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Edible City Solutions—One Step Further to Foster Social Resilience through Enhanced Socio-Cultural Ecosystem Services in Cities

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Abstract: Nature-based solutions have not been able to actively involve citizens and to address successfully food security, poverty alleviation, and inequality in urban areas. The Edible City approach promises a strategic step towards the development of sustainable, livable, and healthy cities. We introduce the conceptional framework of Edible City Solutions (ECS), including different forms of urban farming combined with closed loop systems for sustainable water, nutrient, and waste management. We review scientific evidence on ECS benefits for urban regeneration and describe the status quo of ECS in Rotterdam, Andernach, Oslo, Heidelberg, and Havana as case studies. We provide an analysis of strengths, weaknesses, opportunities, and threats (SWOT) to explore the capacity of ECS to enhance multifunctionality of urban landscapes with special focus on social cohesion and quality of life. Based on this we identify and discuss strategies for fostering socially relevant implementations for the case study cities and beyond.

Keywords: circular economy; living labs; multifunctionality; urban agriculture; urban farming; urban regeneration; social cohesion

1. Introduction

The majority of humans are exposed to urban environmental conditions that often challenge human health and well-being and also threaten natural resources (e.g., [1,2]). The ongoing urbanisation decreases green space per capita and increases the need to counteract environmental injustice, criminality, and exclusion of vulnerable groups [3]. Rising costs for maintenance of the overall urban infrastructure and for mitigation of climate change impose sustainable and innovative solutions to strengthen urban resilience (e.g., [4,5]).

Hence, urban green infrastructure is being rethought as linking recreation areas and traditional nature-based solutions (NBS; see, e.g., [6–8]). NBS are originally defined as cost-effective solutions that are inspired and supported by nature and simultaneously provide environmental, social, and economic benefits and help building resilience [9]. Over the last decade, efforts to implement traditional NBS, such as parks, vegetation along urban roads, small and medium-scale green space on and around residential buildings, have been intensified and up-scaled. However, these NBS have not been able to significantly increase social cohesion as they mostly invite to ‘stay and use’ passively but not to become actively involved on-site, in an ongoing fashion. This gap needs to be closed to overcome the mismatch of traditional NBS and local citizens.

Edible City Solutions (ECS) are going a step further by deepening the socio-cultural and socio-economic dimensions of NBS. The vision of productive urban landscapes (e.g., [10]) pledges a step towards the strategic development of sustainable, livable, and healthy cities. Urban food production use innovative principles of ecological design, closed material, and energy flows. The environmental benefits of ECS connected to closed water, as well as waste and nutrient loops are widely acknowledged (e.g., [11,12] on ECS; [13,14] on circular economy, [15]). Additionally, other NBS benefits, edible green spaces are socially inclusive, invite citizens to co-create the sustainable development of their society and proactively change urban environment to their benefit and, thus, induce a paradigm shift of urban lifestyle.

Worldwide, Edible City projects have demonstrated emancipative citizen commitment and successful inclusive urban regeneration to a considerably greater extent than other NBS. Initiatives based on edible urban green space directly and lastingly involve citizens in social processes, ranging from co-design to co-implementation and long-term co-management of evolving edible green spaces. Existing Edible City Solutions (ECS) have created impressive benefits for local communities worldwide (a) to effectively overcome social problems by their inclusive and participatory dynamics, alleviating as co-benefit the financial burden of conventional measures regarding security, physical and mental health (b) to launch new green businesses and value chains, creating jobs, products, and services and thereby local economic growth in often disconnected or disadvantaged urban areas (see examples in Figure 1).



Figure 1. Edible city pilots have demonstrated emancipative citizen commitment and successful inclusive urban regeneration worldwide (sources: Nabolagshager; Mundraub; Brighton & Hove Food Partnership; RotterZwam).

Here we (i) introduce to the conceptual framework of Edible City Solutions (ECS), (ii) briefly review scientific evidence on ECS benefits for urban regeneration (iii) describe the status quo of ECS in

five different cities (i.e., Rotterdam, Andernach, Oslo, Heidelberg, and Havana) as case studies and provide a SWOT analysis of ECS to explore the capacity of ECS to enhance multifunctionality of urban landscapes with special focus on social cohesion and quality of life. Based on this we (iv) identify and discuss strategies for fostering socially-relevant implementations in the cities.

2. Materials and Methods

2.1. Conceptual Framework of Edible City Solutions

Edible City Solutions (ECS) focus on urban productive landscapes including the wide range of different forms of urban farming, building integrated farming, agro-forestry, aquaculture, biomass production for energy, among other productive and ornamental purposes and services combined with closed loop systems for sustainable water, nutrient, and waste management (Figure 2).

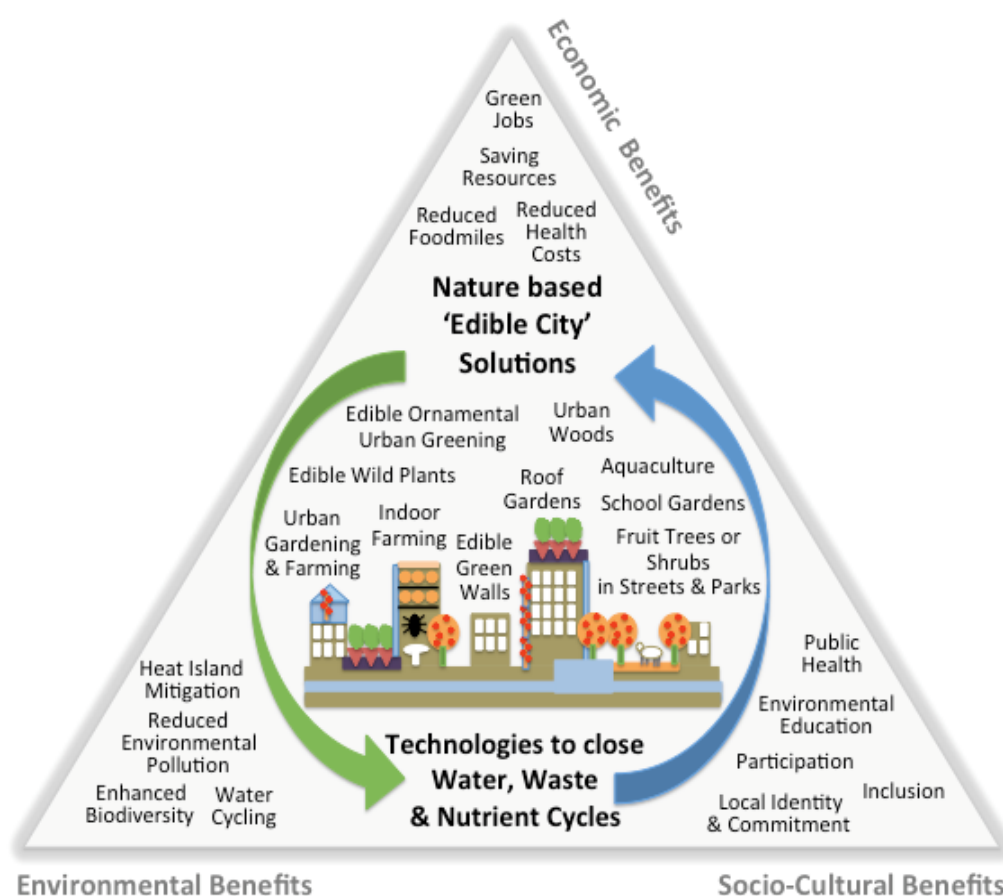


Figure 2. Examples for nature-based ECS and benefits.

Our ECS concept amplifies the benefits provided by nature-based solutions from supply of ecosystem services such as cooling, air, and water cleaning, habitat services, or recreation effects (e.g., [7,16]) towards provisioning services that address food security, poverty alleviation, and inequality in urban areas [12]. The elements of this 'Edible Green Infrastructure Concept' includes edible urban forests, edible urban greening, different gardens and parks, school gardens, allotment gardens, community and domestic gardens, edible green roofs and vegetable rain gardens, edible green walls and facades, but not intensive urban agricultural practices. Our ECS concept includes also these practices managed in a sustainable way such as commercial indoor farming, high-yield commercial gardening, biomass feedstock, aquaculture, and livestock and new innovative cropping techniques in urban areas, such as hydroponics or 'organoponics' [11]. Commercial urban rooftops and vertical farming offer an untapped potential to systemically integrate farms into buildings [17,18]

and drive economic resilience of cities. Beyond the effects on social integration and environmental sustainability ECS present opportunities for significant improvements to food supply, zero-km food, and local economy.

Depending on the local situation of users and producers, ECS combined with closed loop technologies to close water, waste, and nutrient cycles fulfill diverse functions including food production and community building and are promising to contribute to reducing socio-economic and environmental problems. Examples of high technology ECS which demand a greater planning frame and require new technical standards are edible city trees, hydroponic glasshouses, tomato-fish loop roofs, or green walls for cooling installations. Low technology ECS are already spread all over the world, are user friendly, and driven by the will of being active and productive at the same time (e.g., espalier fruits, sit-and-eat fruit gardens, educational and school gardens, agro-biodiversity gardens as observatories, kitchen herb walls, or urban honeybee hotels). The mostly community built urban farming areas support the huge bunch of benefits and co-benefits for urban climate and quality of life of urban dwellers.

2.2. Literature Review on ECS Benefits for Urban Regeneration

To review research on ECS benefits for urban regeneration, we screened articles in the Web of Science by using keywords covering the different Edible City Solutions (ECS; see Section 2.1; i.e., 'urban farm*' OR 'urban garden*' OR 'building integrated farm*' OR 'urban agro-forestry' OR 'urban aquaculture' OR 'urban biomass production' OR 'urban horticulture*' OR 'urban food production' OR 'edible cit*') and keywords covering urban regeneration (adapted from [19]), i.e., 'urban regeneration' OR 'environmental justice' OR 'social inclusion' OR 'equity' OR 'health' OR 'well-being' OR 'revitalization' OR 'renewal' OR 'rehabilitation' OR 'urban development'). A keyword search (August 2018) in the Web of Science revealed > 3600 references in English related to different ECS and urban regeneration in the "topic" OR "title" fields since 2010, but only 20% of these were developed in social sciences, psychology, health or economics that mainly deal with the socio-economic dimension of urban regeneration. In a first step, we screened the titles and abstracts of the remaining articles and eliminated articles that are not related to our topic (144). Second, we eliminated articles without access to the full text version and unanswered requests of full text (3). Third, we made a full text review of the remaining articles to gather the relevant information. The whole process was conducted independently by three reviewers. Only 28 papers were identified that directly address ECS and urban regeneration. About one half of the studies focus on physical and mental health and well-being and the other half on sociology and education, there were only few studies on economic effects (e.g., [20]). We also included twenty other papers and grey literature found by cross-references in our research. Here, we highlight current evidence of ECS benefits for urban regeneration, but we do not aim on a complete screening of all existing literature, as social sciences often use publication modes that are not included in the database of Web of Science.

2.3. Case Studies for Status Quo Analysis of ECS and Strategy Development

The five selected cities (Rotterdam, Andernach, Oslo, Heidelberg, and Havana) suffer from typical social challenges due to urbanization, including functional transformation and densification trends and provide a broad basis of NBS experience. The cities strictly highlight urgent urban challenges like inclusiveness, social cohesion, well-being, mental and physical health, safety, and criminality.

We used a combination of descriptive and analytical research methods to explore the capacity of ECS to enhance multifunctionality of urban landscapes with special focus on social cohesion and quality of life in our case study cities and beyond. Status quo analysis is based on a systematic review of available documents of cities administrations and expert knowledge provided by the city representatives involved. The following aspects of the case study cities have been explored: amount of implemented ECS; governance and policy framework related to ECS, decision-makers and their objectives regarding ECS, barriers to ECS implementation, relevant awards for cities, and specific

challenges. After a systematical review of published information and available grey literature about each case study city we analyzed the main contact persons in the cities and provided a questionnaire where we collected formal knowledge about: (i) Governance and strategies of social relevant issues; (ii) Management of green infrastructure and urban master plan concerning valorization of green infrastructure through edible solutions; (iii) policies and guidelines for fostering social and climatic resilience and the internal ranking of challenges in the city (i.e., inclusion, equitability, livability, beneficial social networks, and individual well-being) and (iv) we discussed the city's visions on ECS implementation and collected first ideas on Living Labs to be defined in a further step of our research and action plan. We use the SWOT analysis to effectively explore the strengths, weaknesses, opportunities and threats to address complex strategic situations [21]. Based on the SWOT results we develop general strategies for effective ECS implementation, which in turn will be adapted to the city-specific strategies to improve Edible City Concepts (Figure 3) for our case study cities. Here, we present results of Step I (Status quo, SWOT and city-specific visions for our case studies), discuss general strategies to improve Edible City Concepts and provide first drafts for Living Labs (Step IIa). Future research (Step IIb–Step IV, Figure 3) will co-create action plans and define Living Labs based on multi-stakeholder involvement. These living labs will be co-implemented at different scales, impacts on urban regeneration monitored to constantly evaluate effectiveness of implementation for optimization. This knowledge will provide in turn a wide range of experience to other cities that are developing master plans on ECS implementations for a worldwide growing network of Edible Cities.

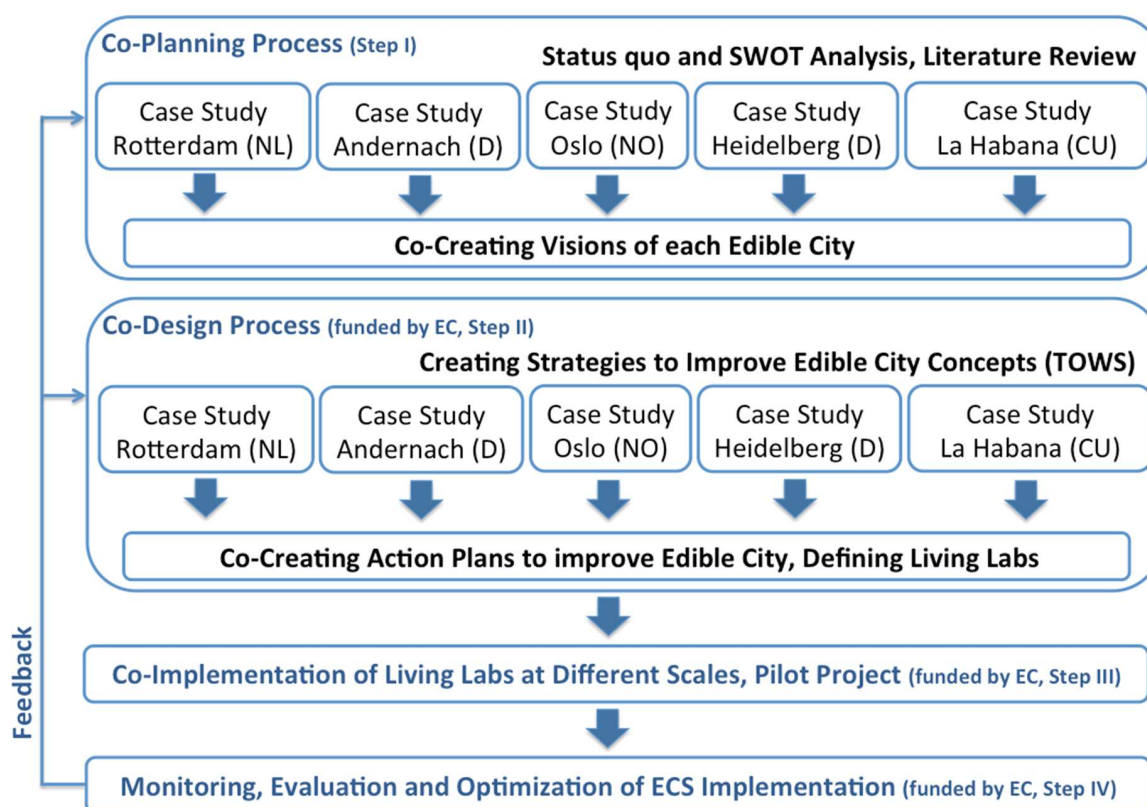


Figure 3. Methodological approach of implementation and mainstreaming of ECS.

3. Results

3.1. Scientific Evidence on ECS Benefits for Urban Regeneration

In developing countries, urban horticulture is mainly a strategy for achieving food security, equitability, and inclusion. Urban gardeners generally have low incomes and need to cultivate vegetables for food supply and as a source of income [22,23]. The high potential of urban agriculture

to respond to a rapidly emerging food demand has been demonstrated in Havana, Cuba [24]. However, food insecurity is also a phenomenon in developed countries and food-banks are increasingly used worldwide (e.g., [25–27]). As an example local governments from Northern Italy offered urban allotment gardens on public lands to encourage low income senior citizens to produce their own food, benefit health, and overcome loneliness by social interactions in the gardens [28].

ECS offer a strong contribution to improve urban livability, social and individual well-being in the developed countries as urban sprawl and loss of peri-urban agricultural land continues [20,29]. Sociologically, urban farming favors both social inclusion [30,31] and reduction of gender inequalities, as urban farmers are often women in both developing and developed countries [22,32].

The great demand for inclusive green spaces is directly linked to the city's duty to assure environmental justice among residents, healthy and good urban quality of life and to provide social benefits and co-benefits in ecological and economical dimensions that contribute to a sustainable way of living [30,33,34]. However, research on how sustainable lifestyles can be shaped is widely lacking. A study in a french allotment garden on mechanisms of change towards sustainable lifestyles induced by governmental policies and related resistance to pro-environmental practices were not systematically related to shared concerns [35]. Three gardener types were identified: (i) few pro-environmental 'wild life friendly' gardener with coherent life style; (ii) numerous 'Cultivating for pleasure' gardeners, that implemented pro-environmental practices but not concerns and (iii) numerous 'Clean and order-loving' gardeners, that are respecting pro-environmental rules like other allotment norms [35]. Yet, pro-environmental policies have to address the value-action gap by diffusion of ecological concern to foster sustainable lifestyle changes.

Urban quality of life as a hierarchical multi-attribute concept is defined and monitored by monetary (e.g., hedonic price, willingness-to-pay, cost-benefit, positional value), subjective (e.g., life satisfaction, subjective well-being, ranking/rating evaluation), and quantitative methods (see review [36]). 'Willingness-to-pay' valorizes the implementation of urban green spaces and is also related to the 'will to invest': the highest readiness to invest in green spaces was directed to the green space next to the doorstep [37].

A large body of literature demonstrated the overall ECS benefits for human health and individual well-being involving positive effects on air quality, physical activity, social cohesion, and overall stress reduction (e.g., [38–41]). There is a strong relation between mental and physical health of residents and reachable urban green space. Low accessibility to health promoting green space affects mainly low-income people, while well-off households in the same neighborhoods can remedy the lack of urban green services (e.g., by air conditioning or staying at country side residences on weekends or during vacations [42]). The main public concerns against food produced in urban landscapes are related to the high pollution loads in urban soil, water, and air (e.g., [43]).

ECS provide important economic, social and cultural spaces where knowledge related to agricultural practices is transmitted and through which households may improve their income and livelihoods [44,45]. Since long, community gardens in low-income areas integrate successfully diverse cultural and socio-economic backgrounds [46,47]. Thus, integration or intercultural urban gardens aim to dismantle social and cultural boundaries by gardening and space-making practices (e.g., [48]). The main beneficiaries of ecosystem services from Barcelona's urban gardens are elderly, low-middle income, and migrant people [47]. Furthermore, urban gardening and grassroot-based revitalization project have positive effects on the social cohesion of neighborhoods [33,42,49,50]. Crime and environment are strongly intertwined, environmental justice can reduce crime and security related costs [51].

Undesired effects of green gentrification are discussed and can be avoided by co-creation, and co-implementation with local communities [52,53]. Inclusive approach to re-nature cities encouraged planners to move away from re-wilding approaches to urban landscapes that can serve as nodes for urban agriculture and community garden spaces more connected to communities concerns about food security, job creation and human health [30,53].

School gardens can be used as an efficient policy tool to foster environmental and health education of future generations across different socio-economic groups and to create more environmental equity in urban areas (e.g., [54–56]). ‘Culinary gardening’ was valued as personal, social and gustatory pleasures by working-class students that radiate from the garden to whole school culture [57]. School gardens demonstrably helped to attenuate origin and class inequality as reason for poor achievement at school [56]. Beyond school gardens, other urban gardens support children's biophilia as private gardens and yards are the most preferred space for nature experiences [58].

The implementation of ECS reduces the ecological footprint and food miles of cities. Thus, urban food production has already taken place for decades at the gate to a regenerative agriculture in the future [15]. The possibility of urban self-reliance in food is frequently questioned. Although urban farming is booming, there remains a large skepticism from, e.g., agricultural science and food producers to urban farming activities and its contributions to urban self-reliance in food [59]. Experiences of community-supported agriculture (CSA) today mainly located in the peri-urban areas of cities [60] can provide examples, how to successfully connect rural and urban farmers for mutual learning in order to enhance the ECS productivity. Grewal and Grewal [59] calculated, that post-industrial North American cities can reach significant levels of local self-reliance in food, but require an active role of city governments and planners, public commitment, financial investment, and labor and conclude that the overall benefits to local economy and community may outweigh the cost.

3.2. Status Quo of ECS in Case Study Cities and SWOT Analysis

Rotterdam, Andernach, Oslo and Heidelberg provide a broad basis of ECS experience and face typical societal challenges in European cities. In addition, the case study of Havana as a pioneer of self-sufficient ECS, enables us to reflect beneficial experiences and facilitate mutual support and interconnections beyond Europe (see Table 1).

Rotterdam (Netherlands with 631,000 inhabitants and 1.2 million in its agglomeration) is the parade example of a multicultural city in Europe with all the challenges and opportunities that such diversity presents. The Dutch agriculture and food sector is the 2nd largest exporter in the world, and the 1st in Europe accounting for 9% of the national GDP using one of the smallest carbon footprint (2014). This efficient, effective, and large production takes place at the gate of the city of Rotterdam already for decades. Nevertheless, within the city walls at a micro-scale, there is a green movement and initiatives going on like in many other cities worldwide. Rotterdam and its city administration, as a member of the ‘100 resilient cities’ network, already has experience with NBS in general but also with NBS-implementations anchored in the urban master plans. Rotterdam counts to date more than 200 nature-based Edible City Solution initiatives mainly grass-roots (Figure 4a). Most of ECS initiatives work with volunteers and often lack professional back-up and continuity in expertise transfer. All of them depend on (private) funds. When granted funds, they lack time, capacity and/or expertise to monitor and to show the funders the social benefits of their organizations. In addition, some initiatives may share the ambition of picking up commercial activities. Rotterdam aims at facilitating with the valorization of their ECS. Here, the main challenge is to guide these fragmented and often vulnerable ECS to a stable network of ECS. Moreover, Rotterdam aims at the integration, employment and education in a socio-cultural diverse society and will overcome the fragile availability of expertise and experience of the existing high potential ECS grass root movements. Thus, Rotterdam’s Living Lab will focus on an empowerment of ECS initiatives by fostering self-sustainment and on the development of a legal framework (Figure 4b).

Table 1. Status quo of ECS in case study cities are described by focusing on current governance and policy, decision makers and their objectives, identified barriers for ECS, awards on urban sustainability held by the cities, specific challenges identified by the city administrations to be addressed by ECS development.

Case Studies	Rotterdam	Andernach	Oslo	Heidelberg	Havana
ECS	Over 200 small grass root initiatives, not associated are most vulnerable to changes	Integration in municipal green spaces	Municipal grant for 2017 for center of urban ecological innovation with 184,000€	Several initiatives from production of ancient grains, local food markets to bee keeper association	Agricultural Area 35 900 ha (2014), >90,000 residents involved, Productivity yield of 20kg/m ²
Governance and policy	Integrated in elected City council with their program, top down, program: "Food & the City" (Gemeente Rotterdam 2012)	Integrated in municipal compulsory tasks, top down, to expand	Municipal Master plan revised all 4 years, adoption of co-designed urban agriculture strategy in 2017, bottom-up	City council (elected all 5 years) initiated IBA (first bottom-up IBA), sustainability programs	National programs for urban and peri-urban food production; Protection of agricultural areas above construction
Decision makers and their Objectives	City council, officials of boroughs, executive committee (major), anchoring main responsibility and simplicity of relations to City council	City council/ "Perspektive gGmbH" Integration of high-quality food supply in municipal compulsory tasks,	City council, City government and elected district councils, establishment of a center of urban ecological innovation (founded 2016) for green transformation	Mayor and City council, ecological committee, Dep. Building and Traffic/Environment, Sustainable food, livable Neighborhoods	Broad support of different levels of city administration to grant vacant land, Enhancing of participation of vulnerable groups Technical Advisory board for a wide network incl. research institute
Barriers	Widely scattered responsibility in different departments, no legal adaption to urban agriculture	Availability of areas and spaces, access to private space, need of optimized procedure in the municipality	Considered as spare time activity not as profession with full-time jobs, legal barriers regarding selling rights for urban agriculture food	Conflict of interest to use specific green areas, regulative barriers on food, contracting and renting schemes renegotiate	Organization of urban food producers, Management of infrastructure and ECS Technologies Isolation of Cuba from the global ECS market
Awards	C 40 Cities Adaptation Planning & Assessment 2015; Sustainable Architecture 2011; Greenest Port 2016	Most Livable City 2013; Land of Ideas 2013	European Sustainable City 2003; European Green Capital 2019	European Sustainable City 1997, 2003; Global Green City 2015; Fair Trade Town 2010	(Un-awarded) World leader of urban agriculture
Specific Challenges	Integration, employment and education in socio-cultural diverse society Overcoming fragmentation and financial instability, fragile availability of expertise and experience of high potential ECS grass root movements	Beneficial social networks across the entire city population; Access to healthy and fresh food for vulnerable groups: refugees and marked by life children	Regeneration of neglected areas and counteract gentrification processes; Inclusion of immigrants with special focus on: women, single parents and high school dropouts	Restoration of abandoned areas and tensed housing market; Social pressure and conflicts of interest in relation to open space use	Preservation of long-term self-sufficient urban food production and optimization towards user-friendly large-scale ECS and fostering local entrepreneurship; Connection of Cuban ECS technologies and knowledge on organic agriculture to the global ECS market and

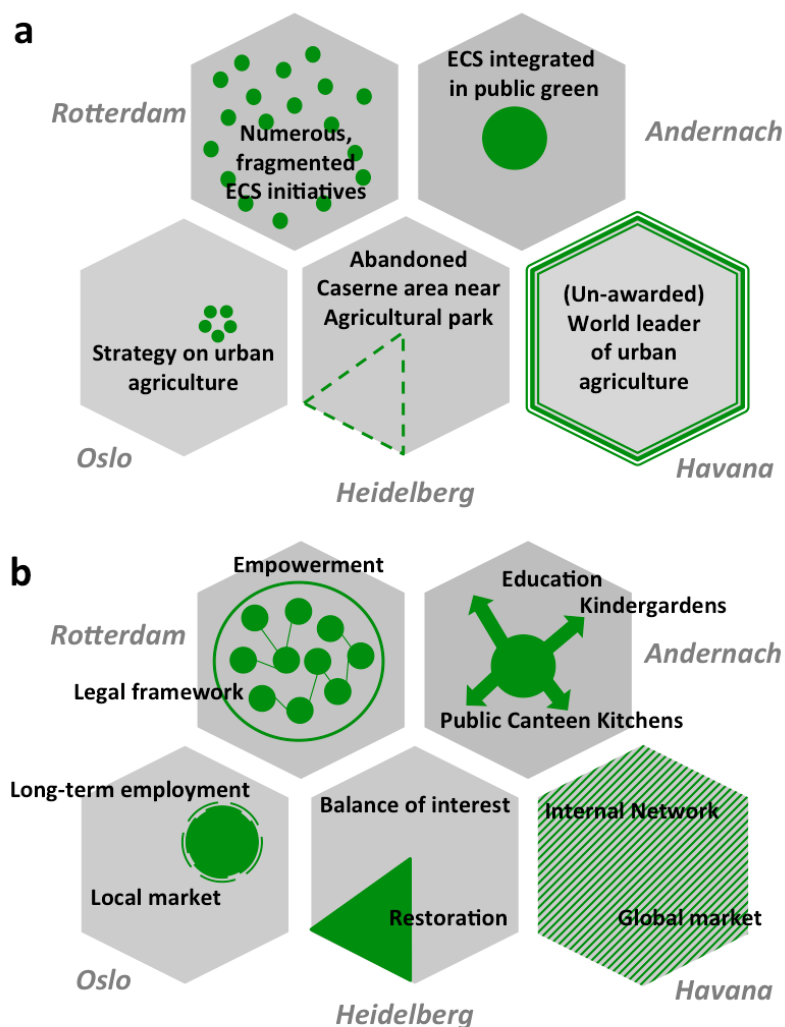


Figure 4. Status quo (a) and target transformation after implementation of co-planned Living Labs (b) in the case study Cities. The green symbols stand for different existing ECS (a) and illustrate the potential development to ECS with greater outreach (b). For details see text on case studies.

In Andernach (Germany, 30,000 inhabitants) ECS were created in cooperation with the 'Perspective GmbH', a local institution for occupation and qualification of permanently unemployed people and refugees. The city aimed to form creative public green space, to support biodiversity and to save money on green space maintenance. Vegetables, culinary herbs or cut flowers turned green spaces into exciting areas for the citizens. Instead of 'Keep off!' one read 'Feel free to pick!'. In 2014 the program to cultivate these ECS was carried out by six workers and one professional gardener. Maintenance costs significantly decreased by involving more citizens, students and elderly people. Andernach demonstrates cost-effectiveness of highly accepted green spaces (Figure 4a) and aim to extent ECS across the city. Accordingly, the aim of the Living Lab is to spread the existing beneficial social networks across the entire city population in order to provide access to healthy and fresh food especially for vulnerable groups in public kitchens, children's homes and refugee camps (Figure 4b).

Oslo (Norway, 660,000 inhabitants; 1.2 million in its agglomeration) has a rapidly increasing population. The settlement is to a large degree segregated according to socioeconomic background, with a 'rich' west and a 'poor' east of the city. For a number of years Oslo has strengthened a network of actors in urban agriculture with a wide range of purposes, e.g., local food, education, social cohesion, inclusion, care, and therapy (Figure 4a). ECS are in line with a revised strategy on urban agriculture that will be launched now. Oslo offers a well-established project cooperation among the agricultural and environmental sectors in administration, SMEs, NGOs, and other stakeholders, including business

associations (e.g., Norwegian farmer's union). The main challenge of Oslo is to strengthen equitability at city scale, the Living Lab will empower local citizens to launch their own start-up and developing market distribution networks for ECS products to provide long-term employment and full-time jobs especially in those neighborhoods with high poverty and unemployment rates (Figure 4b).

Heidelberg (Germany, 156,000 inhabitants) has the challenge to find new uses for more than 200 ha of abandoned land, which became vacant with the withdrawal of the US-Army in 1945. The city has already completed a feasibility study for this site looking at NBS and ECS (Figure 4a). The main challenge of Heidelberg is rent and price inflation, which has led to a severe shortage of affordable housing. The densification trend therefore needs to be stemmed by good quality open space and long-term affordable housing models. The city is holding an International Building Exhibition (IBA), which aims to build up ECS as showcases and lighthouse projects. The main challenge for the Living Lab of Heidelberg is the re-naturing and re-generation of an abandoned area at Heidelberg's city border with combined low and high tech ECS implementations through connecting it to an agricultural park used by different stakeholders with different interests with open access for surrounding local citizens, Figure 4b).

Havana (Cuba, 2.1 million inhabitants) is an exceptional example for urban agriculture on large scale. After the break of the soviet bloc Havana fell into the worst economic crises in history. Since 1994, a governmental strategy made Havana to one of the most successful examples of urban agriculture worldwide. More than half of the consumed food is grown organically on-site. This example shows how ECS can be mainstreamed in a city and provides up-scaling and feasibility knowledge, accompanied by huge experience on urban planning level and strategic implementation (Figure 4a). Urban farmers in Havana use predominately low-tech technologies and practices achieving yields of up to 20 kg/m², 10-fold higher yields than commonly achieved in mixed stands small scale agriculture. Among the used technologies are drip irrigation, organoponics, regular addition of compost, and other good horticultural practices (e.g., the use of well-adapted varieties, mixed cropping, crop rotation, and integrated pest management). In the process, Havana has also become a pioneer in a worldwide transition to sustainable agriculture that produces 'more with less'. Havana's Living Lab will improve the internal network along the urban food and agriculture value chain from agricultural space management, substrate production (e.g., lumbriculture), agro-biodiverse seedlings and seed production, organic horticulture and agroforestry, biodiversity friendly integrated pest management, food distribution, and overall enhanced management of infrastructure and resources. Moreover, Havana aims to innovate the use of water-saving technologies and rainwater harvesting and on the transfer of urban organic horticulture technologies to the global ECS market (Figure 4b).

Based on the literature summarized in Section 3.1 and on the in situ experiences of our case study cities (see questionnaire in Material and Methods), we explore the capacity of ECS to enhance multi-functionality of urban landscapes with special focus on social cohesion and quality of life. The SWOT analysis (Figure 5) clarifies the most important strengths, opportunities, weaknesses, and threats to implement ECS successfully for social inclusive urban regeneration.

The connection between mental and physical health and reachable green infrastructure and NBS is evident in the literature. ECS provide an instrument for urban planning to achieve a balance in highly challenged cities of the 21st century. The contribution of green infrastructure and NBS to climatic resilience is emphasized and broadly accepted, what lacks is the evidence of the social impact of ECS as socially active NBS [6]. Most studies refer to NBS as derivative of green infrastructure and as meeting points that do not cause their users to interact or engage with NBS design and management. There are first evidences, that participation in community-supported agriculture (CSA) shape shareholder food lifestyle behaviors and health outcomes [61]. Thus, ECS can learn from CSA concerning citizen's involvement and sustainable lifestyle changes. However, CSA members are typically women, white, highly educated, and motivated to participate in CSA by a concern for the environment and a desire for locally grown, high-quality, and organic products. ECS implementation in deprived and segregated

neighborhoods (see the case study of Andernach, Figure 4) is more inclusive by addressing diverse and vulnerable groups such as migrants, refugees, or long-term unemployed people.

Internal (Edible City Solutions)	<p>Strengths (selection):</p> <ul style="list-style-type: none"> • Holistic Approach on Multifunctional Productive Urban Landscapes base for self-sustainment • Extensive Knowledge on ECS technologies, experiences and provided ecosystem services • Most relevant actors by the multistakeholder Approach in Bottom up - Top down – Hybrids involved • Multiple benefits for urban regeneration, re-use of resources and economic growth demonstrated in numerous pilots • Effectiveness, innovation and diversification for the local food system • Synergies with Local Food Initiatives of the EU* • Strong involving and activating momentum due to basic needs 	<p>Weakness (selection):</p> <ul style="list-style-type: none"> • Legal barriers for market uptake of ECS products (e.g. Regulations on Food Quality and Safety standards) • Uncertainty on potential Health risks of ECS products • Lack of mainstreaming knowledge on ECS technologies, experiences and provided ecosystem services • Absence of acceptance of ECS especially in vulnerable groups and abandoned areas • Dependent on programs from elected city council
External (ECS in urban landscapes)	<p>Opportunities (selection):</p> <ul style="list-style-type: none"> • High societal relevance: across all socioeconomic groups and around the world ECS are booming • Great potential for urban regeneration and social inclusion of deprived social groups if mainstreamed by urban planning and policies • Learning from well documented numerous best practice examples • Great potential for economic growth by creation of innovative business models for a growing local market and improved value chains for the urban economies in transition • Awareness rising for a broad audience in society for adverse environmental effects that affect health and wellbeing such as: air pollution, CO2, heat island effects, noise and light pollution etc. 	<p>Threats (selection):</p> <ul style="list-style-type: none"> • Land assessment in growing cities • Barriers to expand local food markets • Sectoral functioning of cities and lack of integration of ECS into the urban planning process and of support through urban policies • Green Gentrification

Figure 5. Results of SWOT analysis to explore the capacity of ECS to enhance multi-functionality of urban landscapes with special focus on social cohesion and quality of life.

To reach truly inclusive urban resilience, it is necessary to move out of conventional planning tools of urban green and NBS as green interventions, which invite to use but not encourage participation in planning, design or maintenance as concrete social interaction to foster social cohesion. ECS provide a holistic, multifunctional, and multi-stakeholder approach to tackle radically pressing challenges on urban territories by installing a disruptive change in urban planning already introduced in nearly all cities over the world by demanding citizens willing to change their surrounding living area (see strength and opportunities of ECS in Figure 5). The booming grass-rooted urban farming streams (e.g., over 200 in Rotterdam) can foster a paradigm shift in cities. There is extensive knowledge on ECS technologies, experiences and provided ecosystem services, and on the multiple benefits for urban regeneration, re-use of resources, and economic growth demonstrated in numerous pilots (see Section 3.1.). Our case study of Havana illustrates that local food demands can be satisfied by organically grown food on-site and how ECS can be mainstreamed in a city. The approach on productive urban landscape [10] is promising to integrate ECS of different scale into cities without disturbing the existing city's structure. Moreover, ECS go along with global or local food initiatives (see examples Table 1).

We identified several legal barriers for market uptake of ECS products mainly due to regulations on food quality and safety standards. There remains uncertainty on potential health risks of ECS products due to the high pollution loads in urban areas (e.g., [38]). Studies on healthiness of urban farming products demonstrated clearly that urban farming products can be safer than same products from common supermarkets following simple and low cost planting guidelines and protecting measures (e.g., [62]).

ECS lack mainstreaming on city level to move out of informal state and to become self-sustaining identified as an urgent need by some city administrations (e.g., Rotterdam) to foster social resilience. ECS are often attributed to higher educated middle class people and might not always be accepted by vulnerable groups in target areas for urban regenerations, although best practice examples have overcome these barriers (e.g., Figure 1 and Section 3.1.) and stand for a highly socially inclusive instrument. A main weakness of mainstreaming ECS is the dependence on work programs from elected city councils, here our case studies aim to demonstrate, that long-term commitment of city councils and national programs foster ECS implementation beyond legislative's period (Table 1).

A main threat to the establishment of ECS mentioned in our case study analysis (Table 1) and in literature is the precariousness of land access for ECS, mainly in growing cities [53,63]. Yet, paradoxically for an urban sustainability agendas land for ECS initiatives is mostly transferred for only short periods at a time to stabilize deprived neighborhoods and to provide social service.

4. Discussion

Based on the reported practice in literature and the SWOT analysis of our case studies (summarized in Figure 5), we discuss a pool of strategic alignment to implement social efficient ECS.

4.1. Long-Term and Cross-Sectoral Mainstreaming of ECS

Demonstrated by literature and by our case studies, city administrations started to recognize ECS as an integral part of planning, land use, and zoning ordinances and fill policy vacuums by setting up informal policies and master plans (see Table 1) and by adopting enabling ordinances, regulations on ECS, and fiscal policy instruments (e.g., [64]). Thus, a main strategy is lowering barriers and to changing legal aspects that pose hindrances concerning the supply of locally produced food in order to facilitate higher effectiveness, innovation and diversification for the local food system and to expand local food markets (see, e.g., Living Lab aims of case study cities). There is a need of a better understanding of how local, state, and federal legislations constrain or enable urban agriculture, thus regulation of urban agriculture has to be addressed (e.g., restrictions on sales of agricultural products, tax abatement, urban agriculture fees [64]). The sectoral functioning of cities is frequently identified as critical for ECS integration (see, e.g., Rotterdam, Andernach), which is also the main barrier for many decentralized solutions that aim to improve cities for both environmental and social challenges such as water infrastructure. As an example, Brown and Farrelly [65] analyzed, that barriers are largely socio-institutional rather than technical, reflecting aspects related to community, resources, responsibility, knowledge, vision, commitment, and coordination and underline the urgent need of inter-sectoral professional development and inter-organizational coordination.

Our ECS are conceptualized in combination with closed loop systems for sustainable water, nutrient and waste management (Figure 2). The localization of urban food production becomes a dominant strategy for dealing with limited natural resources in integrated approaches (e.g., permaculture, circular economy) within the existing urban infrastructure [15]. Living, working on a more local scale, producing, and consuming of zero-km food will reduce the overall footprint of our cities and the shift towards a systemic, circular alternative of 'reduce, reuse, recycle, regenerate' will meet demands for future generations [15]. The multi-functionality of ECS in terms of practice and governance is promising for the development of new territorial concepts [66]: cross-sectoral visions, plans, and strategies are needed to embrace the potential of ECS through the exploration and valuation of participatory envisioning processes. Additionally, this cross-sectoral mainstreaming will reduce the current short-term politic modes dependence on programs from elected city council.

Among all case studies land assessment for ECS in growing cities was identified as crucial and the high success of Havana goes along with a national programs for urban and peri-urban food production and a protection of agricultural areas from construction (Table 1). The precarious land access limits in particular disadvantaged communities [53]. Political anxieties related to provide vacant land for urban agriculture consists in perceptions of the polarity between 'urban' and 'agriculture', in doubts

on stability of urban agriculture, in the absence of master plans and on land disposition serving for future growth of the city [63]. Thus, a successful ECS mainstreaming requires a holistic approach on multifunctional productive urban landscapes as a base for self-sustainment and an awareness rising for all target groups such as land use governance, private owner, cooperatives, and housing estate management among others.

4.2. Co-planning, Co-Design, and Co-Implementation

To face these obstacles, most relevant actors should be involved by the multi-stakeholder approach in Bottom up—Top down—Hybrids in order to co-create, co-design, and co-plan ECS integration into urban planning processes. Practitioners of ECS are actively seeking in networks, how urban farming is done elsewhere [64] and gain high social acceptance and integration in neighborhood networks. Though community gardening and do-it-yourself (DIY) initiatives often ask local governments for formal recognition, land access or assistance, the proactive modus vivendi of these initiatives taking over public spaces and the unauthorized creative alterations can challenge the status quo of the municipalities and their exclusive responsibility for planning and produce policy dissonance [67]. Numerous examples demonstrated, that a land use previously inconsistent with existing policies by grass-rooted initiatives turned into supported practices with active participation of governing authorities often via intermediary organizations [67]. This synergy will be the driving aspect for ECS implementation in cities to achieve an inclusive regeneration in target areas and enhance acceptance in vulnerable groups. We identified driving factors for successful co-implementation of ECS concerning socio-ergonomic, socio-cognitive, and socio-economic aspects to facilitate the overall participation of citizens (Table 2). Enhancing reachability, accessibility, and usability of ECS, lateral hierarchies and socio economic participation will particularly help disadvantaged groups in deprived neighborhoods. Certain information technology instruments have been developed to support informed decision making of cities administrations and citizen participation (e.g., [68,69]).

Table 2. Driving factors for successful co-implementation of social efficient ECS.

Socio-Ergonomic Factors	Socio-Cognitive Factors	Socio-Economic Factors
<i>Reachability and connectivity within the urban matrix:</i> Reduce distance from users to ECS and between ECS, enhance walkability and connectivity <i>Accessibility:</i> Allow open participation and barrier-free access <i>Usability:</i> Foster user-friendly processes and design, manageability of ECS	<i>Lateral hierarchies:</i> Power and knowledge distribution in communities to minimize inequalities) <i>Perception and acceptance:</i> Advantages of involvement by multi-stakeholder approaches	<i>Mutual impact on social processes and economics:</i> Foster economic activity affects social life and return Fostering entrepreneurship Support novel and innovative and self-sustaining market uptake of ECS techniques and ECS technologies

4.3. Avoiding Green Gentrification

As benefits for urban regeneration, social stabilization, re-use of resources, and economic growth were demonstrated in numerous pilots the main focus of city administrations lies on upgrading derelict areas with suspended groups suffering from marginalization trends (Table 1, [53,63]). The access of stakeholders within deprived neighborhoods to the knowledge on ECS technologies, best practices, and provided ecosystem services can be facilitated by simple guidelines, practical implementation plans and targeted city investments in ECS. A significant criticism of the ongoing sustainable urban planning is the ‘local trap’ [70], which describes the upgrading of certain city parts fostering gentrification and in consequence supports local hegemonic structures and serving as a flanking mechanism to neoliberalism (e.g., [71]). Within the ECS implementation strategies the threat to foster green gentrification has to be addressed properly to sustain the idea is to create public spaces that are

used by long-time residents, making their ownership of the area more present and visible [63] and confronting the threats of deepening societal inequities by benefitting better resourced organizations and of displacement of lower-income households [53].

4.4. Green Jobs Created by ECS

The high societal relevance of ECS extends to all socioeconomic groups and promise a great potential for green jobs linked to innovative business models for a growing local market and improved value chains for the urban economies in transition. Besides the cost-effectiveness of ECS for the city administration implementing such solutions, a thorough change of business can be initiated. Sustainable financing models and green jobs are revived to contribute to city's economic resilience. Legal barriers for market uptake of ECS products have to be addressed (e.g., Regulations on Food Quality and Safety Standards). Short and regional food supply chains contrast sharply to conventional anonymous supply chains of the global market by geographic proximity, economic viability, social orientation, and environmental sustainability [72]. Short and regional food supply chains are hypothesized as more adaptive to our changing world. ECS implementation enhances food security and will foster effectiveness, innovation, and diversification for the local food system. Effective and resilient entrepreneurship provide greater stability against economic crises compared to large corporations through access to local markets and innovative business efforts. However, research on appropriate business models is scarce (but see [72]). There is a strong need for interconnecting innovative entrepreneurship with traditional technology SMEs and young novel start-ups with new business model approaches. The interlock of processes around the ECS net-chains is crucial to enhance economic feasibility of ECS.

Mainstreaming strategies of ECS have been also criticized in social sciences as being used as device by the local governments to reach the primary goal of economic sustainability and enhanced economic competitiveness [73]. However, the improvement of individual social situation for residents in deprived areas through green jobs also address the environmental and socio-cultural dimension of sustainability and leads to awareness of environmental justice, mental and physical health through well-being and social cohesion.

5. Conclusions

Urban planning is challenged to react to unavoidable densification trends and to growing pressure on environmental justice, social cohesion, livability, well-being, and resilient communities and neighborhoods already leading to increased criminality, segregation, violence against foreigners and refugees, abandoned ghettos and radical political streams, that are observed with growing concerns worldwide. Enhancing the provision of overall ecosystem services is proved to be an adequate instrument to foster urban livability, local identity, and social resilience. Around the world and across all socioeconomic groups, cultural and generational differences Edible City Solutions are booming and demonstrate a high potential for a participatory development of social cohesion. However, we observed a lack of mainstreaming knowledge on ECS technologies, experiences and provided ecosystem services. Short term actions within election periods, the sectoral functioning of city administrations and the current lack of integration of ECS into the urban planning process and of strategic support through urban policies limits exploitation of ECS benefits. Co-planning, co-design, and co-implementation of ECS are crucial to avoid green gentrification and to foster the strong involving and activating momentum of ECS. The holistic approach on multifunctional productive urban landscapes is the base for self-sustained cities. Strategic implementation of ECS rises the individual and public awareness for the paradigm shift of urban lifestyle needed to face successfully the challenges of the 21st century.

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