rate and 35% CHP electricity conversion efficiency, and a conversion factor of 0.35 m^3 CH_4/kg COD, 35.9 MJ/m^3 CH_4 and 0.278 KWh/MJ), the energy value of source-separated blackwater could reach up to 25.6 kWh/m^3 for the highest COD value (Melesse E. 2019). This value is several times higher than the energy requirement at municipal wastewater treatment plant (MWWTP), which is in the range of 0.3-0.5 kWh/m^3 (Mizuta and Shimada 2010). The biogas production can be maximized by adding the organic household waste (mainly food waste) into the anaerobic reactor. Appropriate ratio of BW to OHW is required to achieve efficient biogas production.

d) Handling of anaerobic digestate

Although rich in plant nutrients, the major concern in the treatment and direct reuse of anaerobically digested blackwater is the associated health risk from pathogens. The designed system described in this SiEUGreen project promotes complete closed loop flows of resources and nutrients within the area close to the source of origin with novel post-treatment step of the digestate and establish mechanisms to contribute to a circular economy. With this system more than 75% of the NH_4–N and more than 85% of the PO_4–P released from the anaerobic effluent can be recovered as liquid fertilizer (Melesse, 2019). Similarly, a substantial amount of soluble K can also be recovered in the liquid phase.

The effluent from the anaerobic reactor will be filtered before it is split into 3 lines producing liquid and solid (struvite) fertilizer and algae (Figure 12). The liquid fertilizer will be used in hydroponic cultures in the greenhouse. The treated effluent can also be used to produce a slow-release fertilizer (struvite) and can be used in balcony gardens and the garden plots planned outside the apartment building. The microalgae as green biomass can be used as biofertilizer, animal/aquatic feed and if produced at large scale and in significant amount it can be used as a feedstock for biodiesel. The SiEUGreen project demonstrate the potential production system. Recovery of these valuable nutrients as liquid or solid fertilizer, therefore, adds value to the circular economy and at the same time reduces their impact on environmental pollution.

e) Hygienization and removal of organic micropollutants

Anaerobic treatment systems are not designed to remove pathogens to a level that meet the required regulations (Chernicharo 2006). Moreover, they are not effective to degrade and remove pharmaceutical residues. In fact, for some compounds an increase in concentration is observed after anaerobic treatment (Table 2). This is mainly because most of the pharmaceutical compounds bind with proteins in our body during metabolism or form metabolites. The concentrations of the parent compounds in urine or feaces are therefore low. During the anaerobic digestion process, particularly due to hydrolysis and fermentation, these compounds could be deconjugated and appear in the digestate as their parent form. Disinfection mechanisms need to be integrated for the effluent from the anaerobic reactor to comply with local regulations for reuse or discharge and control of the health risk from pathogens. Integration of UV into the filtration system resulted in the removal of indicator bacteria (*E.coli*) to levels below the detection limit (Melesse, 2019). The treatment chain as integrated technological approaches ensured synchronized nutrient recovery as a nutrient solution, pathogen inactivation, and reduction of active organic substances. The combined effect of the AD, activated granular carbon filtration, and UV treatment removed micropollutants and pharmaceutical residues as shown in Table 2.

Table 2. Removal of Pharmaceutical residues through Anaerobic digestion and Post-filtration system (Gard Østbø & Petter L Grimstad, 2019).

	Raw Blackwater	AD effeffluent	After post filtration	Tap water
Pharmaceutical residues	ng/l	ng/l	ng/l	ng/l
2-Hydroxy atorvastatin (active metabolite of Atorvastatin	16.4	621	5.7	4.3
Acetaminophen (Paracetamole)	220445	13058.5	9.6	0
Amitriptylene (antidepressant)	21.5	19	0.3	0.1
Atorvastatin (for prevention of cardiovascular diseases, lipid-lowering, anti-Cholestrol)	37	467	17.9	29
Caffein	267974	68848	0.5	0
DEET (N,N-Diethyl-m-toluamide or N,N-Diethyl-3-methylbenzamide)	257.5	212	2	0.1
Losartan (Antihypertensive)	1202.6	238.5	4	0.6
Metoprolol (antihypertensive, conjestive heart failure, prevention of migraine headaches)	0	185.6	43	118.7
N-Acetylsulfamethoxazole (antibiotic)	55.9	9.7	7.3	0.77
Trimetoprim (antibiotic)	114.6	82.8	0	0

f) Struvite precipitation from effluent of anaerobically digested blackwater

The environmental limits within which humanity can safely operate is influenced by anthropogenic activities mainly related to P and N flows. P and N in the Planetary Boundary (PB) have shown to be beyond the zone of uncertainty (high risk) causing eutrophication (Steffen et al., 2015). To limit the environmental impact of both N and P, removal of both N and P has become a requirement in many countries' waste treatment systems (Le Corre et al., 2009). On the other hand, the depletion of P resources and the growing demand of P fertilizer to support global food production has triggered the search for alternative renewable P sources (Cordell et al., 2009). Human excreta and animal manure are pointed to as two main renewable sources of P. Phosphorus conservation in urban systems for urban agriculture is, therefore, an important step in the realization of food security through circular resource flow. Precipitation of phosphorus using Fe- of Al-salts is the dominating process for P-removal from wastewater. However, Fe- and especially Al- bound P has low plant availability due to low solubility at normal soil pH (Krogstad et al. 2005).

The precipitation of struvite, a white crystalline substance precipitated mainly as magnesium-ammonium-phosphate MAP ($MgNH_4PO_4 \cdot 6H_2O$) and its analogue K-struvite ($MgKPO_4 \cdot 6H_2O$), from waste streams is widely recognized as a promising strategy for nutrient recovery owing to their elemental compositions and fertilizing properties (Shih and Yan, 2016). However, precipitation of Struvite requires concentrated waste streams as found in liquid from sludge dewatering, blackwater, urine or animal waste. Hence, struvite cannot be easily precipitated from normal strength municipal wastewater. Struvite precipitation occurs in alkaline conditions when the concentration of Mg++, NH_4+ and PO_4^{-3} exceed the solubility products according to the following reaction (Bonmatí-Blasi et al., 2017).

$Mg^{++} + NH_4^{+} + H_2PO_4^{-3}$ ===> $MgNH_4PO_4 \cdot 6H_2O + 2H+$ (eq. 1)

This process is influenced by a combination of physical and chemical parameters, mainly by pH, Mg:N:P molar ratio, reaction time, mixing speed, temperature and ion strength of competitive cations (mainly Ca and Na) that can form other salts with phosphate such as hydroxyapatite ($Ca_5(PO_4)3OH$). Precipitation of Struvite requires a pH adjustment usually close to 9 and ideally a stochiometric ratio of Mg:N:P of 1:1:1. The ratio of Mg:N:P in wastewater varies significantly. Urine and blackwater have higher N compared to P and Mg content. Therefore, to remove the high amount of nitrogen, addition of sufficient amount of both Mg and P is required. Moreover, the pH has to be raised close to 9. Struvite is relatively easy to precipitate in a batch process, but in the last decade several continuous processes are also developed (Ronteltap et al., 2010). The continuous processes are technically more sophisticated and, hence, suited for larger systems. For small volume flows as the case in most decentralized and source-separated sanitation systems, a batch process is considered the most cost-effective solution. The most important control parameters for the struvite precipitation process is the pH, temperature, and source and dose of Mg.

A lab scale preliminary results from urine and blackwater digestate in this project using magnesium chloride ($MgCl_2$), sea water and Mg-Plate as source of Mg showed up to 98% removal of P. Preliminary results of experiments on urine and anaerobically treated blackwater for struvite precipitation using seawater and Mg- plates (with and without current) demonstrated promising options as alternative sources for Mg. The P recovery results with seawater and Mg plates were higher compared to MgCl2. About 91 % P (with 1.3:1 seawater:urine volume ratio) and 94 % of P (with 4:1 seawater:urine volume ratio) were recovered as struvite from urine using seawater compared to 85 % P recovery using $MgCl_2$. Concentrations of total C and total N in the precipitates were 1.8 % and 1%, respectively. On the other hand, the experiment on anaerobically treated blackwater using Mg-plate with electric current as source of Mg removed 93 % and 98 % of P at pH 7.4 and pH 9, respectively.

Moreover, the analysis on the concentrations of Ca2+, Mg2+ and P in the precipitates indicated that seawater treated struvite had higher Ca than on MgCl2 treated struvite precipitates. This is mainly due to the high Ca concentration in seawater. The Mg and P concentrations in the precipitates were comparable. Similar results on Mg and P concentrations observed on Mg-plate treated precipitate of the anaerobically treated blackwater. The total N concentration in the Mg-plate treated struvite precipitate ranged from 4.1 to 7.6 % while the total C concentration remained low (from 0.8 to 1.2 %). However, in all the scenarios outlined above, it is important to emphasize the need for further research involving analysis of the actual Mg:P ratios of the different sources used instead of their volume ratios. In addition, more data sets are required to reach with sound conclusions, in terms of both ease of operation and management, economics, and struvite quality (presence of impurities). Mg-Plate experiment showed efficient and better results as compared to the two Mg sources. Moreover, Mg-Plate do not require NaOH to adjust pH and required less time of reaction.

g) Production of microalgae from biogas digestate and urine as biofertilizer or feed for aquatic systems

The integration of source-separated sanitation, anaerobic digestion of blackwater, and microalgae biomass production may deliver a win-win-win solution for domestic wastewater treatment challenges. It addresses issues of water and wastewater management, energy and nutrient recovery, avoids contamination of water bodies and emissions of odours and greenhouse gases. Microalgae biomass produced from anaerobically treated blackwater effluent or treated algae can be used as a raw material for numerous purposes such as for biofertilizer, animal/fish feed or biodiesel depending on the algal biomass quality and quantity.

12. Dry Toilets - Treatment Options and Recycling of Resources

Dry composting toilet is a type of dry toilets that collect human excreta without the use of water and treat the waste in-situ by a biological process. Composting toilets are traditionally used in rural environments, both in developing and industrialized countries. In developing countries, they often serve as the basic toilet facility for year-round residential homes, and, to a lesser extent, as a public facility. In industrialized countries, they are typically associated with seasonal vacation homes. In the former case, compost toilets tend to be home-built or prefabricated assemblages from local material; in the latter case, they are generally manufactured units, which may (or may not) be required to meet regulatory standards.

Although composting toilets are generally not suited in urban settings, they can be used as a stand-alone toilets in cities. Such dry composting toilets can be equipped with urine diversion and exchangeable or rotating compartments. Faeces, in a sealed chamber beneath the toilet pedestal, are decomposed by microorganisms to compost and used as a green disposal system. About three-quarters of the material is converted to carbon dioxide and water vapour. Due to a low content of readily degradable carbon in excreta and an unfavourable C/N ratio makes the composting process slow. This may, therefore, require addition of a bulking material with readily available C-material and an increased temperature.

In some cases, organic household waste is added to facilitate. However, good composting needs mixing of the material. Some toilets therefore may need to be equipped with manual or electrically driven mixing devices. In a solar assisted system, the process is enhanced by utilizing the sun to provide heat for the composting/desiccation/hygienization processes. Small PV panels can be used to power fans that enhance airflow that can help reduce smell as well as evaporation of excess liquid. Modern dry composting toilets also do not smell (inside and outside) as they are equipped with super-quiet fan and easy to clean materials. Moreover, biodegradable plastics are now on the market and can be used to rap-up the content and empty when necessary.

13. Greywater Collection, Treatment and Recycling

Greywater (GW) is the water collected separately from sewage flow that originates from clothes washers, bathtubs, showers, kitchen, dishwashers and sinks, but does not include wastewater from the toilets. Typically, from a household, greywater (GW) flow is around 65-80% of the total wastewater flow. Further light greywater is more than 80 % of the total GW. Among the many alternative water sources, treated greywater is more available and has great potential for potable water savings. Greywater has a high potential for recycle and local reuse including groundwater recharge, landscaping, and plant growth and, consequently, reduction of domestic wastewater generation from residential areas. Hence, recognizing greywater as a relevant alternative source of water represents an important approach for the sustainable management of water resource.

14. Greywater treatment

a) Nature based greywater treatment systems (infiltration, wetlands, biofilters)

Greywater treatment and reuse can play a fundamental role by converting a significant fraction of the domestic wastewater from a waste to a valuable water resource. Nature based solutions (NBS) for greywater treatment are techniques that mimic the natural processes in urban landscapes to manage, treat and reuse the wastewater with low or no inputs of energy and chemicals. Different NBS have been proposed in the SiEUGreen project including constructed wetlands (CWs), green roofs, green walls/living walls, and compacted biofilter treatment systems.

Greywater treatment by using single-pass biofiltration in porous media and intermittent loading are well known and widespread technology for small wastewater flows for houses and cabins in the Nordic countries. Constructed wetlands, also called filter beds are engineered systems using vegetation, soil, and organisms to treat wastewater (Kadlec and Wallace 2009). Constructed wetlands can remove a range of pollutants (such as organic matter, nutrients, pathogens, heavy metals) from the greywater. The planted vegetation plays an important role in contaminant removal. The filter bed, consisting usually of sand, gravel, fabricated media such as light-weight aggregates has an equally important role to play.

Subsurface flow constructed wetlands (CWs) with pre-treatment biofilters for Nordic climate conditions have been pioneered in Norway (Jenssen et al., 1993). These CWs show excellent performance and produce an effluent quality that is independent of season (Jenssen et al., 2005). The biofilter reduce the organic load and contribute to nitrification. The biofilter can be integrated on top of the wetland filter or as part of landscape beautification in the urban settings (Figure 13). The whole system can be integrated as part of the landscape and the area requirement can be minimized. The experience with greywater treatment in biofilter/filterbed is good, with high and stable removal of organic matter and suspended solids. Phosphorus removal can also be good if special filter media with high P-binding capacity is used.

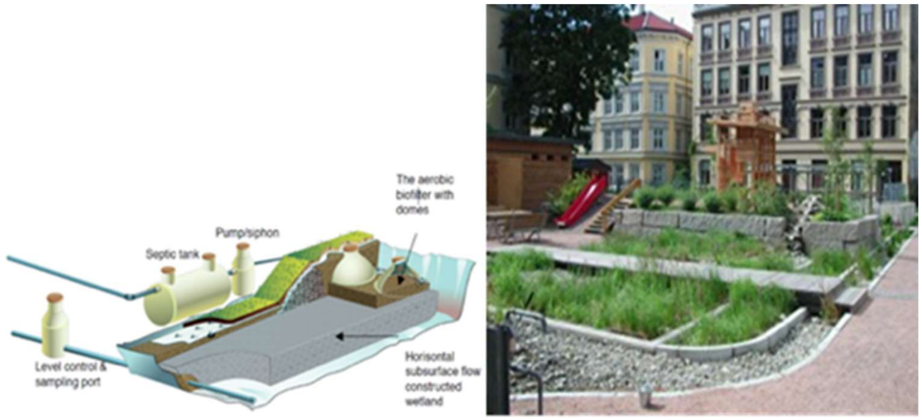

Figure 13. Filterbed system with integrated aerobic biofilter for greywater treatment (Jenssen and Vråle, 2003) and a biofilter combined with constructed wetlands for greywater treatment in Oslo.

b) Compact/Package greywater treatment systems

In the last few years, different compacted greywater treatment systems have been tested at NMBU as part of sustainable solutions for houses not connected to the sewer system (Heistad, et al. 2006, Moges, et al. 2015, Moges, et al. 2017). These systems achieved >90% removal efficiencies for all the parameters determined. The effluent from post-treatment with infiltration trench setup fulfills the new EC 2018 CLASS A water quality requirement (Melesse E., 2019). Recently, a compact biological aerated filters (BAF) system (Rummelhoff, 2019) have been tested as part of the SiEUGreen project and showed promising results as a low-cost technology offering small footprint and low energy consumption. These systems can be adapted to cities at block level or cluster of houses.

15. Greywater as a source of drinking water

Norway

One of the goals of SiEUGreen project is to demonstrate and realize about 90% reduction in total water consumption through improved water use efficiency and on-site treatment, recycling and local reuse of the light greywater stream of the domestic wastewater. Although use of the greywater as source of drinking water is not yet practised, technologies are now available to produce drinking water quality water from greywater. In this SiEUGreen project, processing of effluent from the constructed wetland/Filter-bed to drinking water quality was tried in laboratory scale at NMBU. Preliminary result from the treatment of a source-separated greywater effluent from a constructed wetland (as pre-treatment step) with sequential activated carbon and nanofiltration (0.28 µm) as post treatment showed the potential of achieving a drinking water quality standard. The *E. coli*, as indicator bacteria, concentration reduced from 1.56 X 10^3 MPN/100 mL to <1 (not detected) and turbidity from 27 NTU to < 1 NTU. This effluent is of a better quality than many raw water sources, especially on a global scale. If this is followed by a reverse osmosis (RO) and ultraviolet (UV)) disinfection treatment, pure and safe drinking water can be provided. By returning the treated greywater to the household non-potable use (e.g. for laundry, toilet flush) the water footprint can be reduced by up to 90%.

Changsha

In the Changsha showcase 17 houses are connected to the greywater treatment facilities located in the underground parking lot of building C2. The process train are as follows:

1. First, the wastewater from kitchen needs to be treated in an oil separation tank.
2. Then, the wastewater from washing machines, shower/bathing water and the oil separated kitchen water is mixed evenly through the regulation tank.
3. Considering that the greywater contains a large number of surfactants and organic pollutants (it is important to ensure the effluent quality is meeting the discharge standard) the greywater treatment process adopted in this project is: Regulation tank + Flotation tank + Integrated biological processing equipment + UV + Reverse osmosis.
4. After the UV processing, the discharged water quality shall meet the class A standard of "Cities Sewage treatment plant Pollutant discharge Standard" (GB18918-2002), and the final recycled water quality shall meet the standard for drinking water.

The specific technological process is shown in the figure 14.

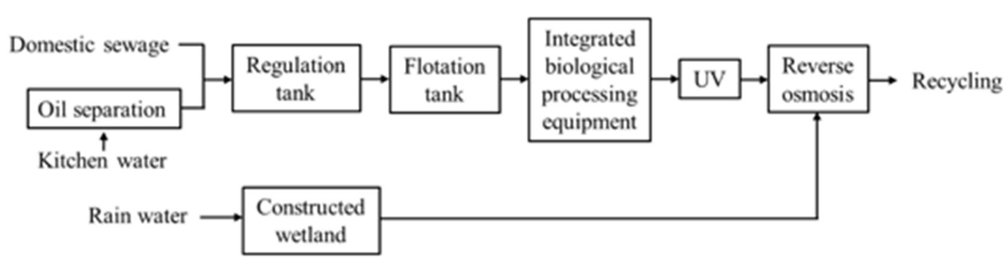

Figure 14. Greywater and rainwater treatment process in Changsha

16. Conclusion

The different Blue and Yellow technological options and the results from some of the experiments demonstrated the potential of achieving a zero-waste system at household and community levels. The value of domestic wastewater and organic household waste as a source of alternative local nutrient-energy-water resources is huge. Sanitized liquid fertilizers, struvite, algae biomass (as biofertilizer), biochar and clean water are produced from source-separated urine and blackwater stream of the domestic wastewater. These fertilizer products can be safely used in a local food production. Moreover, it was demonstrated that source separated greywater can be treated to drinking water quality level. Although the use of greywater as a source of drinking water is not yet practiced, returning the treated greywater to the household non-potable use (e.g. for laundry, toilet flush) can reduce the total water consumption by up to 90%.

Annex: SiEUGreen Technological Options

Component	Product	Technological processes and components	Tested in SiEUGreen	Partner + China	Results from testing	Recommendations
	Urine diverting toilets and urinals	New types of low flush and less maintenance	N		Eg toilet by Laufen Save and urinals by Uridan	Read for use
	Dry composting	Can be combined with solar power for ventilation and heating	Y			Ready for use
	Extremely low flush	Vacuum	Y	NMBU	Can be combined with biogas production	Ready for use
		Other?				
Yellow water						
Untreated urine	Liquid fertilizer	Small scale direct use of diluted fresh urine	N		Liquid fertilizer	Needs dilution (10% urine). Recycling within the same households/small scale
Treated urine	Liquid fertilizer	Bioreactor for nitrification with biofiltration or MBBR	Y	NIBIO	High nitrification rates up to 75% urine, no smell, but sensitive processes	Promising but needs more testing. Dilution and nitrification after storage is an alternative
		Commercial product AURIN Oxidation, hygenisation	Y	IGZ	Tested as liquid plant fertilizer with good effect	Ready for use

		Stored urine (min 6 months)	N		Tested as liquid plant fertilizer with good effect. Smell from NH3.Negative attitudes to urine as fertilizer	Ready for use, but attitudes that users have should be clarified before use
	Algae and biodiesel	Bioprocessing in reactor	Y/N	NMBU	Tested as liquid organic plant fertilizer with good effect	Needs further development
	Solid fertilizer	Precipitation of struvite in reactor	Y	NMBU	Good effect with Mg in seawater and MgCl2 and electroflocculation In lab	Needs further development
		Dried urine and mixed with ash for alkaline storage of urea	N	SLU	High value of stored N in solid fertilizer.	
Brown water						
Faeces and food waste	Solid fertilizer/ soil	Traditional dry composting containers with food waste and bulk material for improved C/N ratio	N		Good compost product if right mix of substrate and bulk material. Systems need regular maintenance	Solutions primarily suitable for small-scale use. Need two years storage of compost.
Blackwater						
Faces, urine and food waste	Fertilizer/soil	Aerobic liquid composting				
	Fertilizer/soil	Treatment digestate by oxidation, dewatering, composting, algae….	Y	NMBU/ NIBIO		
	Bioenergy from biogas production	Reactor type 1: Antec Biofilm (AB) system	Y	NIBIO	Plug flow reactor with biofilm technology. Additional food waste is needed to achieve a net positive energy output	the consistency of black water and ground food waste is probably not well suited for this reactor
		Reactor type 2: Upflow Anaerobic Sludge Bed (UASB)	N		Extensive experience for blackwater and organic household waste in the Netherlands	Small footprint but the high tower feature may be a critical issue when the reactor is to be installed indoors
		Reactor type 3: Upflow Sludge Blanket Anaerobic Baffled Reactor	Y	NMBU	The performance is comparable with the standard UASB	Needs further testing in a upscaled version

		(USBABR)			but the USBABR has a much smaller footprint	
		Reactor type 4: Anaerobic Membrane Bioreactor (AnMBR)	N		Good disinfection capacity, but low membrane flux, membrane fouling, and high capital and operational costs.	
Greywater						
	Clean water for parks and recipients	Natural systems as infiltration, wetlands, biofilters and green walls	Y	NMBU/ NIBIO	Multifunctional systems with many possibilities for local adaptions and	Ready for use
		Compact/Package treatment systems	Y	NMBU		Ready for use
	Drinking water/ irrigation of UA	Membrane systems	Y	NMBU	High water quality achieved with low footprint	Ready for upscaling and further testing
Rainwater						
Rainwater harvesting	Water for irrigation of UA	Collection, storage and treatment	N		Systems for collection are available. Water quality can be polluted and need treatment	Ready for use
Stormwater treatment	Water for irrigation and esthetical use	Natural systems (infiltration, wetlands, biofilters, green roofs, rain beds)	Y	NMBU/ NIBIO	Water quality can be polluted and need treatment before use in irritation of UA	Ready for use
Food waste						
Organic waste from the kitchen, garden	Soil/compost	Traditional warm composting in an insulated container	Y	NIBIO	The process needs bulk material and maintenance (mixing) to avoid smell and insects	Ready for use. For better mixing we recommend a rotating container
	Soil and liquid fertilizer	Bokashi and compositing	Y	NIBIO/ NMBU	Suitable pre-treatment in the kitchen (avoids odors and flies) before composting	Ready for use
	Soil	Vermicomposting	Y	NIBIO	Needs special containers and maintenance. Not all kitchen wastes are suitable for worms.	Ready for use

	Worms and insects for fish feed	Growing insects in combination with aquaponic culture	Y	NIBIO	Effective reuse of proteins in food waste. Needs biological competence and equipment	Present restrictions from food authorities may limit commercial use

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Paper V: Strategies to engage communities into urban agriculture: examples from Aarhus Municipality

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Luciane Aguiar Borges & Sandra Oliveira e Costa

Abstract. This paper describes and briefly analyses the strategies employed by Taste Aarhus program to engage different groups of stakeholders in urban agriculture. The paper is used to develop and test two models to explain the character of engagement and the governance structure of a selection of urban agriculture (UA) initiatives in Aarhus municipality. The first model is used to describe the type of engagement that Taste Aarhus applies in the UA-cases. The second model is used to describe the way the initiatives are organised from a governance perspective, looking into the relations between the main actors involved. Using previously published reports in SiEUGreen, the paper also shows the geographic spread of top-down and bottom-up initiatives. Based on the analysis, it is suggested that Taste Aarhus' strategy to engage stakeholders in UA is manifold and supports a variation of governance structures and engagement characters. This palette of strategies generates different impacts of UA for the city residents, the local communities and the city as a whole. The paper suggests more research to be done on the linkages between governance arrangement, engagement character, and social and economic impact of UA in the social fabric and in the city.

Keywords. Urban agriculture, social engagement, Aarhus, governance, management.

1. Introduction

Many studies regard urban agriculture (UA) as a tool to achieve urban sustainability goals (Menconi et al., 2020; Zasada et al., 2020). Some of them outline the potential of urban agriculture for the revitalisation of urban spaces (Mousa et al., 2020); creation of green jobs and innovation (Batitucci et al., 2019), waste reduction (Hallett et al., 2016; Nicholls et al., 2020), community education and development (Corcoran and Kettle, 2015; Davidson, 2017). A central precondition to achieve these objectives is to engage people in the practice of UA. As simple it may seem, it can be complex and challenging as people may lack time, resources like land to grow food, financial mean, or interest. In addition, urban agriculture is mainly based on volunteer work which means inconsistencies in practice. Strategies to involve people in UA should aim to overcome these obstacles and need to be adapted to each context.

For more than five years Aarhus Municipality in Denmark supports UA through the 'Taste Aarhus' program. Taste Aarhus uses different strategies to engage people with eatable resources found in the city, as well as with urban gardening. Aarhus municipality is also one of the showcases in the SiEUGreen project that enhances the EU-China cooperation in promoting urban agriculture for food security, resource efficiency and smart, resilient cities. Building on the model of zero-waste and circular economy, the project demonstrates how technological and societal innovation in urban agriculture can have a positive impact on society and the economy. SiEUGreen applies novel resource-efficient agricultural techniques in five showcases in selected European and Chinese urban and peri-urban areas.

The main contribution of Aarhus Showcase to the SiEUGreen project relies on the successful strategies Program Taste Aarhus employs to involve people in urban agriculture. Some of these strategies could be replicated in other SiEUGreen showcases.

Giving this background, this study describes and analyses the strategies employed by Taste Aarhus to engage people in UA. It borrows concepts from theories of landscape management and governance (Fongar et al., 2019; Jansson and Lindgren, 2012; Randrup and Persson, 2009a) to outline a framework that aids to analyse the engagement strategies.

The remaining of this article proceeds as follows: Chapter 2 lays out the theoretical dimensions of the research, formulating an analytical framework that is used to deepen the understanding of the governance, management and engagement in UA. Chapter 3 introduces the Taste Aarhus program, and describes some of the strategies employed by Taste Aarhus to engage people with UA; using the analytical framework developed in Chapter 2. Chapter 4 is used to reflect on the potential benefits and challenges that bottom-up and top-down UA brings for urban development in the city. Chapter 5 outlines final considerations.

Taste Aarhus Program

Aarhus is the second-largest municipality in Denmark and is well-known for its bottom-up initiatives involving urban agriculture. Taste Aarhus[11] program has been a key driver of the implementation of more than 200 UA initiatives around the city. The program is managed by Aarhus Municipality in part through self-funding (€1 million), and between the years 2015-2018 in part by Nordea Bank (€1 million). Currently, the program is fully financed by Aarhus Municipality. The main question the program addresses is '*How can cities create more socially inclusive places and communities when focusing on edible nature and urban farming?*'. Ensuring societal inclusion has been the cornerstone of Taste Aarhus program, as it promotes UA 'for all' – for people with different interests and backgrounds, ambition levels, physical and economic possibilities. UA is used as a tool to strengthen the community spirit and engagement. The Taste Aarhus project plays an important role in promoting knowledge of the food system among the urban population. Alongside the project manager, the project also employs a gardener, a chef and a communications specialist who are responsible for supporting the community to set up and get the most out of their gardens.

The Program adopts a broad definition of health including both physical and mental health. UA can generate benefits for physical health via contributions to bodily activity and access to organic food. UA can generate benefits for mental health via contributions to social interaction and community building among participants, hence counteracting social isolation and loneliness. Both physical and mental health benefits can be achieved by the simple act of spending time outdoors in connection to greenspace and engaging with nature.

The Program supports several UA-activities in the city today, either initiated by Taste Aarhus or by local residents. Any person in the city is eligible to start up a garden. Only two requirements are necessary: i) the institution of a democratic structure consisting of a chairperson, treasurer and three other decision-makers, and ii) organising two events per year that are open to the public. The latter is a means of giving back to the community for the privilege of using public land.

[11] http://smagpaaaarhus.dk/

A selection of UA-initiatives are described in this paper, using two theoretical models to illustrate the type of engagement and governance that characterizes the initiatives.

2. Community engagement and governance

This section defines community engagement and explores some aspects of the governance of open spaces.

Community engagement

Engagement means to "provoke new and prolonged interest and participation", interacting with people, events or expectations (Carpenter, 2019: 165). Effective strategies of engagement can ultimately strengthen the sense of community (Nilsson, 2006), increase the level of commitment and the ability of the community to solve problems, and access resources (Slätmo et al. 2020). Strategies for engagement are, therefore used to boost social agency and contribute to empowerment.

Community engagement is *"the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people. It is a powerful vehicle for bringing about environmental and behavioural changes that will improve the health of the community and its members. It often involves partnerships and coalitions that help mobilise resources and influence systems, changes relationships among partners, and serve as catalysts for changing policies, programs, and practices"* (CDC, 1997: 9).

As the definition above suggests, the formation of partnerships and coalitions is a central element to engage communities and bring about environmental and behaviour change. The frameworks illustrated in **Error! Reference source not found.** suggests that there are different stages in the process of engaging communities.

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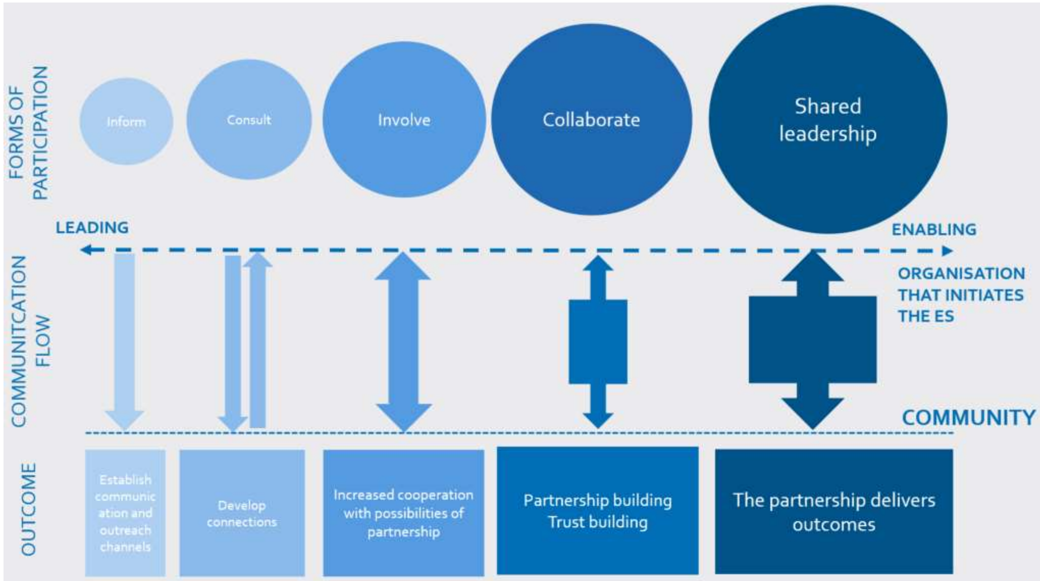

Figure 6: Continuous of engagement. Source: Adapted from CDC, 1997.

The horizontal lines in the centre of **Error! Reference source not found.** describes the communication flow between the public sector responsible for the UA-program. The vertical arrows between these two lines indicates the communication flow between the organisation and the community. When the public sector informs the community the flow of communication is unilateral and the outcome is the establishment of communication and outreach channels, as well as informed citizens. Consulting activities develops connections between the public sector and the community. Still, the communication flows between them are divided. Surveys are a good example of tools for consultation, in which the public sector 'asks' and the community 'replies'. Interactions become more intense when both the public sector and the community share the same means of communication. In Figure 1 this is described as involvement, meaning that increased cooperation with possibilities of partnership emerges. When both the public sector and community collaborate the means of interaction between them is more robust and partnership and trust between both increases. The latter stage of the continuous is 'shared leadership', which means that agency and power are evenly distributed between the public sector and the community, and the partnership delivers services that are of use for the community.

While this framework is simplistic, it places the relationship between the public sector and the community at the centre of the process of any engagement strategy. This matter will be further explored in the following section.

Governance of urban open spaces

Governance concerns the relations between actors, the organisation of decision making and power amongst the parties involved (Jansson et al., 2019). While government depicts traditional hierarchical decision making without the involvement of citizens, the understanding of governance is more inclusive to market-based actors and civil society (Slätmo et al. 2020). In governance, the public actors are flexible to take on different roles while collaborating with non-state actors (Jansson et al., 2019).

Turning to the literature on management of urban open space and greenspace, where UA can be included, we dig deeper into how governance arrangements of these spaces can look like. Jansson et al. (2019) defines urban open space as "vegetation-dominated 'green spaces' (parks, street trees, playgrounds) and hard-paved 'open' spaces (squares, pedestrian streets, piers)" (Jansson et al., 2019: 139). When it comes to the governance of urban open spaces, despite the pivotal role governments play, there has been increased participation of civil society in the co-development of these environments (Ostrom, 2000; Rosol, 2010; Roy, 2011). This shift has been driven by several reasons, among them the shrinking public budgets for the maintenance of the greenspaces, the strengthening and empowerment of civil society through learning and co-production (Ostrom, 2000) and the importance of participation and social inclusion to achieve sustainable solutions (Buijs et al., 2016). Thus, what type of actor is responsible for different responsibilities concerning green space, is flexible.

Jansson and Lindgren (2012) defines three operations that are the basis for the implementation of urban greenspaces: planning and design, management, and maintenance. While this categorisation can be used to understand the division of responsibilities, the interpretation of the categories overlap in the research literature, and the responsibilities are organised differently in different places (see Jansson et al., 2019). With these complexing factors in mind follows a brief explanation of the categories, building on Jansson et al. (2019). Firstly, *planning & design* relates to spatial planning and the creation of new structures and spatial planning of greenspace. Secondly, *management* rather deals with the existing physical structures, and thus concerns the management of the physical space. In addition, management refers to the organising of people and organisations included in the work. While physical planning 'plans space', management 'plans processes'. The responsibility of management can be shared between various public departments and often also outsourced to private actors (Fongar et al., 2019). While maintenance concerns operational matters, Randrup and Persson (2009) argue that park organisations need to be strategic to survive in competition with other departments and should therefore be strategic and future-oriented. Lastly, *maintenance* is a responsibility of the management and regards operational and technical issues concerning the practical upkeep of greenspace (Jansson and Lindgren, 2012). Management can be seen both as one of three parts in this categorisation, but it can also be seen as encompassing the other two parts.

Randrup and Persson, (2009) proposed the Park-Organisation-User model (POU model). The model indicates the relationships between green space, the users of the green space, and the public organisation. In this model, the public organisation is the same thing as the management organisation. In the POU-model, the management organisation takes care of the strategic level (policy), tactical level (planning) and operational level (maintenance), as well as the overall management. The manager organisation takes care of the relations both with the users and with the green space.

Looking at this model, the management organisation carries out management work (including policy work, planning, and operational) of greenspace while the users benefit from using the greenspace. In addition, there can be further interaction between the management organisation and the users via dialogue and participation. Hence, while showing that the manager organisation (can) have an interaction with the users of the green space, it does not show that the responsibility of the management can be shifted to the users, which is an aspect of great importance in UA-governance arrangements. Thus, while helping to understand the governance of UA, it seems the model is in any case more useful to illustrate more traditional governance relations of urban open space. Hence, we need to further adapt the model to inform the governance arrangements in UA.

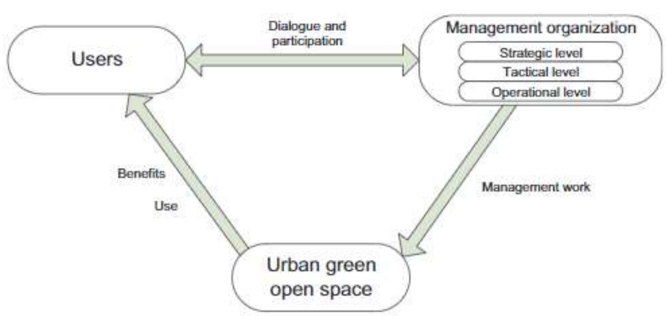

Figure 7. The POU Model. Source: Randrup and Persson (2009).

3. A model for UA governance in Aarhus

A rough categorisation of UA-initiatives can be made based on Lohrberg et al., (2016). Using this categorisation, three types of governance were identified in the gardens in Aarhus:

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(i) *Top-down coordinated within the local government:* corresponds to the initiatives that are solely managed by the Taste Aarhus Program.

(ii) *Top-down coordinated by the local government and other actors (other public actors, civil society organisations):* corresponds to initiatives when Taste Aarhus program partners with other public actors (e.g. school, health services) and/or formalized civil society organisations.

(iii) *Bottom-up with support of the local government:* includes the UA practices that were initiated by citizens with the support of Taste Aarhus program.

This categorisation gives an instant understanding of who is initiating and steering the initiatives in Taste Aarhus. To go deeper into the governance arrangements and show that the variation in governance organisation impacts on the character of the engagement in UA, we have developed the basic understanding from the POU-model into what we call the *UA-governance model*. This model includes four actors and two roles that are crucial in the governance of the different gardens in Aarhus. The UA-governance model suggests that via formal or informal agreements, the UA-practitioners can take such far-reaching responsibility over the planning, design and maintenance of the urban open space that they practically take on the role of 'managers'. Nevertheless, the public sector does not completely 'abandon' its responsibilities and while the users can take on management and maintenance tasks, the task of physical planning still lies within the public sector.

By making 'manager' and 'initiator' generic roles in the model, and thus de-coupling them from the traditional connection to the public sector, the roles are given flexibility and potential to be filled by public bodies, civil society organisations, and private actors as well as civil citizens. The components in the model are seen in table 1.

Table 3. Explanation of actors and roles in the UA-governance model.

Actor	Land owner	Owns the land that will be used for the garden. Can be private or publicly owned.
	Public sector	Has mandate to decide over land use and permissions to use the land. Is in many cases also land owner.
	Users	Can be passive, as vistors, or active, as UA-practitioners, members of a garden actively growing food.
	Civil society	Individuals coming together coming together for collective action. Generally non-profit.
	Initiator	Initiates UA by bringing necessary people and actors together. Takes the necessary steps to establish the garden. This role can

		be taken on by the land owner, the public sector, the civil society or the user. The same actor who takes on the role as the initiator can also take on the role as the manager.
Role	Manager	The manager takes formal responsibility of parts, or all, of the tasks related to planning, design, management and maintenance of the UA and the persons involved. The role of manager is traditionally linked to the public sector and/or the land owner, but can in varying extent be shared or delegated to the users or civil society. Hence, the manager is also a role that can be taken on by different actors, although the final responsibility lies within the public sector.

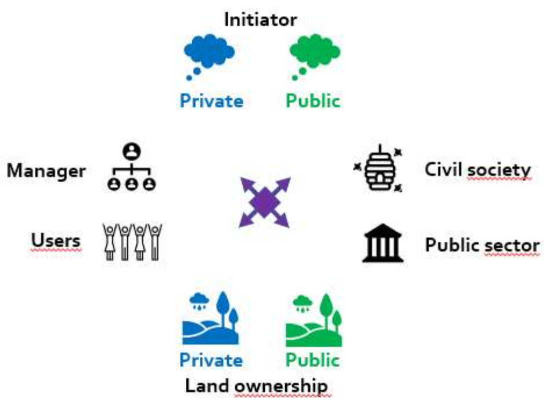


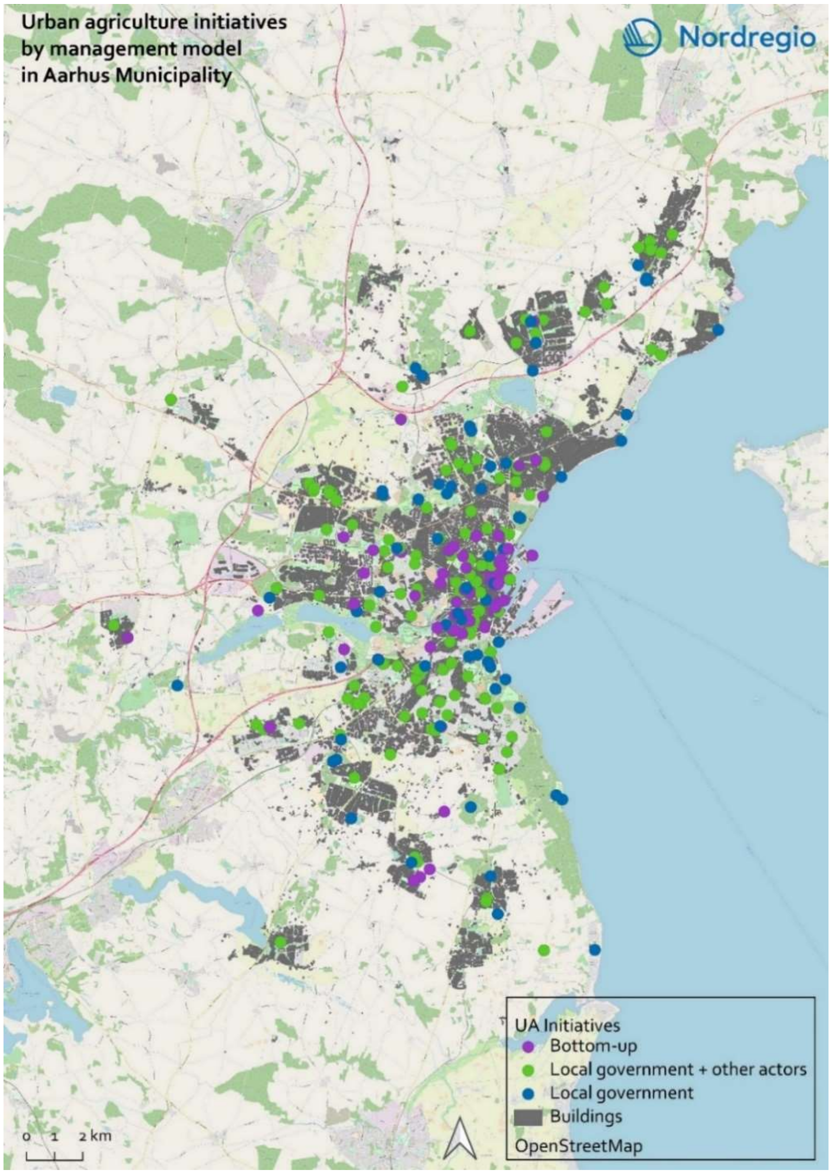
Figure 8: The UA-governance model.

As illustrated in **Error! Reference source not found.**, these actors can interact in a variety of ways to organise governance. While some of the actors could be absent in the governance of some gardens, the public sector and the land owner play a fundamental role and are included in any type of garden. Regardless the land ownership being public or private, the public sector is always the actor that regulates the use of the land and grants permission to use the land for different functions. When the land is public, the public sector could perform multiple roles. The same goes for the private land owner who initiates a UA-project on his or hers own land, manages it and uses it himself or herself.

Differently from the POU model, this model includes civil society as an actor who can initiate and manage a garden, and decouples the sole responsibility of management, maintenance and planning from the public body. By doing this, it offers a more flexible governance structure that goes beyond the traditional models where private or public actors take the lead. In the next chapter, the flexible model is used to illustrate the governance structure in selected UA-initiatives in Aarhus.

4. Analysing engagement strategies in Aarhus

This section analyses five initiatives in Taste Aarhus, using the theoretical framework introduced in the previous two sections.



Map 1: Governance of the Gardens in Aarhus. Source: Nordregio. Map by Shinan Wang.

Error! Reference source not found. illustrates the location of ca 200 gardens in Aarhus and shows their governance types based on the categorisation by Lohrberg et al. (2016). The map reveals that the Program Taste Aarhus has a great impact on the share of UA initiatives in Aarhus. Approximately 25 % of the gardens account for public information on edible resources in the city. The partnership between Taste Aarhus and other local actors (health and educational institutions and civil society organisations) sustain more than half of the gardens in the city.

As **Error! Reference source not found.** shows, the bottom-up initiatives are not as many as others. Most of the bottom-up initiatives are located in intra-urban spaces and as such pinpoint the potential of having UA in central areas of the city.

Text-box 1. The text box shows the great impact of Taste Aarhus on UA in the municipality.

> The public sector has a fundamental role in supporting UA in Aarhus.
>
> Approximately 75 % of the gardens in Aarhus have been initiated by the public sector via Taste Aarhus. 25% of them are managed by Taste Aarhus Program and 50% by another government body (e.g. school, hospital) in collaboration with Taste Aarhus.
>
> Civil society have initiated and managed approximately 25% of the gardens in Aarhus.

Top-down UA initiatives

This section describes top-down UA initiatives in Aarhus. This includes those that are solely managed by the Taste Aarhus Program and also UA initiatives when Taste Aarhus program partners with other public actors (e.g. school, health services).

Coordinated within the local government

One of the cornerstones of Taste Aarhus is rising awareness about eatable resources in the city. To do this, the team working with Taste Aarhus at the municipality is accessible to the public primarily through the '***Green Embassy***', a temporary structure located at the main square of the city (Image 1). In the Green Embassy people find information about the location of the edible sources in the city and are invited to taste food and drinks made with these resources. They can also get 'drop-in' advice on gardening and information about events run by gardening groups. As such, the Green Embassy is an important space for informing the residents in Aarhus about the efforts made by the municipality.

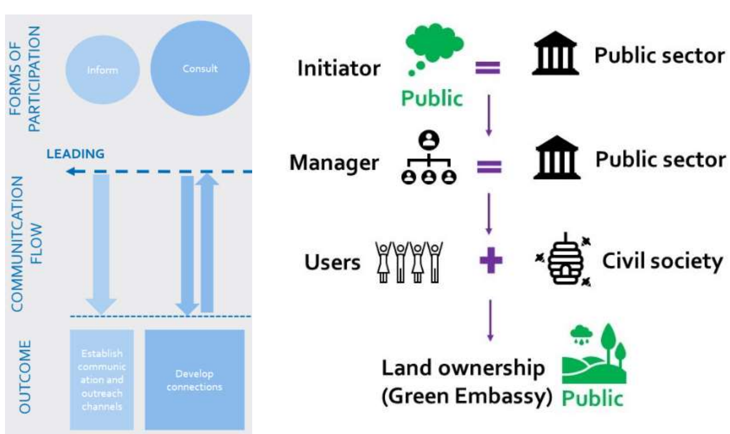


Figure 4: Character of engagement and governance structure of the Green Embassy.

As can be seen **Error! Reference source not found.**, the Green Embassy applies the first step two steps in engaging the public. Using a physical structure at a central public space for reaching out with information gives other possibilities than e.g. the municipality's website. It is, more engaging than, e.g. a post on social media, since visitors of the Green Embassy can actually taste products coming from the gardening in the city, and meet key persons in the organisation. Relating to the engagement continuum, The Green Embassy supports engagement in the form of *information* and *consultation,* directed towards users and civil society.

In another activity, the municipality raises awareness about eatable resources by ***signposting edible plants****.* The signs are located around the city, identifying herbs and vegetables found in forests, public spaces and beaches that could be incorporated into daily diets (Image 2). The notion of "fyld hatten" (fill the hat) is used in promotional materials. This is based on the 1241 law stating that one can take from nature as much as one can fit in ones' hat. The purpose of the signposting is to encourage people to harvest crops in the city to use at home. Eatable plants in Aarhus include rams and different types of fruit. On their website, Taste Aarhus program publish recipes including the eatable resources in the city. The success of this strategy has become evident when comparing the more intense harvesting of edible plants in areas where a sign was placed in comparison with another area with the same plant but without signage.

Again, the public administration via Taste Aarhus is the initiator as well as the manager of the activity, and users are informed about their rights and possibilities to use the urban resources. In this case, the outcome of the engagement character, *information,* helps the users to directly interact with and benefit the urban landscape. An illustration of the governance structure and character of engagement would be similar to the one for the Green Embassy, though excluding the consultation.

Image 1: Green Embassy. Source: Aarhus Municipality.

Image 2: Taste Brabrandstien. The sign says 'eat me'. Source: Aarhus Municipality

Coordinated by the local government and other actors

Taste Aarhus also partner with other public actors and civil organisations to promote UA. One added value of this strategy is that UA function as a means to breaking silos and connecting different departments of the municipality. For example, a farm owned by the municipality is a living lab for pupils from different schools and kindergartens across the city who can visit and experience growing vegetables. Every year, different groups of children have their own plot and learn how to cultivate. This is a useful strategy to make children realise where food comes from and also to nurture care and respect for nature. In this respect, the program offers an opportunity to strengthen the relationship between people, nature and food – a connection that is often lost in the urban context. In this case, the land ownership is public, and the initiative comes from the municipality. The farm is managed by the public administration, while children are *involved* as users of the farm facilities, see Figure 5.

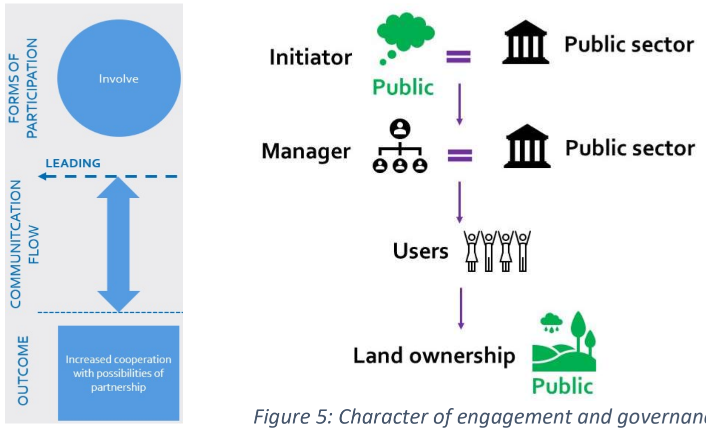


Figure 5: Character of engagement and governance structure of the public farm.

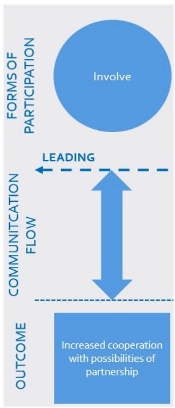
Bottom-up UA initiatives

Taste Aarhus supports a multitude of gardens that varies in terms of size, number of members motives for being started. '**Pier 2**' was formed in 2017 by a group of enthusiastic citizens. The garden was set up by a construction site in the harbour. The initiative came about following a workshop that promoted the use of underutilised spaces in the city for gardens. The community garden consists of approximately 45 small gardens built up of pallet frames.

Image 3: Pier 2.

Possibly due to the central location and relatively large size, this garden attracts a variety of participants, both with respect to where they come from and their purposes to be there. Although participants are generally people who live in the inner city in apartments, their similarities appear to end there. For some, the garden is a chance to strengthen bonds with family or friends, like between grandparents and grandchildren. For others, it is a chance to meet new people.

In this case, civil persons took the initiative and are also the ones using and managing the garden, with some support from the public sector via Taste Aarhus. The land ownership is private, belonging to a real state developer. In this UA-case, there are strong elements of *involvement* between the civil society, the public sectors and the private land owner, as the residents are doing parts of the maintenance of the urban open space (Figure 6). The members of Pier 2 are taking care of an underutilised space where new residential houses will be built. While this garden offers an opportunity to people who live in high-density parts of the city to grow food and reconnect with nature, it is also a mean of making an area under construction become a place for social interaction.



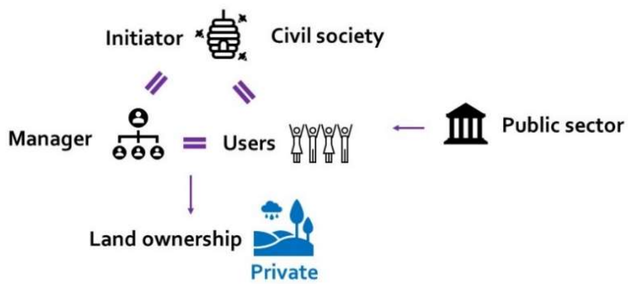


Figure 6. Character of engagement and governance structure of Pier 2.

Rather different from Pier 2 is the **Orchard of Skovvejen**, one of the earlier Taste Aarhus projects which began in 2015. A group of neighbors sought a common space where they could come together. They approached the municipality about clearing an area that was overgrown with shrubs behind their houses and planting fruit trees there (Image 4).

Image 4: Houses backing onto orchard of Skovveien.

Skovvejen is a relatively wealthy area, with average house prices around €800,000, and the people who initiated this garden already knew each other. All of the houses have gardens, but they are too small to house fruit trees. Given this, one might expect negligible social capital benefits from this project.

In fact, the residents were pleasantly surprised by how much the shared space has brought them together. The children from the houses now play together in the shared space rather than in their own yards. This space (and the fruits) is also available to the public, and several public workshops have been held there about how to plant and care for fruit trees. In this case, the initiative came from the residents to use public land for common activities. The case shows clear examples of shared leadership over space and activities taking place there.

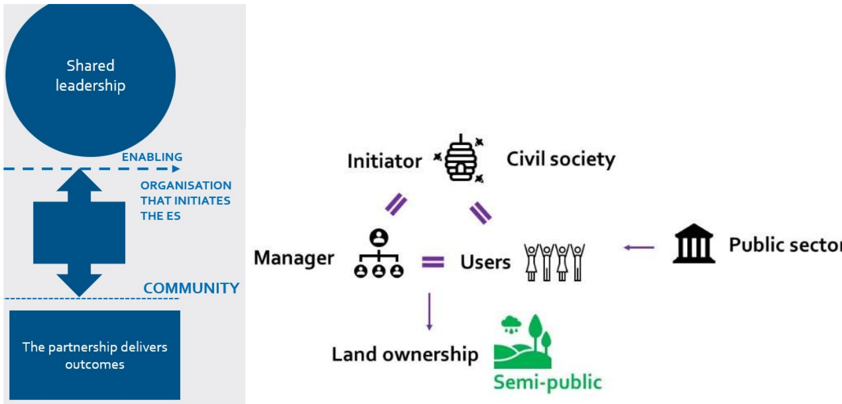


Figure 7. Character of engagement and governance structure of the orchard of Skovveien.

5. Final considerations

This article has pointed to various important layers that need to be shed light on to understand the social organisation of UA-initiatives. Sorting out the different actors, roles and variations in initiation and management are important steps to be able to evaluate the social impacts of the initiatives in Aarhus, both for individuals, for the communities and for the city as a whole. Table 2 synthesises the analysis of the cases.

Table 4. Synthesis of the character of engagement and governance in the UA-initiatives.

	UA-initiative	**Initiator**	**Form of participation**	**Manager**
Top-down	Green Embassy	Taste Aarhus	Inform & Consult	Taste Aarhus
	Signposting	Taste Aarhus	Inform	Taste Aarhus
	Farm	Taste Aarhus	Involve	Taste Aarhus
Bottom-up	Pier 2	Community	Shared leadership	Community
	Orchard of Forrestvejen	Community	Shared leadership	Community

As shown in the geographic mapping of initiatives in Aarhus, the majority of UA is initiated by Taste Aarhus. These spaces for UA offers other types of social impact than the bottom-up initiatives do. While the UA initiated by Taste Aarhus e.g. involves the public via raising awareness of what the city offers in terms of eatable resources, the bottom-up initiatives offer spaces for social interaction and community building since their governance structure motivates the users to take responsibility for tasks related to the management and maintenance of the urban open spaces. When successful, such collaborations can lead to the empowerment of the local individuals and a closer connection with nature.

Since the bottom-up initiatives often are located in intra-urban spaces, they show a potential to reactivate underutilised spaces in the city while contributing to more alive and safer public spaces. These initiatives thus have a lot of contributions to make not only to the participating individuals and community itself but also to the city as a whole.

From a social perspective, UA is clearly a valuable tool in enhancing social capital, though the way this happens appears to vary from garden to garden. In some cases, bonds between acquaintances are strengthened through participation, and in other cases, new bonds are created between people who were previously strangers. Larger gardens appear to bring less proximal people together. Yet, we do not have adequate knowledge about the level of interaction between participants in these gardens to assess their contribution to the development of social capital, but we can reflect on the outcomes.

From a political perspective, UA appears to present at least some opportunities for new forms of engagement with the political ecology of the city. The democratic structure required by the Taste Aarhus project is instrumental here; however, the opportunity to use public land also appears to elicit a degree of ownership. In at least two cases, this ownership has lead participants to take action in seeking to secure permanent changes to the urban structure following engagement with temporary initiatives.

The UA located within e.g. education and health institutions does not influence as much the quality of public spaces in Aarhus, as many of these gardens are not entirely open and accessible to the general public. The restricted access is due to several aspects, among these their location in private land, inside hospitals and schools, or preserving the privacy of the vulnerable groups involved in UA. The gardens that are open to the public, offer another potential to activate bypassers and for the UA-practitioners to contribute to inclusive activities in public space.

The top-down UA should not be seen as less important for the social life in the city. While perhaps being more superficial in the way the city residents are engaged, the activities like signposting of eatable plants are rather inclusive since they offer knowledge and low hanging fruits (in a double sentence) for individual who might have less time or interest to engage in a more profound and long term manner.

Taste Aarhus is a top-down initiative supporting bottom-up initiatives in urban agriculture. By supporting bottom-up initiatives, the municipality shows appreciation for the activities that are carried out and support self-organised management of urban greenspace, and by including a wide array of initiatives, Taste Aarhus has the potential to reach a wide variation of residents with the ambition to create *socially inclusive places and communities when focusing on edible nature and urban farming*, as the overall goal states. More demographic knowledge about participants would be useful in shedding light on the economic dimension of societal inclusion. Related tasks in SiEUGreen are to further evaluate the social and economic impacts of UA in Aarhus.

Acknowledgement

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