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Vulnerability Analysis of Urban Agriculture Projects: A Case Study of Community and Entrepreneurial Gardens in the Netherlands and Switzerland

Ladina Knapp, Esther Veen, Henk Renting, Johannes S. C. Wiskerke, and Jeroen C. J. Groot*

CORE IDEAS

- We identified the main challenges and perturbations faced when an urban agriculture (UA) project is established.
- The analysis was based on a vulnerability and resilience framework.
- Perturbations stemming from biophysical factors did not have a decisive impact on the continuity of UA projects.
- Perturbations related to socio-institutional factors were the most threatening to the continuity of UA projects.
- Our case studies give an insight in potential perturbations and responses by UA projects in the Netherlands and Switzerland.

ABSTRACT

Small-scale bottom-up urban agriculture (UA) initiatives have a large potential to improve the quality of life in cities through their impact on ecological and social processes. However, it is unclear which criteria determine their successful establishment and continuity. We assessed these criteria for 29 projects in the Netherlands and Switzerland using a vulnerability analysis framework. We analyzed biophysical and socio-institutional criteria for project establishment by conducting interviews with project leaders. Projects were scored for their exposure to perturbations and their sensitivity and resilience after a perturbation, resulting in an overall vulnerability score per project. We found that the vulnerability of UA systems depends strongly on local circumstances. The main perturbations and causes of vulnerability originate from social-institutional and human conditions, such as the institutional sphere, assistance of local authorities, and the determination of project leaders. Different sources of resilience were found, such as social protest, and project leaders' adaptation to local circumstances. Biophysical factors were of less influence as the adaptive capacity of projects provides resilience against such perturbations. As perturbations are case-specific, targeted policies would be desirable to support these promising initiatives.

URBAN AGRICULTURE has become rather popular nowadays, and different ways of growing food in cities have emerged to include community gardens, rooftop gardens, and city farms (Lovell, 2010; Turner, 2011; Veen et al., 2012). Attempts to produce food in cities often originate from social initiatives and depend on available socio-ecological niches, defined as multi-dimensional spaces of opportunities that are constrained by biophysical, socio-cultural, institutional, economic, or technological factors (Ojiem et al., 2006). Small-scale bottom-up urban agriculture (UA) initiatives like community or entrepreneurial gardens are examples. We define community gardens as non-commercial gardens that are collectively managed to produce crops, vegetables, fruit and/or flowers for self-supply, and we define entrepreneurial gardens as small-scale commercial garden projects

L. Knapp and J.C.J. Groot, Farming Systems Ecology Group, Wageningen Univ., PO Box 430, 6700 AK Wageningen, the Netherlands; E. Veen, Rural Sociology Group, Wageningen Univ., PO Box 8130, 6700 EW Wageningen, the Netherlands and Applied Plant Research, Wageningen Univ. and Research Centre, PO Box 430, 8200 AK Lelystad, the Netherlands; H. Renting, Rural Sociology Group, Wageningen Univ., PO Box 8130, 6700 EW Wageningen, the Netherlands and Resource Centre on Urban Agriculture and Food Security, c/o Kastanjelaan 5, 3338 AN Leusden, the Netherlands; and J.S.C. Wiskerke, Rural Sociology Group, Wageningen Univ., PO Box 8130, 6700 EW Wageningen, the Netherlands. Received 25 Oct. 2014. Accepted 17 Nov. 2015. *Corresponding author (jeroen.groot@wur.nl).

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cultivating similar products. Both types of UA projects have a large potential to improve the quality of life in cities through their impact on ecological and social processes in the urban environment (Lovell, 2010). The most evident benefit of UA is that food is produced in the city, hence in close proximity to consumers (Lovell, 2010). However, UA is becoming popular not only for food production but also for its multiple other functions (Jansma et al., 2012). For instance, by transforming empty spaces into productive spaces (Mougeot, 2000) UA projects contribute to important ecosystem services, such as pollination and seed dispersion (Ernstson et al., 2010a). Such UA projects also decrease the financial burden of managing urban green spaces by delegating it to local management (Colding and Barthel, 2013). Moreover, UA projects generally increase the amount of vegetation in a city which may regulate levels of humidity (Lovell, 2010) and lower temperatures in the city, capture dirt and gas deposition, and increase stormwater absorption (Deelstra and Girardet, 2000; Leeuwen et al., 2010; McPhearson et al., 2015). An increasing amount of literature argues that UA projects like community gardens lead to the creation of social capital (Evers and Hodgson, 2011; Firth et al., 2011; Glover, 2004; Mendes et al., 2009; Saldivar-Tanaka and Krasny, 2004). Community gardens may also improve participants' nutrition, increase their physical activity, and positively change their mental health (Lovell, 2010; Wakefield et al., 2007). Besides, community gardens have educational value, most notably in schools, for instance regarding nutrition or the environment (Guitart et al., 2012; Heim et al., 2009). In summary, UA projects are not only thought to deliver ecosystem services—which cities need to safeguard to ensure urban human wellbeing in the long run (McPhearson et al., 2015) —but also to have social benefits for urban areas.

The establishment of UA projects depends on various factors. The niche character of small-scale UA initiatives makes their development and persistence strongly dependent on the dynamics in the prevailing biophysical and socio-institutional environments. Hence, they require a good level of resilience to withstand both gradual and sudden changes. However, the available knowledge on their initiation, establishment and resilience is scarce, especially with regards to European countries. According to Clavin (2011), most of the available information on community gardens is in regard to the United States and Australia. Also, Guitart et al. (2012) argue that the academic literature on community gardens generally focuses on projects located in disadvantaged multicultural neighborhoods in the United States. They indicate the need to further study UA projects outside of the United States, to increase knowledge on the different types of "motivations, benefits and challenges" faced in other countries (Guitart et al., 2012, p. 369). Moreover, there is a lack of research on the practical processes that take place when initiating an UA project (Mendes et al., 2009) or regarding the challenges UA projects face during the early phases of establishment (Corrigan, 2011). Furthermore, the mechanisms that induce municipalities to endorse these projects are not clear, nor are the policy consequences that UA projects might have (Mendes et al., 2009). Literature on the topic mostly describes the potential positive externalities that UA offers, via case studies. Yet, understanding how UA projects are being established is crucial for understanding which main criteria need to be satisfied to successfully develop such projects, especially because, thus far, there has been little attention for a resilient supply of non-disaster related ecosystem services in urban areas (McPhearson et al., 2015), to which UA gardens can contribute.

To shed more light on the initiation, establishment, and resilience of UA projects, the main aims of this paper are to (i) analyze which circumstances and socio-institutional and biophysical components are needed to establish an UA system in a given neighborhood, (ii) identify the main perturbations that may threaten an UA system's continuation, and (iii) assess the vulnerability of these UA systems to the perturbations. The research presented in this paper focuses on the establishment and management of 29 UA projects in the Netherlands and Switzerland, thus focusing on projects outside of the United States.

We understand urban agriculture as the production of food in an urban context, "at all levels from commercial horticulture to community projects to small scale hobby gardening" (Garnett, 1996, p. 300). The 29 projects we studied are either community gardens or entrepreneurial UA projects. We define community gardens as non-entrepreneurial gardens producing edible products in an urban area, to which there is a collective element such as collective ownership of the garden or a shared responsibility for the gardening work. Community gardens may be established by one or more initiators, including private individual initiatives, social organizations or movements, and public institutions. We define entrepreneurial UA projects as those that sell their harvests. These include social enterprises such as initiatives supporting the activities undertaken in the project with the resulting income. Entrepreneurial projects may include large-scale urban farms or small-scale projects where products are sold to the public or are processed for their own restaurants.

Urban agriculture is a potential strategy to increase the resilience of cities (McPhearson et al., 2015) "with respect to uncertainties, complexities and major crises" (Barthel et al., 2013, p. 14), not only because UA increases the availability of food, but also because UA increases the diversity of food sources (Barthel and Isendahl, 2013) and makes it possible to maintain knowledge about growing food (Barthel et al., 2013). An important difference on the relation between urban agriculture and resilience between these definitions with those of other authors, however, is that we do not look at how UA projects can improve the resilience of *the city*, but rather we study the resilience of UA projects *themselves*.

To understand the challenges and establishment of UA projects, we follow Ernstson et al. (2010b), and understand urban areas as "human dominated ecosystems" in which social

dynamics play a large role. They are simultaneously, however, "coupled socio-ecological systems", as the human dimension interacts with the ecological dimension (Berkes and Folke, 1998). As for urban *areas*, urban agriculture *projects* can be considered coupled socio-ecological systems (see Eakin and Wehbe, 2009): they are not only affected by human influences such as institutions, policies, and the motivations of project leaders, but also by environmental aspects mostly related to the resources needed for UA projects (e.g., soil, water, sun, pests, or diseases of plants) and the impact of agricultural activities on the biophysical environment. In our analysis of perturbations for UA projects, we focus on both the ecological and the human dimension.

The social-ecological systems of UA projects face perturbations, to which they are vulnerable. However, they also have a certain level of resilience, which enables them to endure. We understand resilience as the capacity of an UA project to react and overcome perturbations so that they can continue functioning. This is in line with the definition of resilience as presented by Carpenter and Folke (2006). They see social-ecological resilience—as argued, we consider UA projects to be socio-ecological systems—as the capacity to absorb shocks, utilize these impacts, reorganize, and continue without losing fundamental functions. Resilience thus informs us about the potential viability and lifespan of an initiative. The resilience of a system depends on various aspects such as management capacities, financial funds, access to information, infrastructure, institutional sphere, type of actors involved, biophysical situation, and the different goals established. As a consequence, resilience is context-specific (Smit and Wandel, 2006). The diversity of components and processes in a system and the degree of self-organization affect the resilience of a system (Tidball and Krasny, 2007). According to Okvat and Zautra (2011) and Barthel et al. (2013) a large diversity of components and high degree of self-organization can be found in nearly all community garden projects.

Vulnerability assessments analyze a given system in particular local circumstances (Eakin and Luers, 2006). In this study, the vulnerability assessment of the UA projects is based on the conceptual approach proposed by Adger (2006), who relates the vulnerability of systems to the combined effects of the *exposure* to perturbations (either an external stress or a shock), the *sensitivity* to these events, and the possibilities for adaptation or *resilience*. A perturbation is a change in the driving variables of the system that originates either from the socio-institutional, or from the ecological environment of the system, or both (Turner et al., 2003; Fig. 1). A perturbation can be sudden or gradual. In the latter case, often a threshold has to be reached before the system is impacted. The processes of the system are changed by the perturbation; when the disturbance is strong the system may be unable to recover and continues performing at a lower level, or may even collapse (Smit and Wandel, 2006). The level of exposure of a system is determined by the probability of occurrence or frequency of a perturbation and its strength (Gallopín, 2006), whereas the sensitivity of a system shows the level to which the system is affected or modified due to a perturbation (Adger, 2006). The behavior of the system after the perturbation can be expressed as its ability to adapt (adaptive capacity), or its ability to retain or restore its original performance (resilience). Thus, the

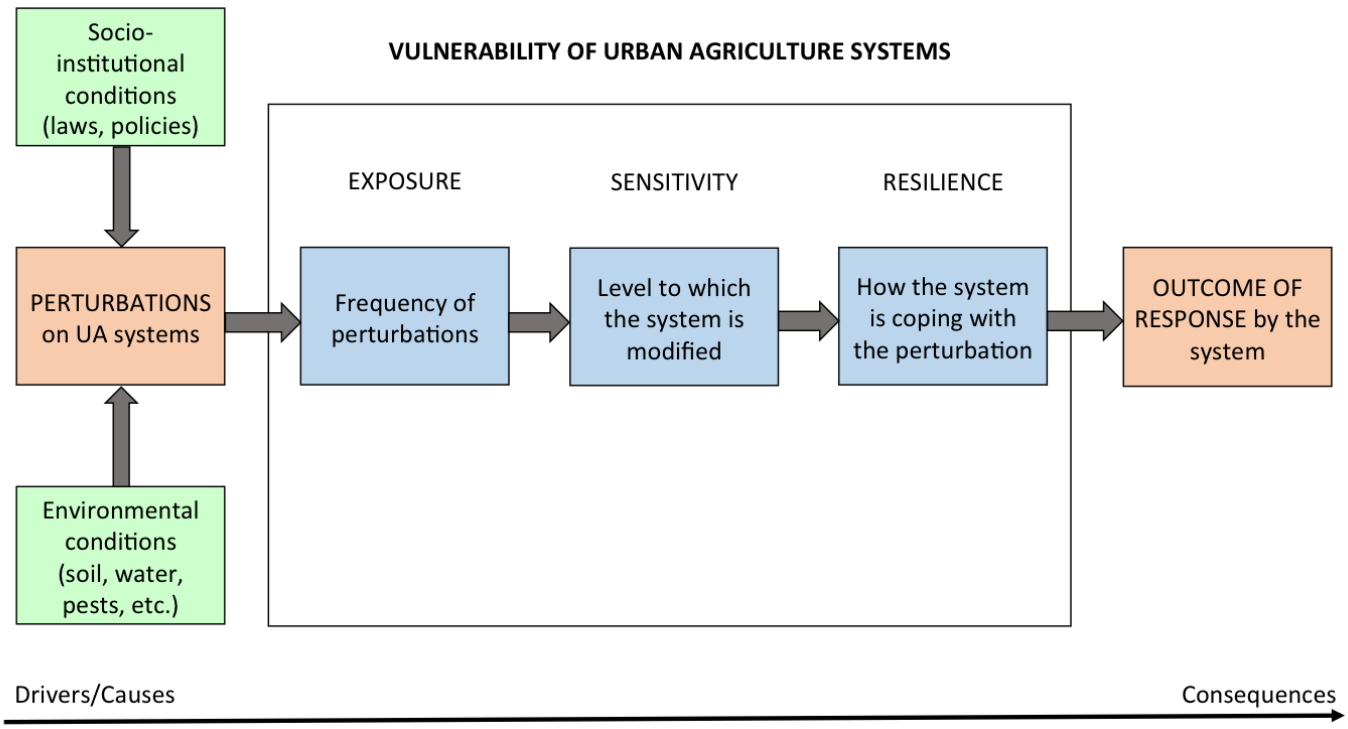

Fig. 1. Vulnerability framework for urban agriculture projects, adapted from Turner et al. (2003).

adaptive capacity of a system is the capacity to adapt or modify itself in a way that it can cope with and recover from the perturbation (Adger, 2006).

MATERIALS AND METHODS

We started our research with a literature review, which we used to create an overview of available information on the two types of UA projects we focus on in this paper (community gardens and entrepreneurial UA projects) and their establishment, benefits, and the challenges they face. Another important output of the literature review was the creation of an overview of most common perturbations for UA projects. As the quantity of available academic references was low, we also considered publications outside of peer-reviewed literature. This is justified because the establishment of UA projects and the challenges they face is often well described in the grey literature. We supplemented the literature review with interviews with various experts on UA in the Netherlands.

The literature review and the interviews with experts were also used to create a list of both types of UA projects in the Netherlands. This list was complemented by information from the website Farming the City (http://farmingthecity.net/, verified 13 May 2016), which lists various projects in the Dutch region Randstad (Amsterdam, Rotterdam, the Hague, and Utrecht), the country's center of urban development and industrial activity. We focused on this region for practical reasons and because it is the most urbanized area of the Netherlands, which supports the notion of urban agriculture. Projects in Switzerland were identified via an Internet search. We created a list of 22 projects in the Netherlands and 7 projects in Switzerland (Table 1). Projects were selected if they fitted the definition of urban agriculture as used in this research.

We used semi-structured interviews and questionnaires to study the projects. For each project we used either a semi-structured interview, that is, an interview conducted face-to-face or by telephone, or a questionnaire sent to project initiators or project leaders. We conducted 21 interviews and received eight competed questionnaires. Interviews were done face-to-face when the contact person had time to show the project. They were conducted over the phone when there was no opportunity to meet (visiting projects in Switzerland was not feasible either). Questionnaires were sent out when the contact person did not have time for an interview at all. The majority of questions were qualitative and based on the overview of perturbations and other project characteristics we found through the literature review. Semi-structured interviews lasted between thirty and sixty minutes. They were recorded and transcribed. Although the semi-structured

Table 1. Projects included in the analysis.

Project name	Starting year	Type of UA project	Location
Moestuinman	2011	Community garden	Rotterdam
Vrijgroen I	2010	Community garden	Leiden
Vrijgroen II	2012	Community garden	Leiden
Ghandituin	2011	Community garden	Rotterdam
Voedseltuin	2011	Community garden	Rotterdam
Tuin aan de maas	2007	Community garden	Rotterdam
Het Bergwegplantsoen	2009	Community garden	Rotterdam
Tuin op de Pier	2012	Community garden	Rotterdam
Buurttuin Transvaal	2011	Community garden	Amsterdam
Valreepgarden	2011	Community garden	Amsterdam
Buurtmoestuin de Middenmoes	2010	Community garden	Heerhugowaard
Bikkershof	1987	Community garden	Utrecht
Buurtmoestuin de Trompenburg	2009	Community garden	Amsterdam
Stadslandbouw Schiebroek Zuid	2011	Community garden	Rotterdam
Heiloo Garden, to be established	2013	Community garden	Heiloo
Tussentuin	2012	Community garden	Rotterdam
Zuidpark Amsterdam	2012	Community garden	Amsterdam
De Groene Campus, to be established	2013	Community garden	Helmond
Educatieve Moestuin	2013	Community garden	Amsterdam
Daktuinen Beuningenplein	2012	Community garden	Amsterdam
Dakakker	2012	Community garden	Rotterdam
Uit je eigen stad	2012	Urban farm	Rotterdam
Beaulieu	2010	Urban farm	Geneva
Gemeinschafts Garten Landhof	2011	Community garden	Basel
Stadion Garten	2012	Community garden	Zürich
Frau Gerolds Garten	2012	Community garden	Zürich
HEKS	2008	Community garden	Bern and Basel
L'arbre à Palabre	2013	Community garden	Biel
Lorraine	2011	Community garden	Bern

interviews allowed us to more fully discuss the answers given than the questionnaires, questions in both research methods were the same (Table 2). This allowed us to analyze the results of these two methods together.

The interview transcripts were coded with the Atlas Ti Software package for interview analysis (http://www.atlasti.com/index.html, verified 13 May 2016). The main subjects originating from the interviews were highlighted and categorized under different concepts, such as project origin, project establishment or perturbations. Some of the perturbations found resembled the ones found in the literature, while other perturbations were 'new'. These new perturbations were added to our overview of perturbations for UA projects. We then selected the ten most common perturbations.

Interviews and questionnaires also gave insight in (i) the level of *exposure* of the systems to these ten perturbations, (ii) their level of *sensitivity*, (iii) their level of *resilience*, and (iv) an *overall vulnerability* level. We used the interview and questionnaire information to manually score exposure, sensitivity, and resilience to these ten perturbations for each UA project, which together led to an overall vulnerability score. The scoring was done in the following way. First we transformed the qualitative data into quantitative measures: based on a qualitative analysis of the data and on a comparison of one project to another, we scored the levels of exposure and sensitivity, varying from LOW with a score 0.0, to MEDIUM with a score 0.5, to HIGH with a score 1.0. (For the level of resilience, we reversed the scores because resilience is positive: hence, the level HIGH is scored 0.0, the level MEDIUM is scored 0.5 and the level LOW is

Table 2. Interview questions.

Theme	Questions
Origins of the garden	1. How did the idea of having a garden start?
	2. Was it hard to find a plot of land?
	3. Why did you choose this site?
	4. What was the expected distance to urban center, infrastructure, markets and facilities? What is the actual distance?
	5. What were the minimum and maximum surface area of the garden that you targeted before site selection? What is the actual area?
	6. Who were the main actors implied in the process? (entrepreneurs, residents, policymakers, property development, education and youth)
	7. What kind of constraints did you face when establishing the project?
	8. What legal status does your community garden have?
Management of the garden	1. How did you manage to establish a garden? What were the first steps?
	2. What are the main challenges you are presently facing?
	3. How will you manage the garden? (Individual plots or collective plots? How many members?
Legal issues	1. Were there any rules concerning urban agriculture?
	2. Was it hard to convince the authorities or were they in favor of the garden?
	3. Did the authorities help you to find the land?
	4. Do you plan to sell the products? If yes, How do you deal hygiene and food sales regulations?
Economic issues	1. How are you financing the garden?
	2. Do you get support from the authorities?
	3. Is the project economically viable?
	4. What were the biggest costs?
Agronomy	1. How did you do to evaluate the quality of the soil, of the air, water?
	2. Do you have soil test reports (OM, nutrient status, pH, environmental assessments pollutants)?
	3. How did you evaluate the area of the garden? (sun and wind exposure)?
	4. How did you decide on which crops you are going to produce?
	5. How did you choose the size of the garden?
	6. Do you farm organically? Why?
	7. Do you use compost? Urban waste? (closed cycle?)
	8. Where did you get the seeds?
	9. How will you handle biodiversity in the garden?
	10. How will you handle sustainability? How do you have access to water?
Users of the garden	1. Who is using the garden?
	2. What is the motivation of the users?
	3. What are the benefits that you would like to have from this project?
	4. What is the main goal of the community garden?
	5. What type of neighbourhood is it?
	6. How many labour hours are spent or will be spent approximately? What is the availability or labour?
Concluding question	1. Which main elements need to be there in order for a community garden to be established and successful?

scored 1.0). Second, we averaged these three scores (exposure, sensitivity, and resilience) to obtain an overall vulnerability assessment that was scaled between 0 and 1, which we derived for every project analyzed. This enabled us to compare the different projects. Third, we used these scores to calculate the average, normalized vulnerability to the different perturbations (Table 3), which helped us understand which of the perturbations on our list can be seen as most challenging. To recapitulate, the vulnerability scores of the UA projects researched are based on the interpretation of the data retrieved from the interviews undertaken with these 29 projects.

There are a few considerations regarding the methods used. First, the results of these 29 projects cannot be generalized to all UA projects in the Netherlands and Switzerland or in Europe. The list is not complete and many different types of projects remain to be studied. We found that UA projects are rather different and locally specific. Therefore it is not possible to design a blueprint on how to establish an UA project or which perturbations will be faced by certain projects. Furthermore, we did not give an overview on the urban agriculture policies in the Netherlands and Switzerland, since policies seem to vary from city to city, or even from one neighborhood to another. Nevertheless, our case studies do give an insight in potential perturbations, and do show examples and patterns with regard to the establishment of urban agriculture in the Netherlands and Switzerland.

Second, the amount of information retrieved from this research was larger for community gardens than for entrepreneurial UA projects. This was due to the fact that we found many more community gardens than entrepreneurial UA projects. Moreover, not much literature was found concerning entrepreneurial urban agriculture. Thus, due to a smaller amount of information on entrepreneurial projects, less observations and conclusions were made.

Third, some of the projects contacted were not yet established, or were in the process of being established. These projects were included in the research, since it was interesting to see what type of challenges the leaders were facing presently. It also meant, however, that we could gather less information regarding the management of those projects. More generally, the age and life-cycle stage is an important factor to take into account in characterizing initiatives and their vulnerability to perturbations.

Finally, the vulnerability scores of the UA projects researched were based on an interpretation of the data. As we studied a large number of projects, it was not possible to do a full vulnerability assessment. This would only have been possible if fewer projects would have been chosen. We decided on a larger number of projects rather than a more thorough vulnerability assessment to better identify the sources of perturbations to the systems.

RESULTS

Characteristics of Urban Agriculture Projects

Urban agriculture projects in the Netherlands and Switzerland seem to be developing increasingly. Most of the 29 UA initiatives started recently (Table 1). Seventeen gardens started in 2011 and 2012, whereas only one project started before 2007 (as early as 1987). Most projects originated from private individual initiatives (19 of the 29 projects), meaning one person or a small group of persons started it. The other projects were established by social movement initiatives (3 projects), building owners (2 projects), housing cooperatives (2 projects), charitable initiatives (2 projects) or a school (1 project). In the case of community gardens, the leaders and participants generally lived in the neighborhood where the project was located (15 of 26 projects).

The community gardens were either established on empty plots, on green squares in the neighborhood, or on rooftops. The majority of gardens were located in residential neighborhoods that were primarily occupied by private residences, whereas entrepreneurial projects were located in industrial, commercial areas, or in parks.

Most community gardens only had collective plots where harvesting produce was done collectively (20 of 26 projects). Six projects had individual plots, all containing one collective plot with herbs, fruit trees and berry bushes. Entrepreneurial UA projects varied from having large plots for production (2 projects) to small raised beds (1 project), while all entrepreneurial projects also had small plots where customers could harvest their products directly.

Table 3. Perturbations experienced by community garden projects and their scores for exposure, sensitivity, resilience, and resulting vulnerability.

Perturbation	Exposure	Sensitivity	Resilience	Vulnerability
Insecurity of land tenure	0.71	0.81	0.83	0.57
Lack of policies	0.79	0.71	0.83	0.55
Departure of leader	0.52	0.87	0.73	0.55
Withdrawal of subsidies	0.79	0.79	0.96	0.53
Lack of remuneration	0.40	0.37	0.73	0.38
Lack of support neighborhood	0.92	0.94	0.88	0.66
Unsafe urban environment	0.65	0.77	0.96	0.51
Insufficient soil fertility	0.81	0.46	0.98	0.47
Polluted soil	0.56	0.54	0.88	0.42
Mean	0.68	0.69	0.87	0.51

Most of the projects studied had a legal status, ranging from foundations to associations. A legal status is required to qualify for funding.

Community garden participants varied from active participants who visit the garden at least once a week, some of which are also a member of the foundational or associational board, to participants who visit once a month or less. Most garden leaders indicated that the common element is that participants were all residents of the surrounding neighborhood. Gardeners or farmers from entrepreneurial projects were employed to take care of the project. In some cases volunteers participated.

The interviewees indicated that community gardens could generally be started with limited financial resources, due to low costs for establishment and maintenance. Several gardens received subsidies from local authorities, the national government, foundations, or competitive grants for creative urban projects. Participants sometimes contributed financially as well. For community gardens the amounts invested varied from €500 (excluding gardening tools) to €85,000 for a 1-yr budget. These budgets varied according to the goal of the garden, the number of people included, whether or not staff was hired, the size of the garden, and the location and type of plot (e.g., whether located on a roof, on a polluted plot in need of sanitation, or on a plot with only grass). Large rooftop gardens generally invested more funds (up to €140,000), since more technical expertise was needed. Before the installation of every project the soil was tested, financed by local authorities or housing companies. Investments of entrepreneurial projects varied between €8,500 and €1,000,000 for the first year.

Considering production methods, most of the project leaders indicated that they tried to identify a good combination of crops, vegetables and herbs. As a consequence, most projects could be considered as diverse poly-cultures and generally crop rotations were practiced. None of the UA projects used chemical pesticides or artificial fertilizers. The main inputs were manure and compost. The manure was either bought, or received for free (for example from pet farms or acquaintances such as farmers or horse riders). Compost was bought or produced with vegetable scraps of participants, organic restaurants or an own restaurant (at two entrepreneurial projects).

Main Perturbations and Strategies

The interviews revealed that some perturbations were more challenging than others. Interestingly, project leaders did not consider all the perturbations suggested in the literature to be challenging. For example, a perturbation mentioned often in the literature is polluted soil, including the challenges to keep the production safe (Harms et al., 2013; Leake et al., 2009), yet interviewees indicated that if soil was polluted, raised beds were established or the soil was sanitized via support of the local authorities. Project leaders therefore did not consider soil pollution an important impediment for community garden establishment so long as there were possibilities to avoid or remediate these problems.

Some of the project leaders mentioned soil fertility as a limiting factor, as a lack of inherent fertility (sandy soil) or low organic matter content which takes a long time to improve. Most projects did not face many problems regarding pests and diseases. When problems arose, project leaders tried to adapt either by changing the type of plants or by bringing more diversity into the garden:

> "We do have insects on some vegetables like borecole and broccoli, but we just try something else, instead of killing the insects to get some produce out of it, we just put other vegetables." (Respondent #6)

Moreover, most leaders considered growing produce a learning process, for which they used a trial and error method. This was different for entrepreneurial projects, for which pests and diseases and the lack of nutrients did represent an important perturbation. However, such projects employed farmers or gardeners that know how to adapt to such perturbations.

One of the most important perturbations mentioned by respondents was the duration and security of the availability of the plot, which was usually unclear, as expressed by one of the leaders:

> "It's not really clear, what I did do is I asked if next year we are still in business and they said yes [...]. So basically it seems like every year they give us the green light, but [...] they could put us away of the plot before we harvest the products." (Respondent #1)

Community garden leaders adopted different strategies regarding this land tenure insecurity. Some counted on social protest if the garden were to be expropriated or taken away, others stated from the beginning that they would leave the area once it would be used for other purposes. For entrepreneurial UA projects the availability of the plot varied between 10-yr agreements to agreements needing to be renewed every year.

We found four main issues concerning the organization of gardens: (i) building a group of motivated people, (ii) vandalism in the neighborhood, (iii) theft of vegetables, and (iv) knowledge on gardening. However, being integrated in the neighborhood was expected to help overcoming all four of these organizational issues. Many garden leaders (21 of 26) indicated that support of the neighborhood was of crucial importance for the establishment of a community garden and to become an integrated part of the area. Some of these four issues were less pressing for entrepreneurial projects; farmers or gardeners who worked in the projects were motivated to work and did not have many knowledge issues. Further, these projects all had a fence around them, protecting them from vandalism and theft. Neighborhood support was important for finding clients, however. Vandalism impeded the establishment of one project studied. However, respondents indicated that if the garden is well integrated in the neighborhood, social control over the garden strengthens, so that vandalism or disturbances in the garden may decrease. Theft of vegetables can become a perturbation when it happens frequently. Participants of most projects found it disappointing when thievery

occurred, but it was not recurrent and solutions were found in all cases. Leaders proposed different strategies such as producing an abundant amount of vegetables, social control by the neighborhood or negotiating with the people who take the vegetables. The idea of abundance is the following:

> "I really believe in the abundance so if there is enough, people won't steal, people won't demolish [...] I am a big believer of the abundance philosophy [...] I am also trying to create more of such gardens in order for there to be the situation where there is more food than what people need [...]." (Respondent #1)

Other leaders thought that theft could be regulated by social control. When residential houses surround the garden, social control to regulate theft is higher, especially if the garden is well integrated and accepted by the local residents:

> "The first things I can remember here is that a tree got stolen, taken away with the roots, and then one time all the rhubarb was stolen, two big bags of harvest whereas we've never seen that person here before. But there is a lot of social control because there is the building here [...] with old people in it, and they always look down [from their building] at the garden." (Respondent #7)

Gardening knowledge was an issue for specific projects established by Transition Town (http://www.transitionus.org, verified 13 May 2016) in Rotterdam, a network of people whom try to change their neighborhood or city into a "healthy, resilience and vibrant " area, which aimed to create a local food network via the multiplication of community gardens in a neighborhood. In such a case, it seems participants' knowledge of and interest in gardening is an important criterion in order for the garden to be self-sustained, especially when the project is not an initiative originating from the residents themselves.

Vulnerability Assessment

We found a number of potential perturbations to the UA systems in this study. To compare different reactions of the projects to similar issues, we focused on the perturbations which were common to most of the UA projects: lack of land tenure, lack of policies, departure of the leader (lack of leadership), withdrawal of subsidies, lack of remuneration, lack of support from the neighborhood, an unsafe urban environment (theft, vandalism, drug dealing, sex tourism), lack of demand for products, lack of nutrients/pests, and polluted soil.

We scored each UA project studied for its exposure, sensitivity and resilience on these ten perturbations. The average of these three scores (scaled between 0 and 1) represent the vulnerability score of each system for each of the ten perturbations. Based on these scores the average, normalized vulnerability to the different perturbations was calculated (Table 3). The largest threats to the UA projects were the lack of support from either the community (neighborhood) or the policy environment (subsidies). Other important vulnerabilities were related to uncertainties associated with the unsafe social environment (e.g., vandalism, theft). Problems with soil quality in terms of pollution or low fertility were considered to have lower importance, just as the lack of remuneration (Table 3). However, for entrepreneurial projects the vulnerability to various perturbations tended to differ from those for community gardens. For entrepreneurial projects, the biophysical yield-reducing conditions such as a lack of nutrients/pests had a high vulnerability score, and a lack of remuneration had a medium vulnerability score.

The projects generally showed very high resilience to the perturbations with an average score of 0.87, whereas the exposure and sensitivity of the project was often considered lower, with average scores of 0.68 and 0.69 (Table 3). Resilience scored high because of the flexibility of projects. Community gardens in particular were characterized by a large resilience to deal with the perturbations. In fact, even if biophysical factors were not adequate, leaders continued their projects and adapted to the circumstances via trial and error methods. This was different for the entrepreneurial projects, where employed professionals were responsible for sufficient harvests. Nevertheless, there was also considerable variation in the individual project scores, in particular for exposure and sensitivity (Fig. 2). For both characteristics, six projects (21%) scored lower than 0.5. The differences in scores between projects with low vulnerability (between 0.18 and 0.28; Fig. 3a) and high vulnerability (between 0.53 and 0.63; Fig. 3b) was largest for the perturbations related to lack of land tenure and policies, unsafe urban environment and soil pollution. The projects with high vulnerability in Fig. 3b are the entrepreneurial projects. As mentioned above, such projects score high in terms of exposure and sensitivity in certain categories that are less relevant for community gardens, such as remuneration, demand, subsidies, nutrients and pests. Nevertheless, also in these cases resilience scores were relatively high because of projects' flexibility. The projects with low vulnerability scores were mostly established by housing corporations, private building owners or institutions. These projects did not face perturbations that

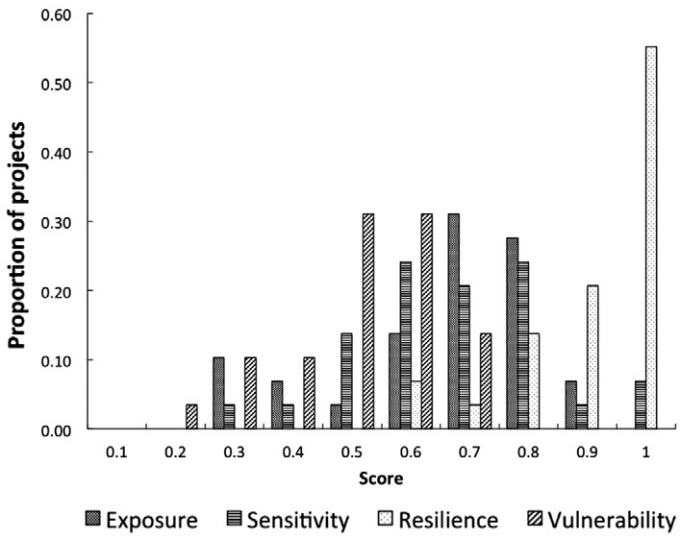

Fig. 2. Frequency diagram of the exposure, sensitivity, resilience and resulting vulnerability to different socio-institutional and biophysical perturbations of community garden projects.

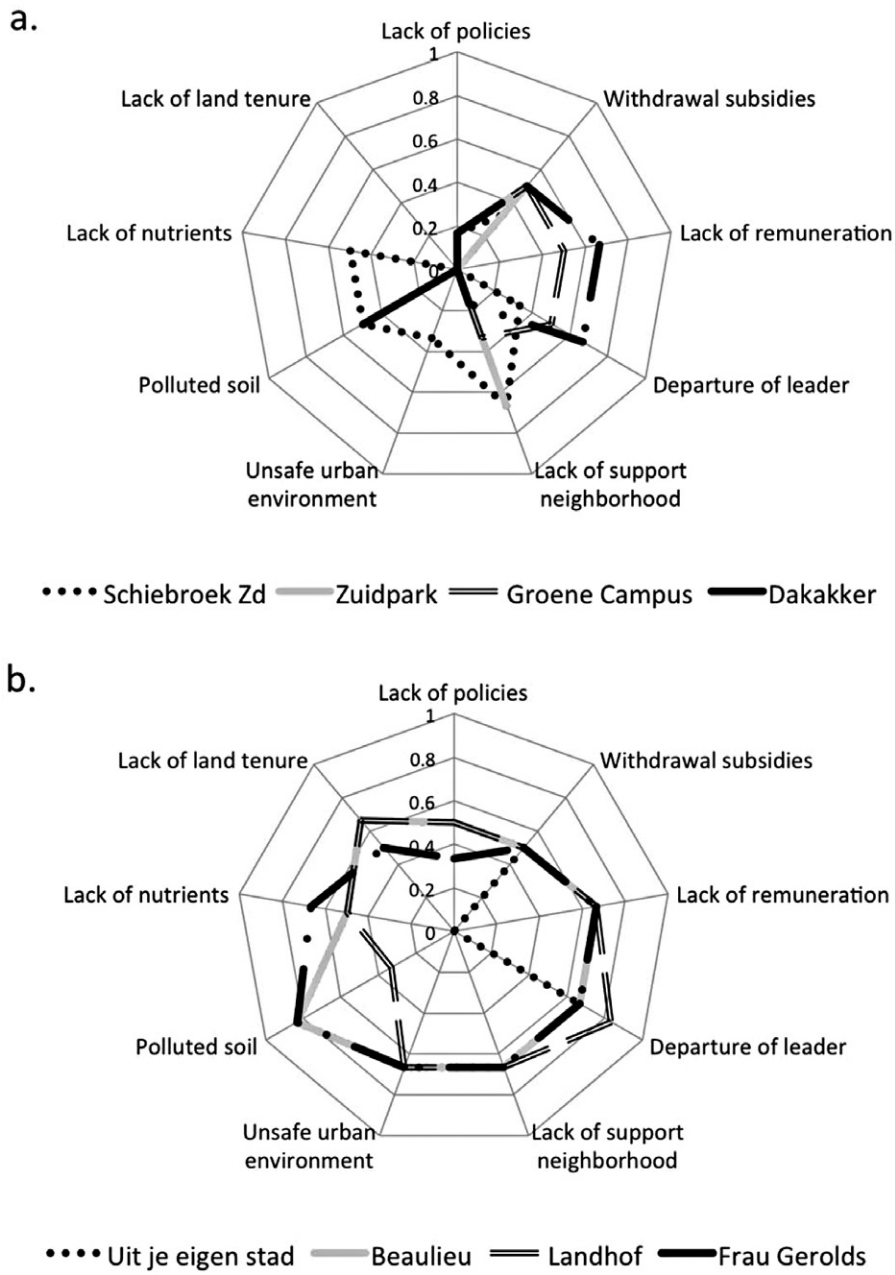

Fig. 3. Scores for individual perturbations of projects with low (a) and high (b) overall vulnerability.

are generally high for other UA projects, such as lack of land tenure. No correlations were found between vulnerability and structural project characteristics such as age or size of the garden, or the number of participants.

Three Exemplary Projects

As it is beyond the scope of this paper to discuss all 29 projects in detail, we chose to discuss three of them more specifically: Heiloo's project, Valreep, and Vrijgroen I (Table 4). The three selected projects have low-medium vulnerability scores of 0.55 (Heiloo), 0.35 (Valreep), and 0.65 (Vrijgroen I). These projects were chosen because they clearly show differences in local socio-institutional circumstances and how these circumstances affect the UA system. Moreover, these examples illustrate how three specific perturbations (lack of land tenure, departure of leader and lack of support from the neighborhood) affect a system, and how systems react differently to such perturbations. A closer examination of these three specific perturbations is interesting because they play clear but differing roles in the three projects. Moreover, the fact that these perturbations are linked, illustrates how perturbations can interact with each other, affecting the vulnerability at large.

Exposure to the lack of land tenure was high in all three cases because the plots were not owned by the leaders of the projects, but by the municipality. In project Heiloo, the municipality imposed strict conditions in the form of an extensive list of legal restrictions, which could not be met by the project. In this case, therefore, other perturbations were linked to the perturbation lack of tenure, such as lack of support from local authorities. The leader of project Heiloo decided to change the

Table 4. Perturbations experienced by three selected community garden projects and their vulnerability-scores (v-score) for exposure, sensitivity, resilience and the aggregate vulnerability score scaled to the range 0–1. Note that low resilience leads to a high score regarding vulnerability.

Project	Exposure	Sensitivity	Resilience	Vulnerability score
		Lack of land tenure		
Heilo	High (v-score 1): Municipality owns the land	High (v-score 1): Municipality established conditions under which the plot could be used by project	Low (v-score 1): Municipality conditions were not fulfilled by project leader	High (v-score 1.00): Project was not established on that plot
Valreep	High (v-score 1): Municipality owns the land	High (v-score 1): Illegal project	High (v-score 0): Although illegal project uses the land	Medium (v-score 0.67): Project was established on illegal plot
Vrijgroen I	High (v-score 1): Municipality owns the land	High (v-score 1): Municipality can end project whenever wanted	Low (v-score 1): No social protest from majority of neighborhood	High (v-score 1.00): Project was ended
		Departure of leader		
Heilo	High (v-score 1): Project only has one main leader	High (v-score 1): Lack of support for leader, too much burden	Medium (v-score 0.5): A group of residents supports the project but not really involved	High (v-score 0.83): Although some residents are enthusiastic the entire burden falls on one leader
Valreep	Low (v-score 0): Project has different leaders and squatting movement supports it	Low (v-score 0): Project supported by garden leaders and squatting movement	High (v-score 0): If one of the leaders leaves, another is available	Low (v-score 0.00): Project supported by various leaders
Vrijgroen I	Medium (v-score 0.5): Project has around five core participants	High (v-score 1): Lack of leadership	High (v-score 0): If one of the leaders leaves, another is available	Medium (v-score 0.50): Project supported by more than one leader
		Lack of neighborhood support		
Heilo	High (v-score 1): Neighborhood support needed to establish project	High (v-score 1): Lack of neighborhood integration	Low (v-score 1): Project not established due to lack of support from neighborhood	High (v-score 1.00): Project not established in the first plot due to lack of support from neighborhood
Valreep	High (v-score 1): Neighborhood support needed to establish project	High (v-score 1): Lack of neighborhood integration	High (v-score 0): Project attracted many participants	Medium (v-score 0.67): Project established but needs continual support
Vrijgroen I	High (v-score 1): Neighborhood support needed to establish project	High (v-score 1): Lack of neighborhood integration	Low (v-score 1): Project did not attract many people	High (v-score 1.00): Project ended due to lack of support

location of the garden to a plot not owned by the municipality. He is now planning another UA project on the grounds of an institution for mental illnesses. In the case of project Valreep, the municipality did not allow use of the selected plot. The garden therefore became an illegal project, a status the project accepted. We interpreted the resilience of project Valreep as higher than that of project Heiloo because Valreep was established in its planned form despite the perturbation– illegal but functioning– whereas Heiloo adapted to the situation by looking for another location. Moreover, project Heiloo is still in development. A lack of land tenure also affected the project Vrijgroen I. Again, the owner of the land was the municipality. During the second year of this project the municipality decided to stop the contract to build a parking lot. The lack of land tenure was linked to the perturbation lack of integration into the neighborhood; if the project had been well integrated in the neighborhood, social protest might have appeared. However, social protest did not occur, therefore we conclude that this project had low resilience regarding neighborhood integration. In fact, project Vrijgroen I used to be in the business center of Leiden and the leader believes that the project was "too hippie like" and simply did not fit the neighborhood in which it was located.

Project Valreep scored a high level of resilience for all three perturbations. One of the reasons for this was the type of leadership. Not only active residents were in favor of this project, the squatting movement also supported it. The resilience of project Heilo was relatively low as it was mostly one leader trying to establish it. Although some residents were interested in the project, they did not play an active role and were no potential leaders. The rather low level of resilience of project Heiloo was also linked to the fact that there was a lack of support from the neighborhood. One of the conditions set by the municipality was that 70% of the surrounding residents had to be in favor of the project. As residents were afraid of vandalism, this condition was not met. Hence, the project was not established.

The analysis of the three projects above clearly shows that perturbations and sources of resilience are not strictly independent. For project Heiloo, the lack of support from

the neighborhood was linked to the fact that the urban environment was unsafe. The latter is also associated with a lack of policies, including the lack of political will to make residents more confident and less in fear of vandalism. Since local authorities were dealing with the establishment of UA projects for the first time and no policies were in place for this type of activity, they established a long list of regulations. This ended up impeding the establishment of urban agriculture projects rather than supporting them. Project Vrijgroen I's land contract was cancelled by the municipality, mostly due to a lack of integration in the neighborhood, hence a lack of neighborhood support. This shows that the project's resilience was relatively low. Finally, although project Valreep was illegal, social support was high thanks to the squatting movement; the project was established nonetheless. The Valreep project therefore showed higher resilience than the other two projects analyzed. While the same perturbations were of relevance to these projects, the systems' resilience differed enormously because of local circumstances, such as local leadership and support from institutions, social movements, local authorities and the neighborhood. Important to mention, however, is that building resilience is a process. It is built over time and thus does not only depend on specific circumstances and project characteristics, but also on whether or not a project has had time to develop.

DISCUSSION

The vulnerability assessment of the UA projects presented in this paper operationalized and applied the conceptual approach as proposed by Turner et al. (2003) and Adger (2006), relating vulnerability to exposure and sensitivity to perturbations, and to the resilience of the system. By identifying perturbations common to UA projects, understanding how systems react to these perturbations, and seeing the solutions they come up with, we showed the systems' resilience. Furthermore, we illustrated that vulnerability scores may vary strongly, depending on the origin of the perturbations and at what level they affect the system. Hence, although several perturbations were of relevance to almost every project, the systems' resilience differed enormously. The vulnerability of a system depended strongly on local circumstances such as leadership, and external support from for example institutions, social movements or local authorities. Most importantly, the scores given to each concept of the vulnerability assessment enabled us to distinguish which perturbations affected the systems most. We found an interesting difference between biophysical health aspects and socio-institutional factors, which we discuss below.

Perturbations from Biophysical Conditions

Respondents did not consider every perturbation identified in the literature review as an important perturbation to their project. An often-mentioned perturbation for UA systems is soil pollution and the following health consequences that might arise, thus impeding the establishment of UA projects (e.g., Engel-Di Mauro, 2012; Harms et al., 2013; Leake et al., 2009; Säumel et al., 2012). In our research, however, soil pollution was not seen as a main perturbation. This is not to say that soil pollution is not to be monitored; it appears necessary to ensure food safety of urban products. Therefore, more studies are needed on how to monitor soil pollution and a number of guidelines are to be established- also with regard to the type of species and techniques that are best adapted when polluted environments do occur (Säumel et al., 2012). We should realize, however, that if this leads to excessive regulations, this may limit the establishment of UA projects and may itself become a perturbation (Okvat and Zautra, 2011).

Yet, as indicated, such biophysical health-related aspects were not seen as key perturbations to the systems we studied. This is because the resilience to these perturbations was high; projects were flexible enough to adapt to the environmental problems they faced, for instance by mobilizing the required knowledge. Hence, project leaders found solutions to polluted plots, either by replacing the soil with fresh soil or by using raised beds. With regard to pests and diseases, most of the researched projects were based on trial and error methods to mitigate yield reducing effects, and for instance replaced crops by other more adapted crops. Hence, the source of resilience is the flexibility of the system, such as to change from one crop to another. Interviews with leaders from entrepreneurial projects also showed that they are rather flexible and can easily adapt to local circumstances.

Perturbations from Socio-Institutional Conditions

Most of the perturbations we found to be significant originated from socio-institutional factors; they were related to institutions, the political sphere, leadership, land tenure issues or UA systems' social environments. Overall, the projects studied were not yet institutionalized, meaning that they were not yet incorporated into a structured system. Coherent sets of policies and institutional arrangements for urban agriculture and gardening are still largely lacking or poorly developed in many cities. Perturbations such as a lack of land tenure, a lack of policies and a withdrawal of subsidies are all related to this "policy vacuum" (Lachance, 2004). In this case it is difficult to judge whether it would be better to leave the "policy vacuum" as it is, or to design a legal framework for the establishment of UA projects. Most of the projects we encountered are bottom up initiatives, started by local residents. If a legal framework—including restrictions—is applied to UA, this might impede the establishment of such projects. Nevertheless, legal frameworks that support land tenure contracts can enhance the security of such projects. Indeed, Mansfield and Mendes (2012) argue that the role governments *should* take regarding urban agriculture is not well established and needs to be clarified.

Milburn and Vail (2010) highlight that the support of the neighborhood is important for the success of a project. We

found that not having neighborhood support is indeed a major perturbation and might result in the project not being established. Projects that do manage to get established may face a lack of social control against vandalism or theft when they are not well integrated in the neighborhood, and entrepreneurial UA projects may encounter a lack of clients. In a worst-case scenario, the neighborhood might even protest against the project. The interviews showed that social movements were also of great importance to sustain UA projects. However, it was difficult to identify the factors that particularly make projects successful, since all but one of these projects have been established rather recently, and thus it was hard to evaluate the successfulness of projects over a longer timeframe.

Vandalism and theft were also mentioned in the literature as perturbations to the system (Reynolds, 2011). Although one of the projects studied could not be established due to vandalism problems in the neighborhood, project leaders of many other systems argued that the project enhanced the quality of life in the neighborhood. For instance, sex tourism or drug dealing diminished and there was less dumping of trash. Moreover, UA projects can increase the value of the neighborhood and diminish the costs of the local municipality for the maintenance of green areas (Been and Voicu, 2006; Colding and Barthel, 2013).

CONCLUSIONS

In this paper we focused on the main perturbations affecting UA projects, both community gardens and entrepreneurial projects, and their resilience regarding these perturbations. We identified different potential sources of perturbations and associated forms of resilience of UA projects. Although it is difficult to make an overall conclusion as UA systems vary a great deal, depending on local circumstances, we did find that most perturbations originate from human, social and institutional conditions, such as policies, institutional support and motivations of local leaders. We found such socio-institutional perturbations to be most threatening for the continuity and performance of UA projects. While projects do encounter perturbations stemming from biophysical factors, project leaders and communities more easily adapted to these circumstances and continued their projects.

The relatively large impact of socio-institutional perturbations, as compared to biophysical ones, resonates with the work of Barthel and Isendahl (2013). In their paper on the resilience of the food supply in Constantinople they conclude that the most severe threats to food security were social in nature, even though the city faced serious biophysical perturbations such as difficult winds and fluctuations of Nile river dynamics. In another paper, Barthel et al. (2013) argue that the network structure of associations and their ability to mobilize social, cultural and economic capital influences their abilities to preserve and revitalize urban landscapes. These authors therefore state that resilience theory is in need of a 'political turn'. Indeed, our research suggests that (local) governments can influence the successfulness of UA projects in their cities. This is a hopeful finding, considering the many benefits such projects may bring to urban areas. Hence, we support the conclusion of McPhearson et al. (2015, p. 154): "governance practices can provide opportunities for utilizing urban [ecosystem services] and building urban resilience reflexively to meet multiple needs [...] and can create a sense of community".

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