Sustainability **2015**, *7*, 4511-4523; doi:10.3390/su7044511

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Communication

Zero-Acreage Farming in the City of Berlin: An Aggregated Stakeholder Perspective on Potential Benefits and Challenges

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Academic Editor: Marc A. Rosen

Received: 10 February 2015 / Accepted: 10 April 2015 / Published: 16 April 2015

Abstract: How can buildings be combined with agricultural production and what are the major potential benefits and challenges for the introduction of zero-acreage farming (ZFarming) in Berlin from the relevant stakeholders' perspectives? These questions were explored through a series of interviews and stakeholder workshops held between 2011 and 2013. The aim was to identify the most suitable building-integrated farming model for the Berlin metropolitan area and to develop guidelines for the model's successful and sustainable implementation through a stakeholder-driven approach. This paper provides an aggregated synthesis of the outcomes derived from the qualitative interviews and stakeholder workshops. As the results reveal, the stakeholders perceive potential benefits and challenges related to the issue of ZFarming in all dimensions (economic, social, environmental and political).

They largely agreed on the importance of focusing on local resources, using energy-efficient production—including social and educational aspects—and developing new market structures when introducing ZFarming to the city of Berlin. The stakeholders identified urban rooftop greenhouses (RTG) as the most promising farming model for Berlin. In a joint collaboration of all stakeholders, a manual for RTG was developed within the participatory innovation process that addresses the identified problems and challenges associated with future implementation and governance of RTG in Berlin and beyond.

Keywords: urban agriculture; innovation; participatory approach; rooftop greenhouse; key informant interviews

1. Introduction

1.1. Background

Inner-city gardening already has a long tradition in Berlin (Germany). Traditional urban gardening types include family food gardens, school gardens, and garden plots, which are located throughout the city. According to official statistics, 3000 ha (3% of Berlin's area) fall under the official land use code of an allotment garden ("Schrebergarten") [1]. They were established in the 19th century to improve the self-sufficiency of inhabitants with lower incomes, such as workers, families with multiple children or elderly citizens. Similar to what has been observed in most cities throughout the industrialized world in the Global North in the cases of victory gardens and war gardens [2,3], urban agriculture in Berlin became particularly important in times of crisis, and urban garden facilities were primarily important to provide fruit and vegetables during times of limited food access.

A new momentum has developed in recent years whereby urban agriculture occurs not only in garden plots or urban brownfields but also in and on urban buildings. New types of initiatives and urban food producers now focus on urban farming activities, which connect food production to the built environment of the city. The term "zero-acreage farming" (ZFarming) is used to describe all types of urban agriculture characterized by the non-use of farmland or open spaces [4]. ZFarming may include rooftop gardens, rooftop greenhouses (RTG) and edible green walls, as well as innovative forms, such as indoor farms and vertical greenhouses [4]. In recent years, ZFarming projects have increasingly been planned or established by nonprofit associations, commercial or semi- commercial start-ups and private initiatives throughout many cities worldwide [5]. Similar activities can also be observed in the city of Berlin, where projects are planned or implemented for both social and commercial purposes.

1.2. Zero-Acreage Farming

Within the worldwide public and scientific discourse, urban agriculture with its various forms has been considered as a possible strategy to combat the challenges posed by global megatrends, such as urbanization and climate change [6]. Scholars from various disciplines and throughout the world have addressed how urban production can serve as a new framework to change the common practice of food production, food processing, food transport and consumption [3,7–13]. The underlying principle of the productive urban city can even contain a shift of common conceptions when it reaches a point where "rural" and "urban" categories themselves no longer clearly denote legible spatial units any longer [14] and cities are being defined as "Continuous Productive Urban Landscapes" [7].

Although ZFarming is at an early stage of research, the development of innovative and sustainable concepts in the field of ZFarming has increased in recent years. Existing studies refer to holistic frameworks, such as multifunctionality or sustainability, and acknowledge the integration of agriculture into urban areas as a strategy that has economic, environmental, and social effects [4,5,15]. In the Global North, the issue of agriculture in and on urban buildings has recently begun to attract significant attention and has increasingly been discussed and investigated in cities in Canada and the U.S. [9,16–19]. Thomaier *et al.* [5], who analyzed 73 worldwide ZFarming projects, revealed that ZFarming generates innovative practices that may contribute to sustainable urban development. Besides growing food, it produces a range of non-food and non-market goods. It involves new opportunities for resource efficiency, new farming technologies, specific implementation processes and networks, new patterns of food supply and new urban spaces. Specht *et al.* [4] compiled an overview of opportunities and limitations of ZFarming from the literature and concluded that ZFarming has a high potential and has attracted promoters globally. The analysis demonstrated that despite its multiple positive functions, ZFarming faces several challenges, such as the problems of high investment costs, technical uncertainties or exclusionary effects.

Most previous studies of ZFarming focus on one specific type. Open-air rooftop gardens, which have the longest tradition, are primarily investigated with regard to their social impacts or technical implementation [20–23]. Regarding enclosed forms, scholars investigate general potentials or present practices of building-integrated agriculture (BIA) [18,19,24–26], defined as the practice of locating high-performing hydroponic greenhouse systems on buildings [25]. Additional studies examine the potential and feasibility of indoor or vertical farming as an opportunity for large-scale urban food production in multi-story vertical greenhouses [27–29].

Although practical examples of non-commercial rooftop gardens can be found all over the world, the most prominent large-scale or commercial rooftop farms are found in North America. Well-known examples are the New York based start-up "Brooklyn Grange" that uses the roof of a former industrial building for urban farming. The rooftop greenhouse of "Lufa Farms" in Canada was the first commercial RTG. The 1400 m^2 greenhouse of "Gotham Greens" in New York uses hydroponic production techniques. Both companies have already established follow-up RTG projects. "The Plant" in Chicago uses an abandoned slaughterhouse as an experimental field for indoor growing. In Singapore, "Sky greens" established a multi-story greenhouse for urban food production as a prototype for Asian megacities. The "Urban farmers" in Switzerland have created an RTG business prototype for European cities. For research purposes, an "RTG-Lab" has been installed on a new building of the Institute of Environmental Science and Technology (ICTA) in the Universitat Autònoma de Barcelona (UAB) in Spain.

The dialogue regarding the introduction of ZFarming in the context of European cities is still in its infancy. Cerón-Palma *et al.* [15] investigate the barriers and opportunities that technical focus groups (e.g., architects, engineers) associate with implementing Rooftop Greenhouses in the Mediterranean region. Previous studies of large European cities have investigated the potential for rooftop greenhouses in Barcelona (Spain) [15,30–32], rooftop farming in London (UK) [33], and large-scale urban agriculture in the Netherlands [34,35]. To date, no previous studies have focused on Germany, and no previous studies have reported on the introduction and innovation process of ZFarming from a stakeholder perspective.

The aim of the project "ZFarm–Urban Agriculture of the Future" (www.zfarm.de)—was to close this gap and find opportunities for food production in or on urban buildings in metropolitan Berlin according to the following objectives: What are the major potential benefits and challenges of introducing ZFarming in the city of Berlin and which is the most suitable farming model from the relevant stakeholder's perspective?

2. Research Method

To explore these objectives, a participatory and stakeholder-centered approach of "Regional Open Innovation Roadmapping (ROIR)" [36] was selected. The first research step was a series of qualitative interviews (as described by Patton [37]) to achieve an overview of the stakeholders perspectives on ZFarming. We defined different stakeholder groups that we considered relevant to the introduction and implementation of ZFarming projects in Berlin. Our objective required including all stakeholder groups that might be relevant *at any stage of the innovation process* from the initial development to the market introduction. In preparation for our research process in Berlin, seven in-depth interviews were conducted with pioneers in rooftop farming in New York City. These interviews offered the first insights on the topic and directions for potentially relevant stakeholders in Berlin. The stakeholder groups were further defined (1) through the considerations of potential key stakeholder groups for the development, implementation or launch of a ZFarming-project, followed by (2) literature research about on-going ZFarming-related activities in Berlin and (3) the selection of additional stakeholders through snowball sampling (*i.e.*, asking previously interviewed stakeholders to refer additional relevant key stakeholders).

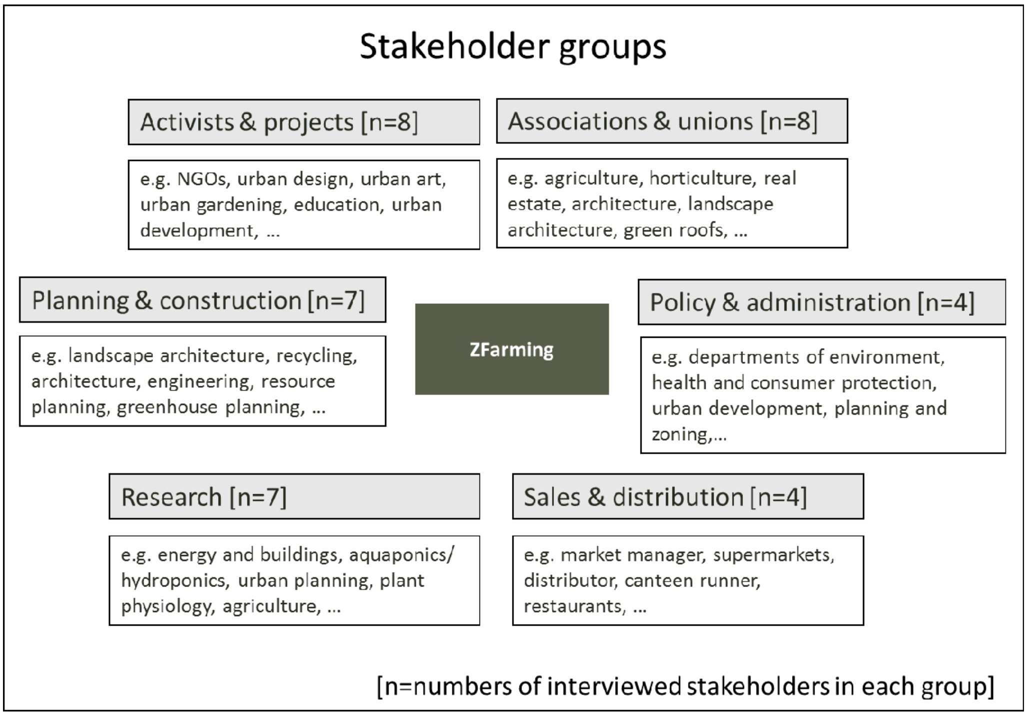

Figure 1. Map of stakeholders involved in the different stages of the potential implementation of a ZFarming project.

The stakeholders were approached and interviewed between 2011 and 2012. As shown in Figure 1, we interviewed 38 stakeholders in the following key informant groups: (1) activists and projects; (2) associations and unions; (3) planning and construction; (4) policy and administration; (5) research; and (6) sales and distribution.

In general, two of the five researchers visited the interviewees, typically in their professional environments. Each interview lasted approximately 60 min. The interviews followed a structured agenda consisting of seven major parts. Each interview began with (1) a general introduction followed by questions on (2) personal experiences, knowledge and associations concerning ZFarming; (3) the potential benefits of ZFarming; (4) the potential problems and risks of ZFarming; (5) social acceptance factors and potential conflicts; (6) barriers and opportunities in the surrounding context and (7) suggestions for additional relevant stakeholders and networks. We transcribed and summarized the content of each interview [37].

Issues that emerged as important during the interviews were extracted and explored further in a series of five stakeholder workshops. Initially, the stakeholders focused on all ZFarming types, including rooftop gardens, rooftop greenhouses, vertical fruit and vegetable gardens and even technologically complex multi-story indoor farms. In the second phase, the participants chose to focus on *rooftop greenhouses* as the most promising type for the city of Berlin. The topic of rooftop greenhouses was examined in detail in the subsequent workshops. Due attention was paid to the technical, social, economic, environmental, administrative and political conditions required to ensure their successful implementation and how these conditions can be established. The ROIR process is illustrated in Figure 2.

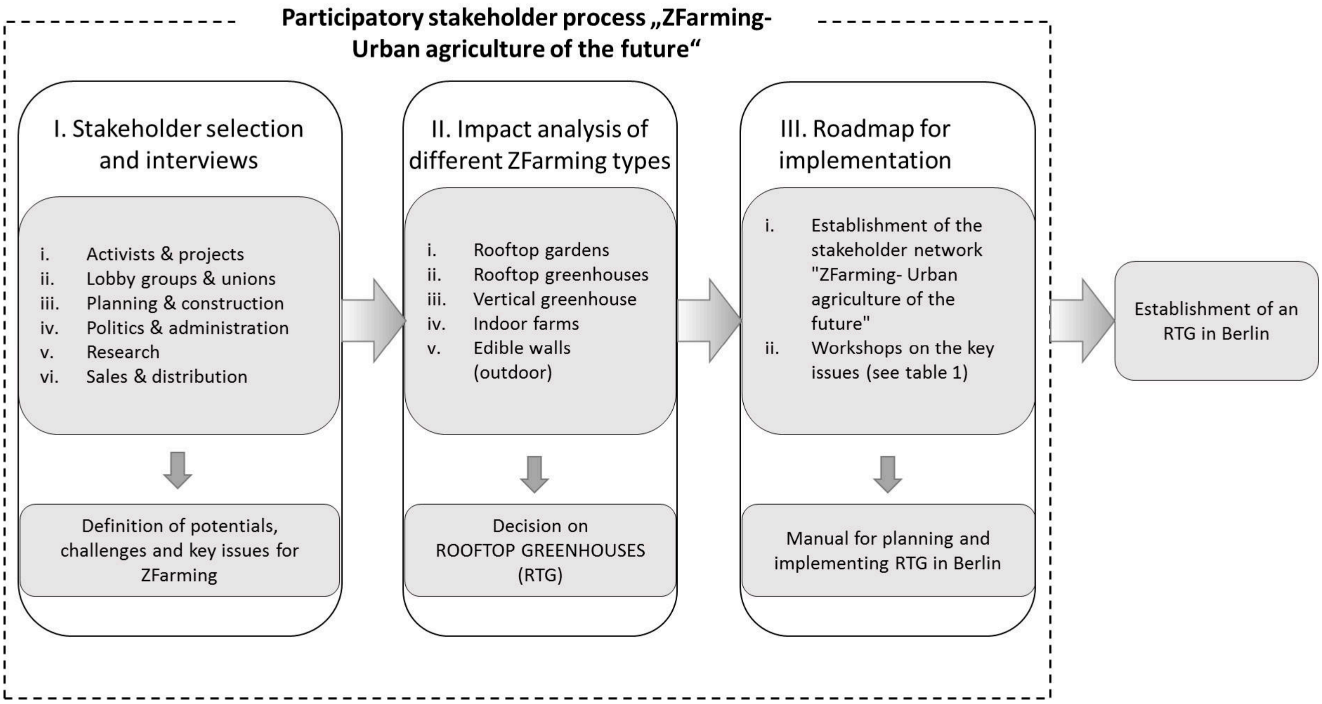

Figure 2. Workflow of the stakeholder-driven innovation process for ZFarming in Berlin (using the ROIR approach, based on Schwerdtner *et al.* [36], adapted to our specific case).

3. Results and Discussion

3.1. ZFarming: Potential Benefits, Challenges and Key Issues for Further Investigation

The interviews provided an overview of the major potential benefits and challenges for the introduction and implementation of ZFarming in Berlin. Here, we provide a condensed overview of these potential benefits and challenges from the perspective of the interviewed stakeholders.

In conclusion, the interviews revealed that the involved stakeholders perceive potential benefits and challenges in all dimensions related to the issue of ZFarming. Most emphasized the positive social benefits deriving from improved community involvement and proximity to the consumers, but they also noted risks associated with specific production methods and neighborhood transformation processes. On the environmental level, stakeholders perceived that ZFarming can help enhance the urban environment and resilience through improved resource efficiency. However, the interviews revealed many unresolved questions regarding the technological feasibility, environmentally friendly production technology and energy optimization. In economic terms, the stakeholders recognized new market and value-chain opportunities. They identified a range of opportunities related to retrofitting and re-purposing old industry buildings, which frequently exist in Berlin's inner-city areas (one famous example is the large vacant buildings of the former inner-city airport, Tempelhof). Nevertheless, respondents also noted the challenges of finding appropriate sites, legal restrictions, economic feasibility and potential competition. On the political level, the stakeholders noticed many synergies with existing strategies, but they also described uncertainties related to planning and policy guidelines in the field of ZFarming, where they predict the need for more integration and clarification in the future.

3.2. Impact Analysis of Different ZFarming Types and Roadmap for Implementation

The key issues for ZFarming that were identified during our interviews (see Table 1) were further explored in a series of workshops that followed the interviews in 2012 and 2013. The relevant potential benefits and challenges were examined in detail by the stakeholder network called "ZFarm–Urban Agriculture of the Future" consisting of approximately 50 experts in the field. For deeper exploration of the potential benefits and challenges of ZFarming in Berlin, we applied the participatory approach of ROIR (as described by Phaal *et al.* [38], and Schwerdtner *et al.* [36]). We attempted to include all the previously mentioned stakeholder groups to ensure that the experts had various backgrounds related to the interdisciplinary nature of the topic.

The workshop series aimed to identify the most suitable farming model from the relevant stakeholder's perspective. The purpose was to address and work on the perceived risks, develop common goals and create a consensus among the different stakeholders so that they could jointly develop guidelines and strategies for successful implementation of one ZFarming type in Berlin.

Step 1: First, the stakeholders compiled and discussed potential ZFarming types, which included rooftop gardens, rooftop greenhouses, vertical fruit and vegetable gardens and technologically complex multi-story indoor farms. Second, they defined a set of criteria that a potential ZFarming project should fulfill to meet the aim of sustainability (e.g., employment, improvement of water efficiency, energy efficiency, educational benefits or market for the products).

Step 2: Based on a comprehensive impact analysis of the expected economic, ecological and sociocultural criteria of the various ZFarming proposals, the stakeholders jointly decided that RTG had the most development potential. For indoor farms, the stakeholders recognized the required amount of energy for lighting, the high investment costs and lack of social acceptance as major disadvantages. For open vertical or rooftop gardens, the climatic conditions in Berlin only allow a very short growing season and the stakeholders estimated little entrepreneurial and innovation potential. In the end, the stakeholders chose to emphasize urban RTG, which they found to be the most promising proposal for Berlin.

Step 3: In subsequent workshops, the stakeholders used their expertise to continue working on the key implementation issues (see Table 1) and developing guidelines for the successful establishment of RTG. The stakeholders' collective knowledge helped to integrate the political, social, technological, ecological and economic perspectives on the topic of RTG. The issues discussed included all relevant aspects from the initial concept of the RTG through the technical and financial feasibility to the successful implementation of RTG. Topics investigated included:

i. Ideas and preliminary planning (e.g., Project aims/Operator models/Use concepts)
ii. Analysis and decision-making (e.g., Site analysis/Construction and planning law)
iii. Marketing and public relations (e.g., Strategic marketing planning/Press and public relations activities)
iv. Production planning (e.g., Products/Production methods/Greenhouse parts/Energy optimization and resource efficiency/Quality assurance and certification)
v. Financial planning (e.g., Economic feasibility/Forms of financing and funding opportunities)
vi. Project support (e.g., Involving the public/Networking)

As the main outcome of the participatory process, a guidebook that addresses the identified potential benefits, challenges and key issues was developed to enable administrators, politicians, citizens and future operators to address ZFarming in Berlin [39].

The applied participatory process could contribute to increasing the potential use of ZFarming in different ways. As a very concrete outcome, the results presented in the jointly published manual for RTG can help to make meaningful use of the potential benefits of ZFarming while addressing associated problems and challenges [39]. Similar to what has been described by Schwerdtner [36] for an earlier application of the ROIR approach, the ZFarming process was highly appreciated by the participating stakeholders because it allowed them to reflect and select various development options. According to Schwerdtner [36], one advantage of the approach that our process confirmed is that it can be used by non-experts and increases transparency about the process and its results among all participants. Moreover, the process enabled the establishment of new cooperation and facilitated the formation of a stakeholder network. Finally, the ROIR process contributed to knowledge exchange between the different stakeholder groups and encouraged knowledge generation for those who participated. The agreement on common goals and strategies for the future development of ZFarming and the other positive effects could only be reached through a participatory method because the stakeholders were not previously connected to each other before the ZFarm project.

Table 1. Compilation of potential benefits and challenges of ZFarming in the social, environmental, economic and policy dimensions from the perspective of the involved stakeholders and derived key issues for implementing ZFarming in Berlin.

ZFarming dimensions	Potential benefits	Challenges	Key issues for implementing ZFarming in Berlin
Social	Educational benefits; Community building (empowerment, fun); Improved consumer awareness and transparency; Improved community food security and food quality; Improved building aesthetics	Health risks (air pollution, use of waste water); Projects and products may not be accessible for everyone (exclusivity); ZFarming projects could increase gentrification processes in neighborhoods; Soilless growing techniques may not be accepted	Integration of educational aspects with ZFarming; Integration of social benefits/social inclusion, Quality assurance and certification; Public involvement (e.g., participatory approaches, media)
Environmental	Improved water efficiency; Improved organic waste recycling; Improved building energy efficiency; Reduced transport emissions; Improved microclimate	Technocracy level may be too high for rooftop greenhouses or indoor farms; Indoor farming: energy input for lighting is too high	Environmental efficiency of (production) technologies; Energy optimization; Resource efficiency
Economic	New economic opportunities for large vacant industry buildings; New marketing opportunities (market demand for regional products is given), e.g., new labels for urban farming products; Improved regional value chains; Projects can be showcased to boost innovations; Potential synergies with rural producers	Difficulties locating appropriate sites for ZFarming; Planning and building laws are strict and difficult for (commercial) practitioners; Rooftop farming creates competition for other uses (e.g., solar energy); Associated technology is too expensive; Operators are often not trained farmers or gardeners; Consumers may reject soilless grown products; ZFarming could create competition for rural farmers	Site analysis, Possible operating (cooperation) models, Strategic marketing planning for ZFarming, Market implementation/distribution; Potential ZFarming products; Economic feasibility; Financing and funding opportunities
Political and legal framework	Synergies with political strategies at the city level; ZFarming meets general societal and urban lifestyle trends	Lacking long-term perspective and political support for projects; Missing or unclear legal framework; Planning insecurities for projects	Integration of ZFarming into political strategies and policy making; Clarification of legal aspects, particularly planning and building law

The next step would be the practical implementation of an RTG pilot project in Berlin, which could not yet be realized through the network members but is currently in the planning phase.

3.3. Potentials for ZFarming in Berlin

Compared to the perspectives on ZFarming in other countries, the major potential benefits for Germany are not perceived in terms of its contribution to food security but regarding its potential for resource-optimization, the development of innovative business models and social cohesion. The pure food production purpose is often perceived as a secondary benefit. This perception can be explained by the fact that most large cities in Germany are surrounded by productive landscapes and already have established regional food chains. This situation applies to Berlin, which is surrounded by the state of Brandenburg: home to many producers of agricultural and horticultural products that are marketed in the Berlin metropolitan area. Most stakeholders perceived that the real value of ZFarming projects in Berlin lay in the various opportunities to educate people, create social interactions and highlight alternatives for food consumption. Moreover, strong benefits were perceived with respect to urban resource efficiency and recycling. The prioritization of social and environmental improvements that has been identified for the case of Berlin has already been observed and described in the international literature for other cases in the Global North [16,17,40,41]. Most stakeholders emphasized that although ZFarming projects should be economically self-sufficient, their major value lies in the production of non-market goods. Therefore, the stakeholders reject purely profit-oriented models. In general, stakeholders estimate the potential benefits related to the actual food production to be higher for cities in other countries that are not surrounded by productive land or where food is commonly imported for longer distances. Higher benefits are further perceived for cities with food access problems (such as in certain shrinking cities in the U.S.) or for very dense cities where land for ground based urban agriculture is not available (such as in certain Asian megacities) where ZFarming is perceived to be more important than it is in Berlin.

Although the results are specific to Berlin to some extent, we hypothesize that the perceived benefits and challenges and the key issues could be transferred to other spatial contexts, particularly other large European cities. We assume that our findings are also relevant for the development of ZFarming in other cities. The compilation of key issues for the introduction of ZFarming could be a promising starting point that can be extended and investigated in more depth both in Berlin and in other cities.

4. Conclusions

Our study indicates that the relevant stakeholders generally perceive that ZFarming can provide an innovative solution for future development in Berlin. RTGs in particular have been identified as a promising model that bears potential benefits for sustainable urban development. However, their implementation is also associated with limitations and uncertainties. To summarize, most stakeholders agreed that potential ZFarming projects should focus on local resources, energy-efficient production, the consideration of social and educational factors and the building of new market structures both to avoid the disadvantages and make meaningful use of the potential benefits. Based on the results of our participatory process, key challenges for the future of ZFarming in Berlin lie in the social inclusion, energy optimization, technological and economic feasibility and the integration of ZFarming into policy making. The various stakeholders should continue to work collaboratively on the development of common goals with the establishment of pilot projects and begin evaluating the "real" impact of RTG projects on the urban environment.

Acknowledgments

Funding from the German Federal Ministry of Education and Research (BMBF) has supported this work (funding code FKZ 16I1619). The Leibniz Centre for Agricultural Landscape Research (ZALF) is institutionally funded by the Federal Ministry of Food and Agriculture (BMEL) and the Ministry for Science, Research and Culture of the State of Brandenburg (MWFK).

We would like to thank Armin Werner, Susanne Schön, Heike Walk, Anna Galda and Sven Wurbs, who contributed to the overall success of the ZFarm project. Finally, we wish to express our greatest thanks to all our interviewees and the stakeholders of the ZFarm network, who fruitfully collaborated with us throughout the entire process.

We appreciate the time and effort that the editors and reviewers have taken to comment on our paper and we want to thank them for their useful suggestions concerning our manuscript.

Author Contributions

All authors contributed to the design of the study, or to the production, analysis or interpretation of the results, derived from the qualitative interviews and stakeholder workshops. All authors read and approved the submitted manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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