

Research article

Co-creating urban green infrastructure connecting people and nature: A guiding framework and approach



Alexander P.N. van der Jagt^{a,*}, Mike Smith^b, Bianca Ambrose-Oji^c, Cecil C. Konijnendijk^d, Vincenzo Giannico^e, Dagmar Haase^{f,g}, Raffaele Laforteza^{e,h}, Mojca Nastran^j, Marina Pintarⁱ, Špela Železnikarⁱ, Rozalija Cvejićⁱ

^a Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan 2, 3584 CS, Utrecht, The Netherlands

^b EcoSol, Edinburgh, United Kingdom

^c Centre for Ecosystems, Society and Biosecurity, Forest Research, Farnham, United Kingdom

^d Department of Forest Resources Management, The University of British Columbia, Vancouver, Canada

^e Department of Agriculture and Environmental Sciences, University of Bari, Bari, Italy

^f Department of Geography, Humboldt Universität Berlin, Berlin, Germany

^g Department of Computational Landscape Ecology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

^h Center for Global Change and Earth Observations, Michigan State University, East Lansing, MI, United States

ⁱ Biotechnical Faculty, Department of Agronomy, University of Ljubljana, Ljubljana, Slovenia

^j Biotechnical Faculty, Department of Forestry and Renewable Forest Resources, University of Ljubljana, Ljubljana, Slovenia

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ABSTRACT

Urban green infrastructure (UGI) and nature-based solutions are increasingly recognized as instruments to address urban sustainability challenges, yet rely on a good understanding of complex social-ecological system (SES) to function adequately. Adaptive co-management (ACM), engaging a broad variety of stakeholders in collaborative learning, is an effective strategy to improve the resilience of a SES. However, ACM studies have been criticized for neglecting the urban context, while also offering little clarity on process objectives and outcomes. To address these knowledge gaps, while also drawing attention to the important issue of socially inclusive UGI development, we present a guiding framework and approach to encourage the ACM of UGI featuring two main components. Firstly, a Learning Alliance (LA) serves as an instrument for collaborative learning and experimentation across different scales. To facilitate upscaling, we propose to establish a complementary Urban Learning Lab (ULL) to facilitate a regular exchange between the LA and legitimate peripheral networks and stakeholders in the city region. Secondly, a stepwise approach to SES analysis serves to engage a representative group of stakeholders in the LAs and ULLs, and support the processes of setting LA objectives and monitoring of adaptive capacity. We illustrate our approach to the ACM of UGI with a case study of LivadaLAB in Ljubljana, Slovenia. Applying the framework and approach, we demonstrate increased adaptive capacity of the SES around UGI as indicated by: 1) improved overall stakeholder salience, in particular for previously disempowered actor groups, 2) increased number and strength of connections between stakeholders, and 3) the consideration of a broader range of sustainable development objectives by stakeholders in their daily practice.

1. Introduction

Urban greenspaces are under increased threat worldwide due to the conventional urbanization trend as well as the current densification agenda (United Nations, 2017, 2015). The expanding urban fabric and degradation of greenspaces poses a threat to continued access to ecosystem services such as stormwater regulation, cooling effects, air filtration and recreational value (Eigenbrod et al., 2011). Urban green

infrastructure (UGI) is an effective means of delivering a range of cultural, regulating and supporting services (Gill et al., 2007; Matthews et al., 2015; Tzoulas et al., 2007), and is a particularly attractive option in compact city development given the pressure to densify urban development within open spaces (Hansen et al., 2017; Kambites and Owen, 2006; Lovell and Taylor, 2013).

Delivering UGI is not an easy task. A wide range of social and ecological processes influence the availability, quality and accessibility

* Corresponding author.

E-mail address: a.p.n.vanderjagt@uu.nl (A.P.N. van der Jagt).

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of UGI (Andersson et al., 2014; Ernstson et al., 2010a). These likely include, but are by no means limited to: climate change influencing temperatures and precipitation; mass migration and urban growth; urban densification or shrinkage; economic cycles affecting levels of public service expenditure; political support for localism; leisure time preferences and sustainable lifestyle trends. Combined, these processes determine the feasibility and integrity of UGI, both from the point of view of biophysical (e.g. urban morphology, local climate) and socio-political aspects (e.g. greenspace policies, available resources, citizen participation in greenspace maintenance) (Byrne and Jinjun, 2009). We derive from this that UGI development is influenced by a complex social-ecological system (SES; Andersson et al., 2014). A SES can be defined as an “integrated system of ecosystems and human society with reciprocal feedback and interdependence” (Folke et al., 2010).

It is essential to take into account the interplay between social and ecological values of UGI to harness its full potential and to better protect it from urban development pressure (Borgström, 2009). If UGI is implemented strategically, it can act as a ‘nature-based solution’ increasing the sustainability of the SES around UGI (Buijs et al., 2016; Eggermont et al., 2015). Doing so, however, poses a challenge to conventional urban planning practices where social and ecological processes are often seen as conflicting rather than synergistic forces (Kabisch, 2015), which can be explained, amongst other factors, by the prevalence of ‘silo’ thinking and technocratic attitudes in incumbent management regimes (Ferguson et al., 2013; Kambites and Owen, 2006). This translates into issues such as limited coordination between public agencies, limited public involvement and UGI advocates not being able to claim jurisdiction over functions (e.g. urban planning, maintenance works) influencing the development and condition of UGI (Dhakai and Chevalier, 2016; Ferguson et al., 2013).

In order to arrive at more integral SES governance that takes into account both social and ecological values, scholars have advocated for adaptive co-management (ACM); platforms for inclusive collaborative learning on ecosystem management (Olsson et al., 2004, p.86). ACM involves the engagement of stakeholders at different spatial scales in alternative types of institutional arrangements, operates on a long-term horizon and aims at empowering resource users and communities (Huitema et al., 2009; Plummer et al., 2012). Amongst challenges for the ACM field are to: (1) test the validity of the ACM approach in non-traditional contexts (i.e. beyond fisheries, forestry and water governance); (2) formulate clear goals for ACM platforms and (3) evaluate its outcomes (Plummer et al., 2012).

The development of UGI is one relatively less studied ‘non-traditional context’ in ACM research (Crowe et al., 2016; Erixon et al., 2013). Notwithstanding the relative absence of research reporting on ACM-approaches focusing on urban areas (Ernstson et al., 2010b), cities have been popular contexts for action-oriented researchers to experiment with social learning platforms such as living labs and transition labs focusing on sustainable development themes (Nevens et al., 2013; Voytenko Palgan et al., 2016).

The first aim of this study is therefore to explore different types of collaborative learning approaches, focusing on those described in the transitions literature, in order to identify their potential for the ACM of UGI. Following an overview of the main types of approaches, we conclude that established approaches to urban experimentation mostly focus on nurturing innovation for radical societal transitions and less so on developing adaptive capacity. To support ACM within the urban context, we make a case for an alternative type of collaborative learning approach, the Learning Alliance (LA). LAs are platforms for the mobilization and co-production of knowledge and engage actors operating at different scales and with varying interests in the development of new solutions to societal problems or challenges (Smits et al., 2007; Verhagen et al., 2008). We advocate for LAs to be complemented by Urban Learning Labs (ULLs), which serve to improve the embeddedness of the LA within the broader system of SES governance through establishing linkages with relevant other networks and legitimate stakeholders in the city region.

To deal with the challenges of clarifying goals and evaluating process outcomes associated with ACM (Plummer et al., 2012), we also introduce a stepwise approach to SES analysis that supports LAs in the processes of goal development, identifying relevant stakeholders, planning the right level of stakeholder engagement and monitoring of stakeholder interconnectedness and salience (i.e. a function of power, interest and legitimacy) over time.

In the next two sections we provide a detailed description of established collaborative learning approaches and outline why the LA and ULL platforms working in tandem is particularly suited to encourage ACM in an urban context. This is followed by a detailed outline of the stepwise approach to SES analysis. Subsequently, we share a case study of the LivadaLAB in Ljubljana, Slovenia, in which we demonstrate how the outlined framework and approach to ACM can be applied.

2. Collaborative research approaches for adaptive co-management

2.1. The potential of established collaborative research approaches for adaptive co-management

Urban Living Labs (ULivLs) are one of the most popular types of urban laboratories described in the literature. ULivLs were originally conceived as arenas for testing new products and services aimed at planning low-carbon urban areas. Over time, they have also been applied to deal with other complex problems, such as economic underdevelopment, ineffective city planning and social problems like unemployment or segregation (Juujärvi and Lund, 2016; Karvonen et al., 2013; Voytenko Palgan et al., 2016). ULivLs have a defined and limited geographical scope (e.g., a neighborhood) in order for experimentation to bring about a radical change relatively quickly (Karvonen and van Heur, 2013; Voytenko Palgan et al., 2016). Urban Transition Labs are very similar to ULivLs as a result of their focus on sustainability experiments but more defined in their goal of producing a step-change in society's pursuit of sustainable development (Nevens et al., 2013). In practice, all types of urban laboratories including ULivLs, Transition Labs and Social Innovation Labs engage actors from academia and society in experimenting with new sustainability solutions (Luederitz et al., 2017).

Given the range of stakeholders typically involved in urban laboratories and their experimental character, they could in theory be suitable instruments for ACM of UGI. However, we contend that the focus of urban laboratories is very much on finding new solutions; on the mobilization of users as co-creators of strategies, products and services (Leminen, 2013). The ultimate goal of these types of experiments is to initiate and facilitate transitions, which can be defined as radical changes to established regimes delivering societal sub-systems such as the city or the energy system (Loorbach et al., 2017). This is not necessarily so for ACM, which can also be concerned with sustaining and further developing existing systems through increased adaptive capacity (Folke, 2006). Processes of knowledge sharing and integration, overcoming scale mismatches, inter-agency integration and establishing cross-sectoral partnerships are therefore all conducive to ACM (Armitage et al., 2009; Borgström et al., 2006; Olsson et al., 2004).

Although we do not disagree with the potential value that developing new strategies, products and services (i.e. sociotechnical innovation) could have for SES resilience (Ernstson et al., 2010b), we concur with Farrelly and Brown (2011) that a narrow pre-determined sociotechnical focus on experimentation limits scope for the kind of open networks required for adaptability (Farrelly and Brown, 2011). We contend that urban laboratories, having emerged from the field of transition sciences, are not fully compatible with ACM. To illustrate, the first step in the process of transition experiments is the setting of a goal for the intervention (Luederitz et al., 2017), whereas the adaptive nature of ACM implies goal development needs to be part of the collaborative process and interventions are designed accordingly. In

addition, urban laboratories do not appear to meet the requirement associated with ACM of engaging a multi-scalar and -sectoral group of stakeholders at the ‘systems’ level due to their limited geographical scope. The niche experiments in the urban laboratories do not necessarily mobilize local knowledge or social practices at different spatial and temporal scales required for ACM.

An alternative type of collaborative research approach is the Learning Alliance (LA). The concept originates from the business sector and has been widely applied in the Water, Sanitation and Hygiene sector (Smits et al., 2007). For example, 11 urban LAs were set up as part of a European research project on integrated urban water management (Batchelor and Butterworth, 2008; Butterworth et al., 2008), and research projects relevant to other environmental sectors (Stür et al., 2008). An LA is a diverse group of stakeholders operating at different scales with complementary knowledge (Smits et al., 2007). They have a shared objective to address an issue through a joint approach comprising visions, strategies and tools (Verhagen et al., 2008).

In comparison, the LA appears to provide a better fit with the requirements of ACM than urban laboratories given the explicit focus on producing, mobilizing and institutionalizing new types of knowledge (van Herk et al., 2011), although the literature also emphasizes their contribution to upscaling innovations (Smits et al., 2007). Moreover, the literature on LAs has called for connecting several partnerships, rather than focusing efforts on a single partnership, in order to better support processes of coordination across horizontal and vertical scales (Butterworth et al., 2008; Smits et al., 2007). This is agreement with the notion that SESs emerge through interactions at multiple scales (Folke et al., 2010). We have summarized the main differences between urban laboratories and LAs in Table 1.

2.2. The LA and ULL platforms in practice

Given the complexity of the SES around UGI (Lovell and Taylor, 2013), and limited resources available for stakeholder engagement in research project, facilitating multiple LAs is not feasible in most situations. Rather we propose to set up a single LA at the level of a specific neighborhood or district. The role of the LA should be:

- To develop a shared vision and/or target, along with an experimental initiative or approach to deliver this in practice. This is known to support the engagement of stakeholders from different backgrounds in long-term partnership working (Ashley et al., 2012), fostering interpersonal trust and perceived legitimacy of viewpoints, and ultimately delivering an ACM approach that is successful in increasing SES resilience (Reed, 2008; Stringer et al., 2006; van de Kerkhof, 2006);
- To include both researchers and experts relevant to the topic (e.g., UGI) as well as actors and institutions who provide local knowledge on local socio-ecological dynamics (Gunderson and Holling, 2002; Olsson et al., 2004);
- To engage a range of stakeholders with different roles and representative interests at different scale levels (Andersson et al., 2014), and who have not been collaborating on the focal issue (Pahl-Wostl and Hare, 2004), which allows for improved collaboration across spatial and temporal scales (Connolly et al., 2014); and
- To organize platform meetings a regular basis to support an iterative

process of knowledge development and transfer, which is important for testing new ideas, learning from each other and creating scope for non-linear change (Evans and Karvonen, 2014; Olsson et al., 2004).

The literature on LAs recognizes that new long-term partnerships cannot be easily ‘engineered’ by an external facilitator, and therefore Smits et al. (2007) propose to engage with established networks and platforms that have high legitimacy in decision-making. To achieve this, we recommend to run the LA in parallel with an Urban Learning Lab (ULL), a type of platform not previously described in the literature. The ULL acts as an umbrella platform for the LA to provide opportunities for regular knowledge exchange with relevant peripheral stakeholders and networks across the whole city region (Fig. 1). A ULL facilitates the process of collaborative learning across horizontal and vertical scales, and increases process legitimacy by improving the synergy between the LA and established protocols, routines and cultures (Sandström et al., 2014).

We will demonstrate how the nested ULL and LA platforms can be applied to encourage the ACM of UGI using a case study in Section 4. However, we first turn to our stepwise approach to identifying appropriate LA objectives and stakeholders as well as monitoring adaptive capacity, which is outlined below.

3. Devising a stepwise approach to SES analysis

The common issue associated with ACM of insufficient clarity about desired end-goals, as described by Plummer et al. (2012), is also a concern to scholars in the transition domain (Kivimaa et al., 2017). This also applies to the issue of limited evaluation of outcomes and impacts (Butterworth et al., 2008; Kivimaa et al., 2017; Verhagen et al., 2008; Voytenko Palgan et al., 2016). To address these common issues associated with both ACM and transition management, we advocate for collaborative research approaches to take a systematic approach to orchestrating both the process of goal setting and that of monitoring and evaluation.

To support the facilitation of the collaborative learning process while addressing the issues highlighted above, we devised a stepwise approach to SES analysis. We contend that LAs using this approach for group formation and goal setting will be more successful in developing adaptive capacity within the relevant SES over time. Following this approach is also likely to lead to a more socially inclusive process. This is important as ACM relies on the inclusion of a diverse set of stakeholders (e.g., Armitage et al., 2009). In particular, the development of multifunctional UGI is critically dependent on the coordination of efforts by a representative range of actors across sectors and scales, including informal bodies and a diversity of sociocultural groups (Buijs et al., 2018, 2016; Ernstson et al., 2010a). That is, there is high diversity in human and biological systems (Vierikko et al., 2016). LA facilitators therefore need to ensure all voices have equal weight and validity negating an underrepresentation of disempowered segments of society (Foster, 2011; Perkins, 2009).

There is a broad range of tools for stakeholder analysis available (Brugha and Varvasovszky, 2000; Reed, 2008). The outlined approach to SES analysis, visualized in Fig. 2, is a combination of several of these tools:

Table 1
Main differences between urban laboratories and Learning Alliances.

	Urban laboratories (e.g. Urban Living Labs)	Learning Alliances (LAs)
Objective	Innovation: new products, systems or services addressing urban challenges (‘doing different things’)	Co-creating and exchanging knowledge, leading to institutional change within innovation system (‘doing things differently’)
Role of users	Co-creators	Local SES experts
Scale	Defined & manageable (e.g., city district)	Complex & lacking boundaries
Scope	Single partnership	Multiple partnerships

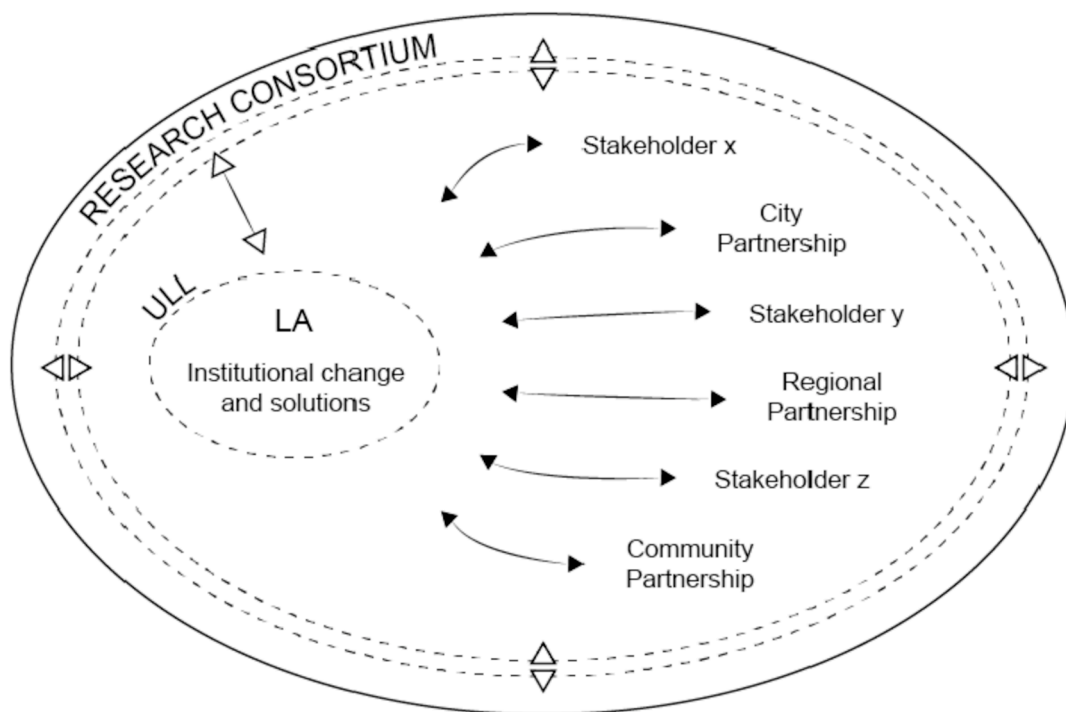


Fig. 1. Illustration showing the linkages between the Learning Alliance (LA) and the peripheral partnerships and stakeholders in the Urban Learning Lab (ULL).

- 1) A ULL Matrix to identify relevant stakeholders and relevant UGI-related instruments and projects that they engage in to explore the current SES around UGI and associated challenges and opportunities;
- 2) Mind Maps to identify underrepresented groups in UGI decision-making that could be engaged as part of the collaborative learning process;
- 3) A Stakeholder Salience Analysis to make an informed decision about which stakeholders to engage to what extent;
- 4) A Stakeholder Monitoring Graph to monitor process inclusiveness and empowerment over time.

The individual tools that are part of the approach to SES analysis are described in more detail below.

3.1. The ULL matrix

The ULL Matrix is a tool to identify relevant stakeholders in order for peripheral actors to familiarize themselves with the current SES around a particular topic. The ULL Matrix lists projects and instruments specific to a city region that are relevant to the research focus. It also scores the thematic alignment of these projects with the research project sub-themes or work packages, which is done as part of the

frequently omitted process of developing an understanding about stakeholder interests (Prell et al., 2009). Completing the ULL Matrix is ideally done through an ‘ideas storm’ exercise that should engage researchers and a number of relevant stakeholders with a good overview of the key issues, activities and stakeholder landscape.

3.2. Mind Maps

The Mind Map contributes to identifying a diverse group of stakeholders with complementary interests and skills (Fig. 3). It serves to map the full stakeholder landscape and to identify potentially conflicting stakes, which is supportive of a socially inclusive process in which the full range of different perspectives are accounted for (Durham et al., 2014; Forestry Commission, 2011). In the present approach, we apply it to identify all relevant stakeholders influencing or affected by a project or instrument described in the ULL Matrix. By ‘primary theme’ we refer to relevant research themes and by ‘stakeholder type’ to their status as NGO, public body, community group, etc. To visualize power relationships, stakeholders can be color-coded based on their strategic, tactical or operational role in the planning hierarchy. In broad terms, by “strategic” we refer to actors involved in setting of long-term goals, by “tactical” to those setting goals on the basis of

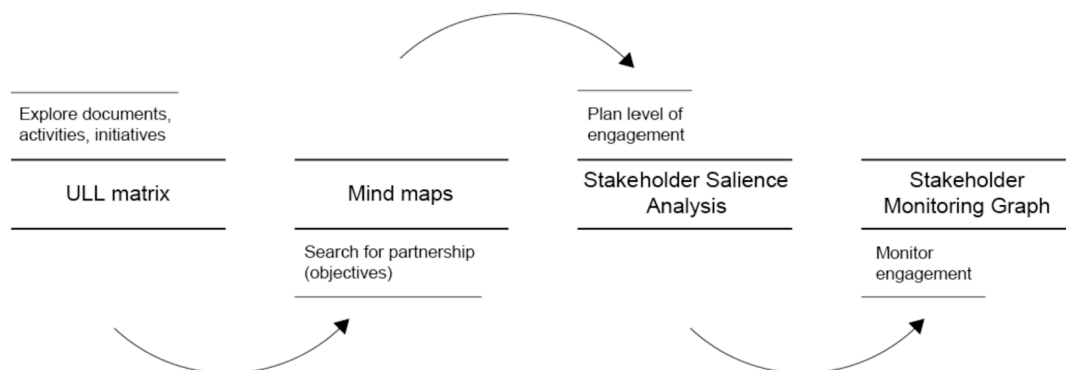


Fig. 2. Overview of the tools that are part of the outlined approach to SES analysis.

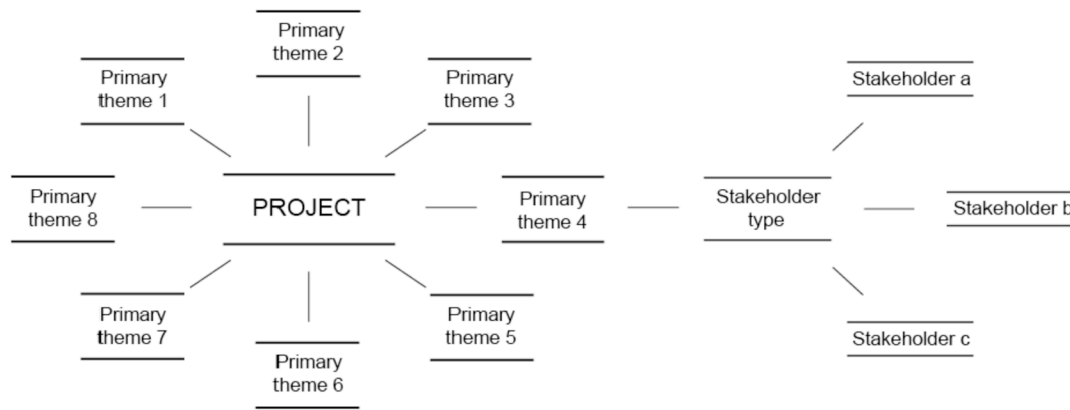


Fig. 3. A template for producing a Mind Map.

strategic planning for smaller time- and spatial scales, and by “operational” to operational planning and delivery (Borgström et al., 2006).

3.3. Stakeholder Salience Analysis

Understanding and effectively dealing with stakeholder salience, a dynamic function of power, interest and legitimacy, is an important challenge associated with approaches to encourage ACM. That is, an adequate understanding of the SES and its adaptive capacity is unlikely to be achieved without engaging all salient stakeholders. We considered the salience score as an indicator of the extent to which stakeholders should be managed and monitored closely (Nastran, 2014; Neville et al., 2011). Power-Interest (P-I) Matrices, one of the most common techniques for stakeholder analysis (Mathur et al., 2007; Reed et al., 2009), can be applied to assess stakeholder salience through scoring them on two dimensions: power (level of influence and control) and interest (level of concern and involvement) around the focal topic (Start and Hovland, 2004).

Following Mitchell et al. (1997) and Nastran (2014), we propose to consider the attribute of legitimacy, in addition to the attributes of power and interest, in salience assessments. A legitimacy score is derived based on a qualitative evaluation of the appropriateness of a stakeholder's claim around the focal LA topic; considering this attribute is therefore likely to improve the social inclusiveness of the process. We conducted repeated salience measurements over time to account for stakeholder dynamics (Brugha and Varvasovszky, 2000; Reed et al., 2009), as further discussed below.

3.4. Stakeholder Monitoring Graph

We developed a new kind of stakeholder analysis tool – the Stakeholder Monitoring Graph – to monitor and evaluate the adaptive capacity of the SES around UGI in a given city region using a single instrument. It is essentially a modified social network analysis (SNA) in which the nodes representing stakeholders display relevant attributes such as salience and planning hierarchy. The SNA component of the graph reveals communication networks and identifies interconnected clusters of stakeholders (Connolly et al., 2014). We applied this tool to assess adaptive capacity of the SES over time.

4. Case study: LivadaLAB

The following case study of LivadaLAB in Ljubljana, Slovenia, provides an illustration of how the framework and approach to encourage the ACM of UGI outlined above could be applied in practice.

4.1. The challenge

To bring stakeholders together in a process of co-learning around UGI development in Ljubljana, Slovenia, researchers at the University of Ljubljana organized a kick-off ULL workshop in April 2014 focused on exploring interest in this approach. This engaged a number of relevant UGI stakeholders in the city of Ljubljana, Slovenia, including the Department for Environmental Protection of the Municipality of Ljubljana (Table 2). This started with an exercise aimed at exploring motivations to get engaged in the process.

This revealed that the Department for Environmental Protection was keen to exploit the potential of the co-learning approach to develop a financially more sustainable urban greenspace governance model. Other partners had overlapping motivations such as improving green spaces and sustainable development (Table 2). Following the first round of group discussions, the stakeholders co-defined a shared challenge which was to create a financially sustainable governance model of urban greenspace management through partnership working and citizen engagement. The intended end-result of the collaborative process was to make a lasting impact on conventional modes of governance used to deliver UGI in Ljubljana.

4.2. The process of working towards a solution

During the second part of the workshop, the participants populated the ULL Matrix, which was a list of examples of projects and policy instruments aimed at developing UGI in Ljubljana. Twenty-one projects and instruments were identified, and entered into the matrix. Based on the high number of existing urban gardening initiatives and relevant competencies of the initial group of LA stakeholders in this area, urban gardening was conceived as a potential area for experimentation around the previously identified shared challenge.

The next step was to identify an LA objective to support the process of identifying additional stakeholders providing complementary types of knowledge or resources to the LA. Hence, the seven urban gardening projects identified using the ULL Matrix were further explored using Mind Maps, one for each project (Fig. 4). These were prepared by local researchers based on a desk study and validated by LA stakeholders. The desk study was based on a web search, phone and face-to-face interviews, site visits and academic research on urban gardening initiatives from the wider case study area (Cvejić et al., 2015; Glavan et al., 2016). The seven Mind Maps were compared based on: (a) how gardens were set up (bottom-up versus top-down), (b) who organized it (e.g., municipality, NGO), and (c) which socio-cultural group was targeted.

The Mind Maps revealed that most urban gardening initiatives in the city were aimed at educating school children. These were often set

Table 2
Description of the LA partnership stakeholders in Ljubljana engaged since the research project kick-off.

Partner	Type	Description	Motivation and goals	Roles
Municipality of Ljubljana, Department for Environmental Protection	LG	Municipal department responsible for environmental protection	To explore the potential for co-creating a financially sustainable urban greenspace governance model	Owner of experimental site; co-developing LA goals and objectives; providing policy support
University of Ljubljana, biotechnical faculty	U	University of Ljubljana Biotechnical Faculty is a research organization with relevant knowledge on citizen participation in projects related to peri-urban and urban ecosystems	To experiment with participatory approaches in creating UGI	Coordinating LA and engagement with ULL; LA process monitoring; mentor for young adults; consultancy & advice
TISA, Ltd.	SME	TISA Ltd. is a company providing services in the urban forest management sector (e.g., harvesting and planting trees) and runs a woodchip factory	To engage in urban greenspace development and maintenance	Co-developing LA goals, objectives and ideas for site development; provision of workshops and garden materials
LAVACO, Ltd.	SME	LAVACO Ltd. is a construction company	To engage in urban greenspace development and maintenance	Co-developing LA goals, objectives and ideas for site development; transport of garden materials
ISD - Institute for Sustainable Development	SME	The Institute for Sustainable Development Ltd. provides eco-education and runs projects to educate people about the importance of sustainable development including sustainable consumption, organic food production and permaculture	To promote sustainable development and consumption	Co-developing LA goals, objectives and ideas for site development; provision of workshops

Stakeholder type: LG = local government, U = university, SME = small- or medium-scale enterprise.

up as partnerships between a public school and an environmental NGO. There were also a number of initiatives targeting adults, which were set up by NGOs focusing on creativity, culture and education together with local governments as enablers and observers. We established that 18-29 year-olds were a particularly underrepresented group in urban gardening projects, which we predicted to have a negative impact on the adaptive capacity of the SES. The LA stakeholders confirmed that this age cohort is in danger of being marginalized from urban gardening, and UGI planning more generally, whilst they may benefit particularly strongly from the social and economic effects associated with this activity, especially those who are unemployed. Therefore, it was agreed to engage in a co-learning approach around engaging this particular age cohort in urban gardening activities on a 0.6 ha experimental site.

The local researchers facilitating the collaborative process (UL-BF) repeatedly measured stakeholder salience in order to determine which stakeholders should be engaged to what extent at different stages of LA development. Salience (S), a function of power (P), interest (I) and legitimacy (L) derived using Equation (1), was assessed annually starting from year one.

$$S = \sqrt{P^2 + I^2 + L^2} \tag{1}$$

Stakeholders were engaged either as consultants (0 < S ≤ 3), process supporters (3 < S ≤ 4) or site co-governors (4 < S ≤ 5). As a result of salience assessments, additional stakeholders were invited to join the LA process, including the NGO IBOB given their experience with youth work and interest in exploring the role of urban gardening. Others that joined the process were a group of young adults (18–29 years old), the local community living around the experimental site and the municipal departments responsible for urban planning and youth affairs.

The co-learning process would eventually develop into a plan to engage and support young adults, including school drop-outs and unemployed individuals, in a project to transform an under-used greenspace into one offering multiple benefits, varying from leisure to sports, culture, local food production and environmental education (Fig. 5). Stakeholders IBOB and UL-BF led the process of engaging the young adults to participate in the site experiment, which was called Liva-daLAB, and acted as mentors.

Following the agreement to engage in collaborative learning around a demonstration project of an urban garden, The LA began discussing ideas for site development. Later they experimented with approaches for site co-governance and started organizing weekly workshops on topics such as making a garden plan and developing a production function for the garden. The feasibility of the project and lessons learned were discussed with the ULL at monthly meetings organized by the University of Ljubljana between March 2014 and October 2017.

4.3. Implications for ACM

The temporal analysis of stakeholder landscape using the Stakeholder Monitoring Graph revealed changes throughout the process with a year-on-year increase in the number of connections between stakeholders (Fig. 6). It shows that the LA process had been successful in empowering nearly all of the stakeholders involved, as evidenced in the increase of salience scores over time, especially for those who traditionally played a rather marginal role in urban garden governance (e.g., young adults). The LA included one stakeholder – IBOB – operating at the tactical level. This was evidenced in IBOB challenging barriers such as regulation inhibiting urban gardening on public land and informal norms preventing young adults to participate. Doing so, they played a crucial role in linking up research, policy and practice and in ensuring long-term change.

As the Ljubljana LA brought together some stakeholders for the first time, we predicted the emergence of new relationships and changes to these over time as communication channels become established or are

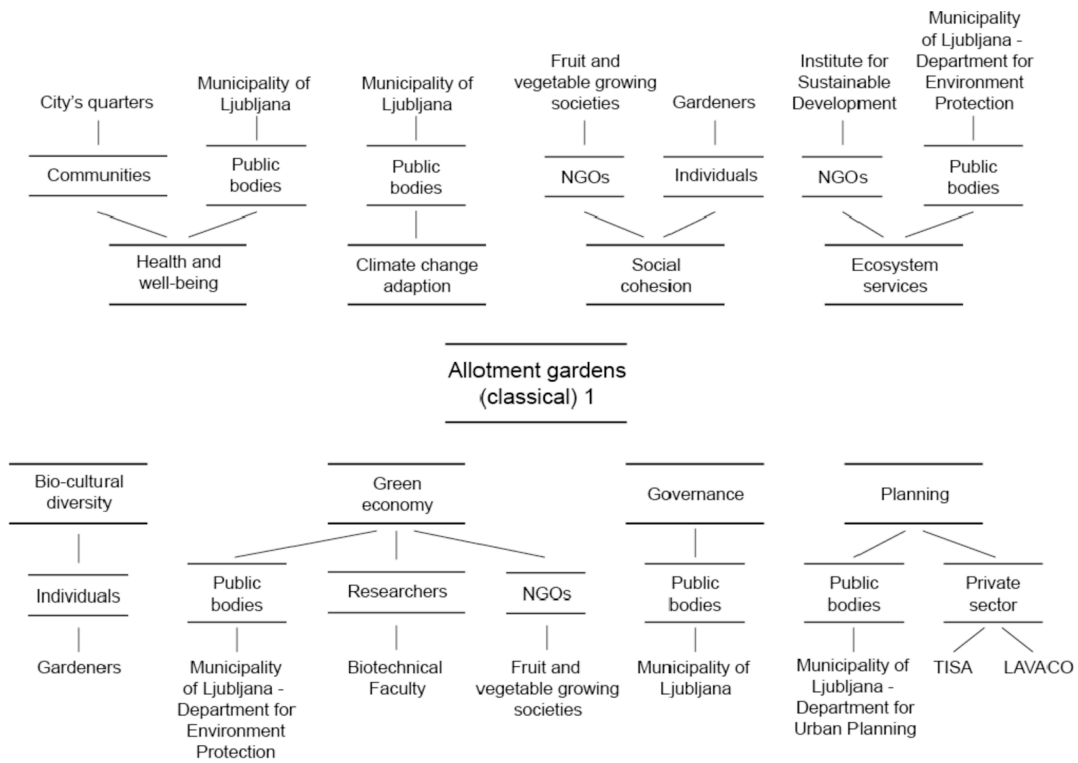


Fig. 4. One of the seven Mind Maps of urban gardening projects that were created showing stakeholders mapped around the eight GREEN SURGE research project themes.

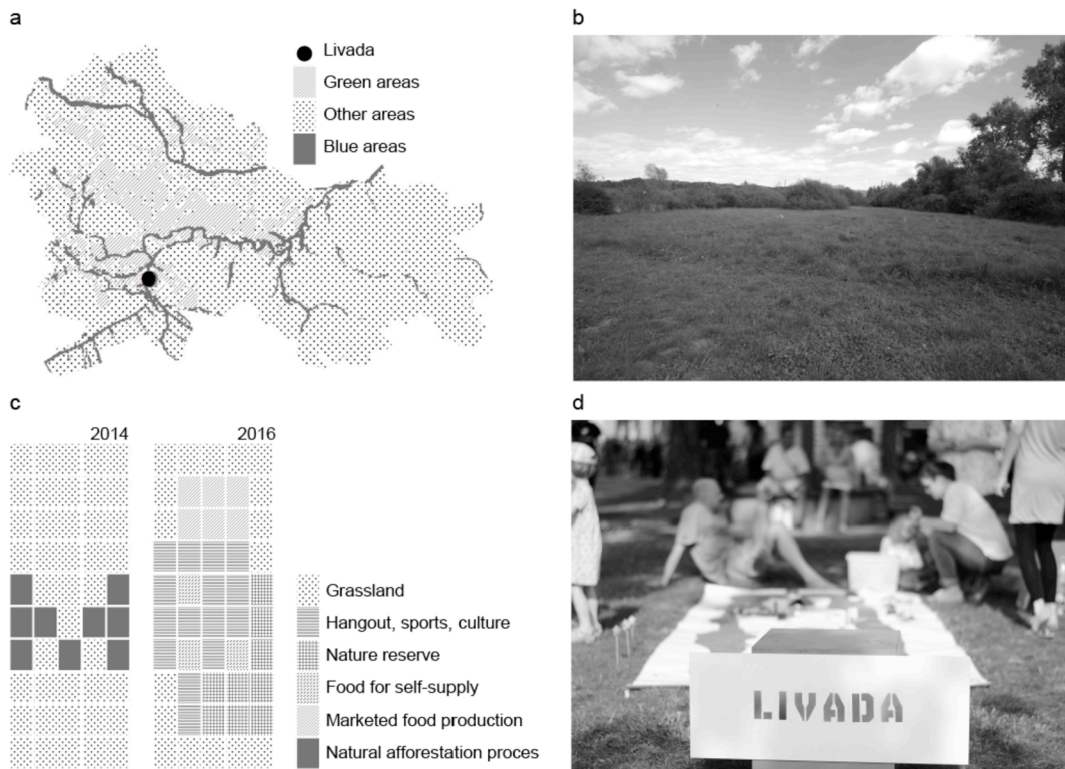
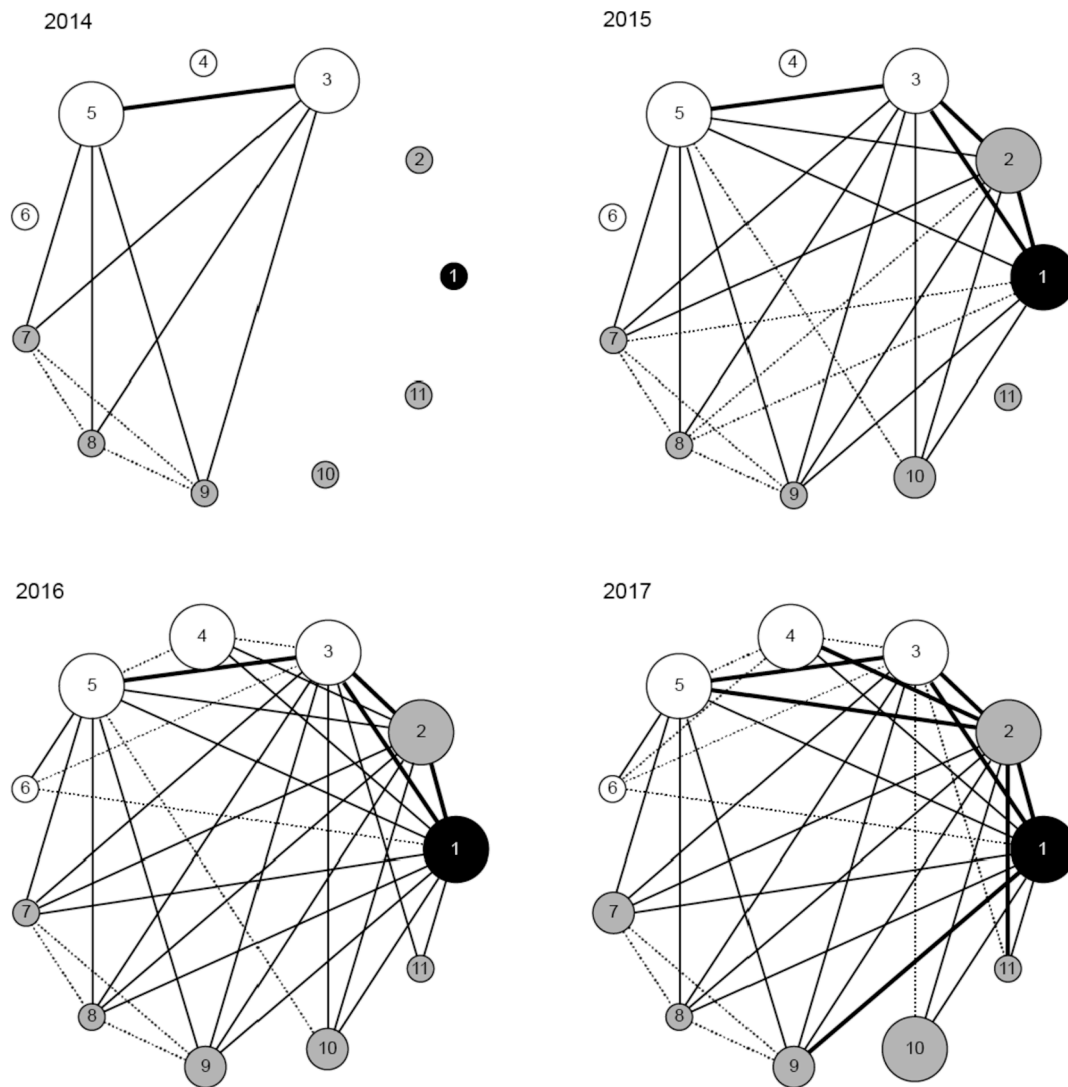


Fig. 5. (A) The Focal LA experimental site location (Livada) within municipality of Ljubljana, (B) site impression from before project started, (C) the site's transformation between the years 2014 and 2016, and (D) impression of a public engagement event in May 2015.



LA partners: 1. Institute BOB; 2. Young adults; 3. University of Ljubljana, Biotechnical faculty; 4. Municipality of Ljubljana, Department for Culture, Youth Sector; 5. Municipality of Ljubljana, Department for Environmental Protection; 6. Municipality of Ljubljana, Department for Urban Planning; 7. TISA Ltd.; 8. LAVACO, Ltd.; 9. ISD - Institute for Sustainable Development); 10. Local community members; 11. Private donors.

Planning hierarchy:		Salience:	Strength of relationship:
Strategic	○	High	Continous ————
Operational	●	Medium	Periodical ————
Tactical	●	Low	Consultation ······

Fig. 6. Stakeholder Monitoring Graphs of the Ljubljana LA based on data for the 2014–2017 period.

improved.¹ Amongst interesting new connections that got established was the one between IBOB and Department of Urban Planning; they had not formerly collaborated on the topic of youth work within the context of urban greenspace management. In addition, it was the first time that the Department of Urban Planning engaged with the Department of

Culture and Youth Sector on an integral approach. Furthermore, the small- or medium-scale enterprises TISA, LAVACO and ISD were rather successful in establishing connections with other LA partners, but not amongst themselves. One of the more interesting changes to stakeholder connectivity later on in the LA process was that, as a result of the co-learning process, the Department of Environmental Protection funded a campaign to promote the engagement of young adults in environmental conservation activities, resulting in a strengthened relationship between both stakeholders in 2017.

A strong strategic relationship between the local researchers and the Department of Environmental Protection all along the duration of the

¹ The stakeholders' interactions were estimated by the LA facilitators on a four-level scale from 0 to 3; '0' for no observed interaction between the stakeholders, '1' for observed procedural communication (communication by consultation), '2' for observed periodical, content collaboration (functional), and '3' for interactive continuous collaboration.

LA process contributed to the application of knowledge and solutions emerging from the LA process towards new policy development. As a direct result of this collaboration, and the LA process more broadly, the Implementation Plan of the city's Sustainable Urban Strategy now specifies that, "Participatory planning and governance of urban green increases the range of ecosystems services provided to citizens. Therefore, the municipality of Ljubljana will promote participatory planning and governance of urban greenspaces, especially with vulnerable groups" (Municipality of Ljubljana, 2017, p. 8). Moreover, the engagement process also contributed to the active use of the term 'ecosystem services' in policy documents by the municipality of Ljubljana to articulate the value of UGI. This was a major achievement as efforts to include the concept into urban development are conducive to better planning of UGI (Ahern et al., 2014).

5. Discussion and conclusions

The ACM of UGI calls for a transdisciplinary process spanning different scales and interests (Armitage et al., 2009). Given the lack of established collaborative learning approaches to encourage ACM within urban contexts, we queried the literature on suitable platforms, which resulted in the identification of the LA as the most suitable instrument for co-learning and experimentation. These are likely most effective when running in parallel with a ULL engaging legitimate peripheral stakeholders, as this allows for dissemination of co-produced knowledge to different spatial, temporal and hierarchical scales. We also developed a stepwise approach to SES analysis for use alongside the LA and ULL platforms. This serves to address known issues around ACM and urban experimentation such as the lack of process monitoring. Since both ACM and UGI require a socially inclusive process in order to be effective, the approach to SES analysis was designed to enable the identification of underrepresented groups with legitimate claims.

A case study of LivadaLAB served to illustrate the framework to ACM of UGI. As visualized in the Stakeholder Monitoring Graph, participation in the LA had empowered most stakeholders, most notably the young adult group and the local community. This can be evidenced by new or strengthened interconnections as well as overall salience level, suggesting that the governance regime had become more polycentric with more stakeholders influencing decision-making. This is predictive of institutional resilience (Buijs et al., 2016; Huitema et al., 2009), and overall adaptive capacity of the SES (Folke et al., 2005).

The analysis of planning hierarchies revealed that IBOB had played a key role in the LA as a boundary spanner between the strategic and operational level, improving vertical connections. This was crucial in terms of connecting the science and policy on the one hand, and the on-the-ground process of garden planning and implementation on the other hand. As a result, all partners felt part of the process, which is an important factor predicting LA performance (Verhagen et al., 2008).

Our analysis of UGI planning practices in Ljubljana revealed that the effects of the collaborative learning framework and approach trialed in this research project on adaptive capacity as shown in the Stakeholder Monitoring Graph, had likely already translated into lasting cultural change. Firstly, we observed a shift in sustainable development objectives of LA partners (recorded but not visualized); the Department for Environmental Protection and youth association IBOB became more interested in (optimizing) the social and environmental outcomes of their activities, respectively. This is indicative of double-loop learning where stakeholders reconsider how their actions contribute to the functioning of a system as a whole (Pahl-Wostl, 2009). Secondly, the LA process has prompted the municipality of Ljubljana to introduce a new policy promoting socially inclusive participatory planning and management of urban greenspaces. This could be an early sign of triple-loop learning characterized by shifts in the UGI development regime (e.g., by including new actor groups or introducing new policies; (Pahl-Wostl, 2009).

The stepwise approach to SES analysis provides an attractive means to support a socially inclusive collaborative learning process. In the

present study, it facilitated social inclusion through: 1) selecting an LA topic focused on the engagement of underrepresented groups in UGI; 2) considering stakeholder legitimacy in the salience calculations, which prompted the inclusion and empowerment of people who were neither powerful nor interested at the start of the process; 3) engaging stakeholders operating at tactical, as well as strategic and operational, levels in order to ensure effective partnership working across scales; and 4) regular monitoring of empowerment and connectivity of all salient stakeholders. We encourage other researchers engaging in collaborative learning to adopt a similar approach.

A limitation of this study is that it remains largely unclear whether such adaptive capacity on paper – improved stakeholder connectivity and salience – also translates into improved UGI planning and governance in practice. To this end, quantitative and qualitative assessments of environmental, social and economic outputs and outcomes of real-world experiments are needed in future research. In addition, self-reports on outcomes experienced by individual stakeholders (e.g., on new relevant knowledge leading to higher quality decisions; improved capacity; improved attitude towards knowledge exchange) would be relevant to include in any future evaluations of ACM (e.g., Frijns et al., 2013; Reed, 2008). What's also still lacking is an idea of lessons learnt during the process. How can we operationalize the 'double helix' of knowledge exchange between researchers and stakeholders? What are some of the key milestones and barriers experienced when orchestrating LAs? How effective were the ULLs in preparing for experimenting with innovative ideas within LAs? This warrants a more in-depth evaluation of researcher-practitioner interactions in collaborative research projects. An example of such an approach is provided by van der Jagt et al. (2017).

We conclude that applying the nested LA and ULL approaches can provide an effective strategy to stimulate ACM within the little-research and complex urban realm. Taking this approach, local researchers in Ljubljana engaged different stakeholders in a co-learning process culminating in the transformation of a derelict site into an urban garden under full management of a young adult group. The process not only improved the SES' adaptive capacity at the *neighborhood* level by empowering previously disengaged people, but also at the *city* level by forging new connections between high-level decision-makers culminating in the development of a participatory governance of UGI policy. Future research is required to validate these findings in different geographical contexts, focusing on different urban SES sub-themes (e.g. urban forests, nature-based solutions) and using a broader range of quantitative and qualitative assessment methodologies.

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