Global Environmental Change 78 (2023) 102627

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Landscape adaptation to climate change: Local networks, social learning and co-creation processes for adaptive planning

Juanjo Galan [a,b,*], Francisco Galiana [c], D. Johan Kotze [d], Kevin Lynch [e], Daniele Torreggiani [f], Bas Pedroli [g]

[a] Department of Architecture, Aalto University, Otaniementie, 14, 02150 Espoo, Finland
[b] Departament of Urbanism, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain
[c] Dept. of Rural and Agrifood Engineering, Universitat Politècnica de València, Cami de Vera, s/n, 46022 Valencia, Spain
[d] Faculty of Biological and Environmental Sciences, Ecosystems and Environment Research Programme, Niemenkatu 73, FI-15140 Lahti, University of Helsinki, Finland
[e] School of Geography, Archaeology and Irish Studies, National University of Ireland Galway, University Road, Galway H91 TK33, Ireland
[f] Department of Agricultural and Food Sciences, University of Bologna, Viale G. Fanin 48, 40127 Bologna, Italy
[g] Chair Group Land Use Planning, Wageningen University, P.O. Box 47, NL-6700 AA Wageningen, the Netherlands

ARTICLE INFO

Keywords:
Climate change adaptation
Community planning
Participatory planning
Landscape planning
Co-creation
Local networks

ABSTRACT

The development of legitimate, operative, and feasible landscape adaptation planning for climate change is dependent on the specific characteristics of the landscape and its inhabitants. Spatial patterns, culture, governance systems, socio-economic structures, planning methods, history, and collectively envisioned futures need to be accommodated. The literature suggests that landscape is a complex and dynamic socio-ecological system, the management and adaptation of which requires systemic and integrative approaches to respond to a wide variety of drivers of change, challenges, and interests. Based on activities developed in 15 European pilot landscapes, we identify some of the key factors and conditions affecting the generation of representative local networks for landscape adaptation to climate change. We illustrate how social learning and co-creation processes can be implemented in them and how their co-produced outcomes can help local communities overcome barriers and address critical issues in adaptive planning. Our results provide a framework for the creation of similar networks in other landscapes, exploring at the same time the interactions between the composition of networks, social learning, and the quality of the co-produced outputs as a fundamental step for the development of Landscape Adaptation Plans to Climate Change.

1. Introduction

Climate Change Adaptation (CCA) constitutes a major and systemic challenge requiring multi-sectoral agreements and involving multiple spatial scales and governance levels. Within this context, landscape-based adaptation has the potential to promote collective and integrative adaptive paths (Van Rooij et al., 2021). At the same time, social learning is an essential process to understand, build, and manage adaptive changes in complex socio-ecological systems (e.g., the landscape) operating under uncertain conditions (Pahl-Wostl et al., 2007).

The literature suggests that landscape-based co-creation processes within highly representative local networks can positively contribute to CCA and that there is an urgent need to better understand the factors affecting these processes (Bernauer, 2013, Newig and Fritsch, 2009). This hypothesis together with major knowledge gaps identified prompted the formulation of the overarching question investigated in this paper: How can the activity of landscape-based local networks better support CCA?

In the 'Literature Review' we firstly present the main existing frameworks, barriers, and types of solutions affecting CCA. Secondly, we focus on the potential that landscape-based approaches and local networks might have to overcome some of the barriers detected and on critical knowledge gaps and related research questions (RQs) affecting their effective use in adaptive planning. In the 'Material and Methods' (section 3) we introduce the activities that were conducted in fifteen European pilot landscapes to investigate the proposed RQs and the

* Corresponding author at: Departamento de Urbanismo, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain.
E-mail addresses: juagavi@urb.upv.es (J. Galan), fgaliana@agf.upv.es (F. Galiana), johan.kotze@helsinki.fi (D.J. Kotze), kevin.lynch@nuigalway.ie (K. Lynch), daniele.torreggiani@unibo.it (D. Torreggiani), bas.pedroli@wur.nl (B. Pedroli).

https://doi.org/10.1016/j.gloenvcha.2022.102627
Received 19 July 2021; Received in revised form 22 August 2022; Accepted 28 November 2022
Available online 9 December 2022
0959-3780/© 2022 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

methods that were used to extract data from each of them. Those data are presented in the 'Results' (section 4) and are further interpreted in relation to the RQs and main knowledge gaps in the 'Discussion' (section 5). Finally, the Conclusions (section 6) present the key findings from the research and their potential utility for CCA.

2. Literature review

2.1. Climate Change Adaptation and Sustainable Development: Frameworks, barriers, and solutions

Climate change induced by human activity has been widely recognized as one of the main challenges affecting the sustainable evolution of socio-ecological systems within homeostatic limits (McLaughlin, 2011; Balbi and Giupponi, 2009; Klein et al., 2005). Moser and Ekstrom (2010, p. 1) define CCA as the "*changes in socio-ecological systems that take place in response to existing or expected impacts in the context of interacting non-climatic changes*". According to Smit and Pilifosova (2001, p. 881), CCA in the context of Sustainable Development and Equity *"involves adjustments to reduce the vulnerability of communities, regions, or activities to climatic change and variability*". Assuming the inevitability of some of these changes, responses have been articulated around two main (and desirably interconnected) approaches: mitigation of the causes, and adaptation to ongoing and expected changes (Duguma et al., 2014; Ayers and Dodman, 2010; Pielke, 1998). These two approaches need to be simultaneously operated at different spatial and governance scales (Nalau et al., 2015; Hallegatte, 2009).

The barriers affecting both climate change adaptation and mitigation are numerous and deeply systemic, but, in the adaptation case, the specific conditions of each site and the management of the existing singularities become especially critical (Nordgren et al., 2016; Laukkonen et al., 2009). Apparently, there is a need to define common grounds in which different groups can get engaged in processes leading to adaptive planning, social learning, and capacity building (Biagini et al., 2014; Moser and Ekstrom, 2010).

In addition, CCA is increasingly considered an opportunity for change rather than a disconnected problem that needs to be fixed to keep the current status quo. The causes of climate change are structural; therefore, mitigation and adaptation need to be structural as well, enhancing resilience (Smit and Pilifosova, 2001). Folke et al. (2010, p. 1), define resilience as the capacity of a system to "*continually change and adapt yet remain within critical thresholds*", whereas Adger (2003) has linked climate change resilience to the existence of a solid social capital and of deep connections between individuals and their surrounding environments. Due to the systemic and cross-cutting character of CCA, the main barriers emerge from the many dimensions involved in the management and evolution of socio-ecological systems: institutional, organizational, economic, knowledge-based, socio-cultural, etc., and prevent the mobilization and implementation of adaptive capacity (Biesbroek et al., 2013, Young et al., 2006). Based on a literature review we performed (see method in Appendix A_part1), CCA barriers can be clustered into seven groups (Table 1, first column).

The literature reveals that various solutions are proposed to overcome the barriers listed in Table 1 and alleviate their negative impact on CCA diagnosis, planning, and implementation (Biesbroek et al., 2013). These solutions are mainly aimed at: (1) promoting more integrative, flexible, path-dependant, and adaptive ways of thinking and planning (Wise et al., 2014, Amaru and Chhetri, 2013; Pahl-Wostl, 2007); (2) endorsing multilevel governance, with a special emphasis in the activation of the lower levels (individuals and communities) (Nalau et al., 2015; Measham et al., 2011; Amundsen et al., 2010); (3) reinforcing participatory and collaborative processes at the local and community level as a way to trigger social learning, social engagement and capacity building (Newig and Fritsch, 2009; Mauser et al., 2013); (4) advancing multi-scalar governance, with a special emphasis on the local scale as the one which is directly connected with people and their direct experience of climate change (Newig and Fritsch, 2009); (5) exploring the potential of highly integrative frameworks to the territory, such as the one provided by the landscape concept (Van Rooij et al, 2021); and (6) developing mechanisms for the mobilization of local resources (Nordgren et al., 2016; Carter, 2011; Measham et al., 2011; Urwin and Jordan, 2008).

Table 1
Main types of barriers and opportunities for Climate Change Adaptation and possibilities provided by local networks, social learning, co-creation processes, and landscape-based approaches (source: literature review, see Appendix A, Table A1).

MAIN TYPES OF BARRIERS AND OPPORTUNITIES for CCA	POSSIBILITIES PROVIDED BY A NEW GOVERNANCE APPROACH (Local networks, social learning, and co-creation processes)	POSSIBILITIES PROVIDED BY A LANDSCAPE-BASED APPROACH
A. Temporal barriers and Short-Termism	Intergenerational approach and consideration of local identity	Process-based approach. Integration of past, present, and future
B. Knowledge barriers and Uncertainty	Detection of knowledge gaps and integration of different types of knowledge. Uncertainty is addressed through scenarios-based approach and landscape models. Promotion of social learning processes	
C. Reactive, Conservative and Non-Systemic approaches	Detection and treatment of divergent interests	Holistic, integrative, and systems thinking
D. Governance and Institutional barriers	Local governance. Close interaction between decision-makers and different community groups	Multilevel governance, combination of top-down and bottom-up approaches
E. Planning and Policy barriers	Promotion of integrated planning and policies. Consideration of landscape character issues. Planning scale adjusted to problem scale. Promotion of community planning and stewardship	
F. Social, Engagement, and Legitimacy barriers	Increase in social acceptance, civil engagement, and public support. Proposals vested with higher levels of legitimacy, ownership, and accountability. Consideration of emotional bonds between people and place	
G. Resource barriers	Mobilization of local resources from different groups for a common purpose	

2.2. Local Networks, Social Learning, and Landscape-based approaches for Climate Change Adaptation

In relation to the barriers and types of solutions described above and as displayed in Table 1, local networks, social learning, co-creation processes, and landscape-based approaches might play a key role in CCA. Here, these concepts are analyzed and key knowledge gaps identified.

Local networks: The promotion of participatory processes involving stakeholders and other actors is backed by various European Union directives promoting more collaborative forms of governance (Newig and Fritsch, 2009). These participatory processes can lead to the formation of social *networks* that increase the resilient and adaptive capacity of societies (Adger, 2003). From a general perspective, a network can be defined as a pattern of relationships between different actors and as the framework in which negotiations and social learning might occur (Pahl-Wostl et al., 2007). Therefore, a balanced involvement of bottom-up and top-down actors in social networks, a deep understanding of the local context, and a decreasing dependence on outside intervention can

positively affect the institutional response to climate change (Amaru and Chhetri, 2013). Moreover, the development and successful evolution of legitimated social networks require deliberate strategies affecting their *structure, substance, and process* (Sandström et al., 2013). Regarding *structure*, the same authors highlight the importance of having a wide diversity of actors and the involvement of governmental representatives. In terms of *substance*, it is essential to achieve a consensus on the goals and agreements even if, initially, there are conflicting interests and diverging perceptions. From a *process* perspective, it is crucial to facilitate stakeholder interaction.

According to Moser and Ekstrom (2010), the activity of networks can face qualitatively different barriers and their operational methods should be adjusted to deal with long-term perspectives, uncertainty, scenarios, and free speculation. In addition, the activity of multi-sectoral networks for CCA should avoid falling into managerial approaches or mere consultancy. Networks should place stakeholderś knowledge, opinions, and aspirations at the center of their discussion and work with key actors from the very start in groups of a manageable size (Few et al., 2007). Overall, according to the literature, the advancement in CCA through the activity of local networks would face the following challenges (see list of references in Appendix A, Table A2):

- o Legitimacy is crucial in terms of how representative and inclusive the process is for local communities and how much the decisions can be accepted by stakeholders and the whole community.
- o Local fittingness or suitability can be understood as the '*quality or state of being especially suitable or fitting* (Merriam-Webster Dictionary)' for the specific characteristics of a particular place. This quality can become a challenge when data and structures are not sufficiently developed at the local scale.
- o The feasibility and utility for planning of the produced solutions is a further challenge, and related to this, their influence on local and regional governance.
- o Systemic and transdisciplinary treatment of the adaptation process is a key aspect to avoid disconnected actions and achieve holistic, multi-functional, and multi-targeted solutions.
- o The transferability and comparability of results are critical, especially when successful outcomes are achieved, or valuable lessons are learned.
- o Acknowledging the roles of different stakeholders and administrations on CCA is essential for forging a connection with overarching and sectoral policies, and with spatial and sectoral planning.
- o Connections to other key planning agendas, like sustainable development, resilience, urban planning, sustainable agriculture, or biodiversity might need specific considerations.

To answer the challenges identified above and as a first detected knowledge gap (KG1), it is essential to **determine key factors affecting the generation of highly operational and representative local networks for CCA**.

Social learning and co-creation processes: There is wide agreement on the importance of social learning in CCA (Plummer et al., 2012; Albert et al., 2012; Tschakert and Dietrich, 2010). Social learning can be conceptualized as a cyclic and iterative process in which individuals learn through social interaction with other people. This process leads to the development of personal behaviours, values, and codes of conduct. According to Pahl-Wostl et al. (2007), despite technological advances and well-financed central control, top-down transitions are failing, and we need to improve social learning and participatory processes leading to negotiated adaptations. In fact, to overcome 'lock-in' situations, '*actors need to learn to recognize how their own frames of reference influence and constrain their thinking and that other legitimate frames of reference exist*' and may be compatible with the available knowledge. Moreover, through social learning and the collective resolution of conflicts, people can become aware of their *'interdependence and their differences and learn to deal with them constructively',* giving way to the co-definition of shared paradigms, goals, and solutions (Pahl-Wostl et al., 2007, p. 9). As argued by Sprain (2017), the whole collaborative process should help participants to overcome their specific interests and explore potential conflicts and synergies with other actors.

Co-creation processes can be described as a process in which different types of stakeholders or actors, after defining a shared frame, get involved in the joint production of knowledge (Mauser et al., 2013. Overall, the generation of operative and representative networks and their capacity to produce adequate outputs through co-creation processes are perceived as major objectives for CCA (Sprain, 2017; Sandström et al., 2013; Wise et al., 2014). In fact, the quality of their collaborative work is connected to the degree to which social learning occurs and participants evolve during their collaboration (Albert et al., 2012; Plummer et al., 2012; Tschakert and Dietrich, 2010; Adger, 2003). In this regard and as a second detected knowledge gap (KG2), it is critical to **investigate the capacity of local networks to foster social learning, co-creation processes, and the co-production of shared diagnoses, visions, and solutions for CCA**.

Landscape-based approaches: The landscape can provide an integrative spatial and social platform (Galan et al., 2020; Nassauer, 2012; Van Rooij et al., 2021; ELC, 2000) where participatory local networks can engage people in the co-creation of solutions, and in bridging existing gaps between communities and higher-level institutions (García-Martín et al., 2016). From a planning perspective, this approach aligns with the critical importance given by classical and new regionalism to the specific conditions of *place*, and to the promotion of more holistic, comprehensive, and integrative planning (Wheeler, 2002) In addition, the importance assigned in landscape-based approaches to local communities connects to literature advocating the potential that polycentric systems and an adequate balance between centralized and decentralized governance might have in adaptive transitions (Newig and Fritsch, 2009; Urwin and Jordan, 2008; Adger, 2003).

The European Landscape Convention (ELC) defines landscape as "*an area whose character is the result of the action and interaction of natural and/or human factors*" (ELC, 2000). Thus, in contrast to other concepts, the landscape is particularly suitable to integrate socio-cultural and environmental issues, and to address the complex spatial interrelations that affect socio-ecological processes (Newig and Fritsch, 2009). According to Nassauer (2011), landscape care and stewardship are both cause and consequence of deep connections between people and their environments and, together with emotional bonds (Raymond and Brown, 2011), can become a key force to promote landscape adaptation to climate change. Moreover, integrated landscape initiatives can favour inter-sectoral, multi-stakeholder processes and, in a wider sense, promote multi-functionality of landscapes, civic commitment, social learning, stewardship, and long-term approaches to cross-cutting issues (García-Martín et al., 2016). Van Rooij et al. (2021) emphasize that, given the complex character of current spatial planning issues, all actors in the adaptation process should be engaged in a way that they can effectively contribute their knowledge and worldviews to the definition of landscape-based visions and strategies. As a third knowledge gap (KG3), we conclude that **further research is needed to confirm the potential of landscape-based approaches in integrative CCA** planning and in social learning processes.

2.3. Specific research questions

Based on the knowledge gaps identified above (KGs), the overarching research question addressed in this paper can be divided into five specific research questions (RQs).

Firstly, regarding the composition and agency of local networks for CCA (Knowledge Gap 1):

- Which factors favour the generation of highly representative and operative local networks for CCA? (RQ1)

Secondly, concerning the capacity of those local networks to contribute to CCA (Knowledge Gap 2):

- How do co-creation processes and social learning affect individuals' perception and engagement in CCA? (RQ2)
- How can their activity produce high-quality outcomes responding to key challenges and barriers affecting CCA? (RQ3)
- Which connections might exist between networks' composition, their capacity to promote social learning, and their capacity to produce high-quality outcomes? (RQ4) Moreover, are these three aspects affected by the personal profile of local network members or by the characteristics of the landscape in which they operate (personal and locational factors)?

One additional question emerges in relation to Knowledge Gap 3: Is the landscape concept useful to frame CCA planning? (RQ5).

3. Material and methods

To investigate the RQs above, the AELCLIC (Adaptation of European Landscapes to Climate Change) project was initiated in 2018 as a joint venture of different European universities, municipalities, regions, and civil organizations to promote the generation of landscape-based networks for CCA (AELCLIC, 2019). The project was funded by EIT-Climate-KIC and was implemented in 15 pilot landscapes representing a sample of the biophysical, cultural, social, and climatic diversity of the continent (Fig. 1). The selection of pilot landscapes attended to the following criteria: (1) location in the different climate change zones identified by the European Environmental Agency (see colours in Fig. 1); (2) possibilities to engage Climate-KIC partners (universities, cities, or regions); (3) inclusion of urban, rural, and transitional landscapes in each climatic zone, and (4) possibilities to collaborate with local third parties (e.g., municipalities).

The AELCLIC project was designed to activate and engage local

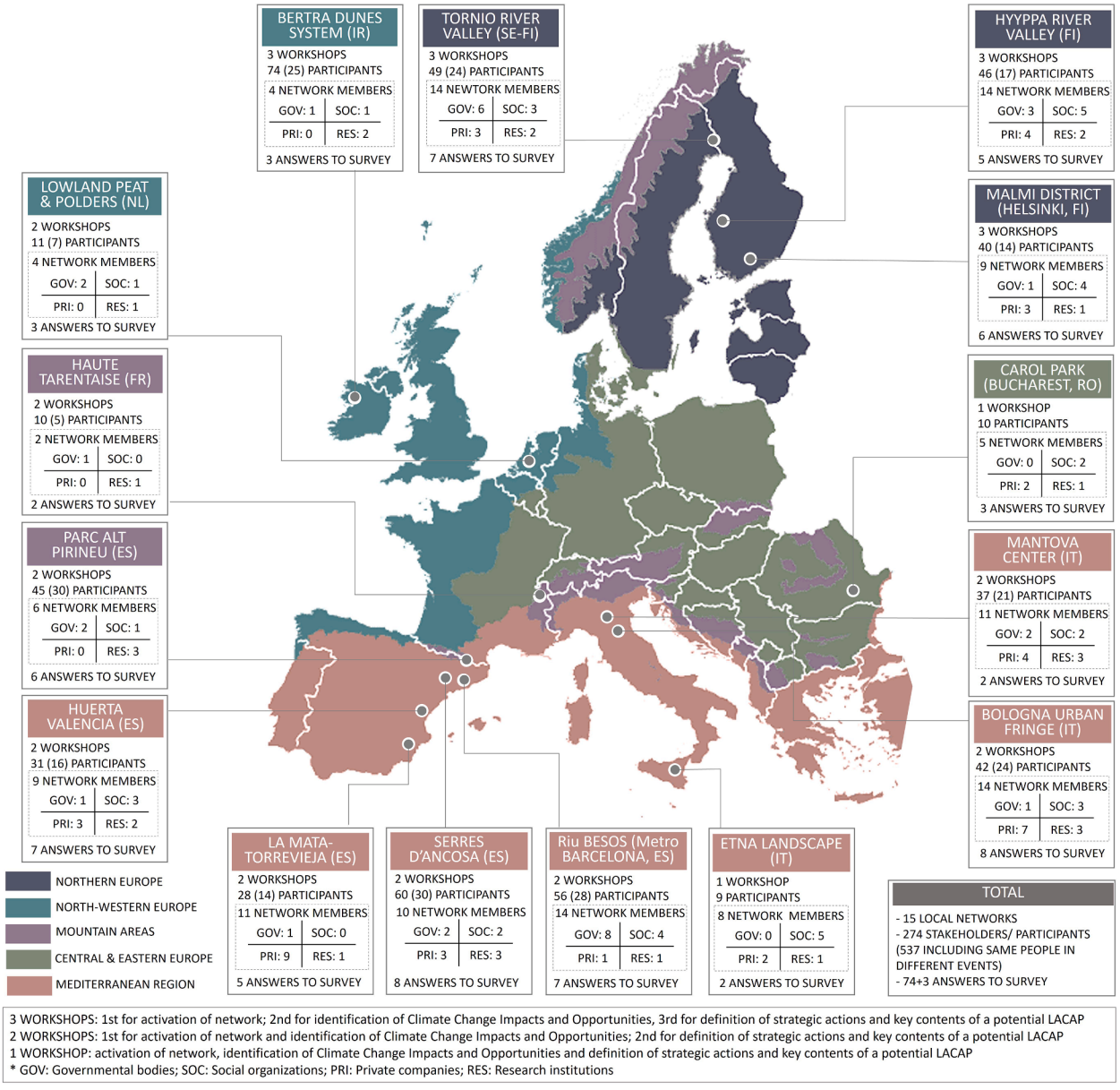

Fig. 1. Pilot Landscapes of the AELCLIC project (in colour, climate change regions according to the European Environmental Agency): location, number of workshops, number of participants (total, and in brackets, the most attended workshop), number of members in the final network (total and per sector) and number of answers to the survey. Bottom: distribution of tasks according to the number of workshops organized in each Pilot Landscape. Source: https://aelclicpathfinder.com/.

communities in CCA through the generation of highly representative local networks with members from the following groups: local/regional authorities; local/regional associations; NGOs; economic actors, and academic institutions. As displayed at the bottom of Fig. 1, the activity and consolidation of the networks were based on a collective work organized around different types of workshops and a common task: the joint diagnosis of the effects of climate change in the local landscape and the co-definition of key contents for a future Landscape and Climate Adaptation Plan (LACAP). The project took place in 2019 and all the workshops were fully documented (see reports at https://aelclicpathfinder.com/). Following the recruitment process described in Appendix A-part2, 274 individuals from different sectors participated in the AELCLIC activities. The networks remained open during the whole process but in almost all pilot landscapes, key stakeholders were identified and invited at the initial phase of the project with the collaboration of local authorities. Each participant kept an independent voice since representatives from the same sector could have different opinions and interests. On average, 18 people participated in each workshop although there were substantial differences between pilots (Fig. 1). This was an adequate number for the conducted co-creation activities, especially if we consider that each workshop lasted around 3 hours and implied the active involvement of all participants.

By the end of 2019, 15 local networks were constituted in the 15 pilot landscapes. The members of those networks expressed their interest in advancing towards the production of local LACAPs and usually included institutions and organizations (see full list in Appendix B). The goals of each workshop and the final composition of each local network are summarised in Fig. 1.

The five RQs were answered using different research methods sequenced in two phases (Fig. 2). Firstly, an assessment based on different variables was produced of the networks' composition, the social-learning and co-creation processes in which they were engaged, and the outcomes that they co-produced. Secondly, a qualitative and synthetic deduction of the factors that affected these three aspects (RQ1, RQ2, and RQ3 respectively) was conducted. The influence of personal or locational factors in the assessment and the possible linkages between the composition of networks, co-creation and social learning, and quality of outcomes were determined through linear regression and correlational analyses respectively (RQ4). The utility of the landscape concept for CCA (RQ5) was specifically investigated within RQ2 since it was hypothesized that it could be one of the variables influencing social learning.

The assessment of issues affecting RQ1, RQ2, and RQ3 (Phase 1) was based on the combination of three methods: (1) a quantitative assessment of a set of variables through Likert questions in a post-case survey; (2) qualitative inputs provided by the participants through a set of open questions in the above-mentioned survey, and (3) reports prepared by the authors after each workshop. The combination of these three methods defined a triangular system for data collection. The use of post-case surveys (Mathis et al., 2016; Zhang and Chen, 2008), and the

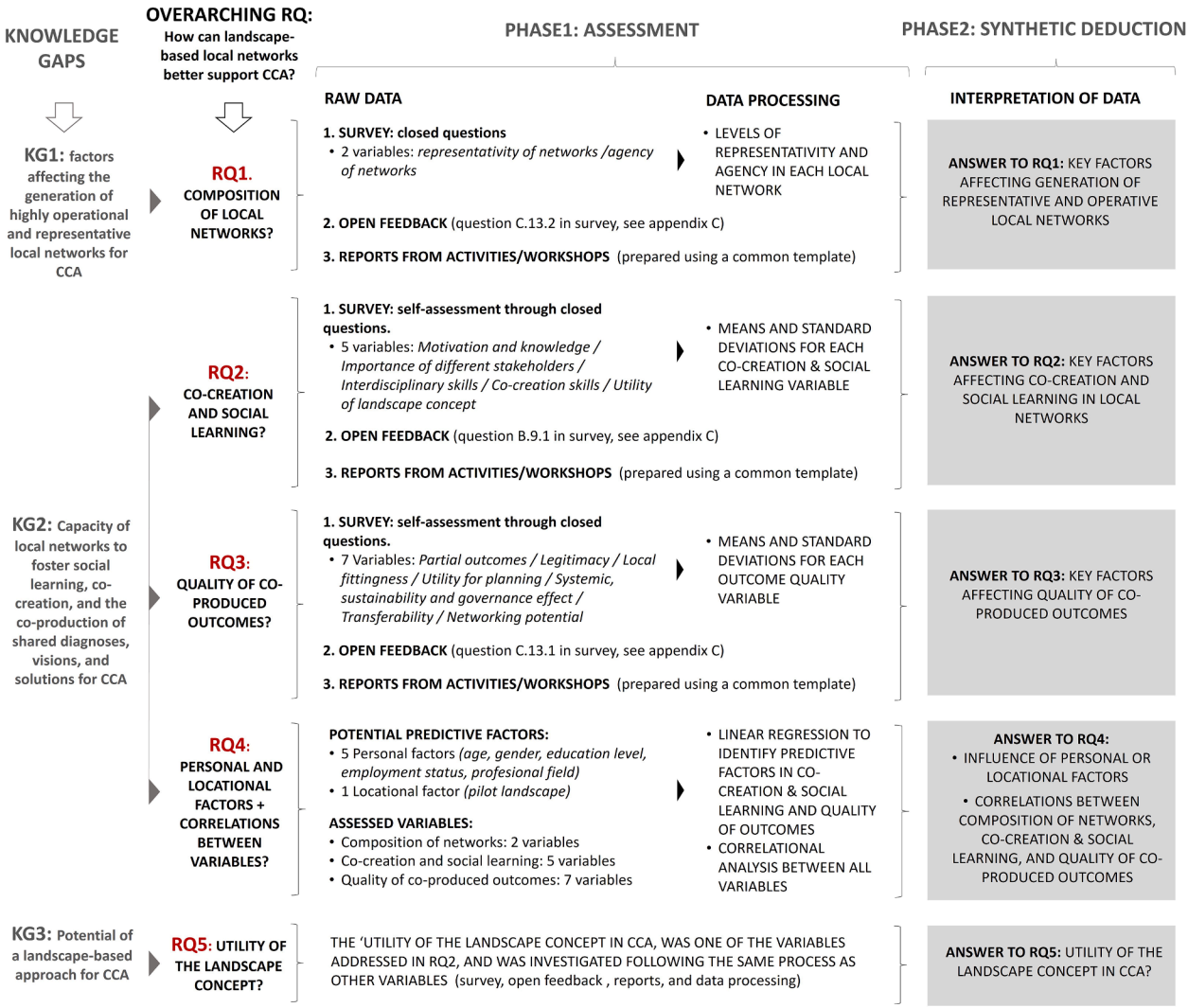

Fig. 2. Research methods applied.

triangulation with other methods (Denzin, 2007; Bryman, 2004) are both recognized practices in social research.

The selection of variables connected with the quality of local networks, social learning, and co-created outcomes was based on the analysis of the literature and on the observations and feedback received by the authors during the conducted activities. These observations and feedback were systematically gathered and documented (AELCLIC, 2019).

The quantitative assessment of the networks was based on two variables (Fig. 2): *representativeness* and *level of agency*. These variables acquired a maximum level when all types of stakeholders were represented (governmental, economic, social, and academic) and were estimated based on the final composition of each local network (Fig. 1; Appendix B).

The quantitative assessment of co-creation and social learning processes was based on answers to an anonymous questionnaire distributed between all the participants at the end of the project. The questionnaire was organized into three sections (see Appendix C). Section "A" (personal information) comprised closed-ended questions addressing five personal factors (Age, Gender, Level of education, Employment status, Professional field) and one locational factor (Pilot landscape). Some sensitive personal aspects like economic status, race, ethnicity, etc., were not included in the questionnaire although they might affect the perception of the landscape and CCA. Section "B" (co-creation and social learning) included Likert-scale questions assessing five variables (*Evolution of motivation and knowledge, Importance assigned to different types of stakeholders, Development of interdisciplinary skills, Development of co-creation skills*, and *Utility of the landscape concept for systems thinking*). Section "C" (Quality of co-produced outcomes) also included Likert-scale questions covering seven variables (*Quality of partial outcomes; Legitimacy; Local fittingness, Utility for planning; Systemic, Sustainability and Governance effect; Transferability;* and *Networking potential*). Some of the variables included sub-variables. In addition, three open-ended questions were included to provide qualitative inputs for the proposed research questions: RQ2) how social learning and co-production could have been enhanced, RQ3) how the impact of the co-created outcomes could have been improved, and RQ1) what additional ideas might have supported the generation of local networks for CCA.

Means and standard deviations were calculated for each Likert question. When a variable included sub-variables, the mean of the variable was calculated as the arithmetic mean of its sub-variables. Answers to the open-ended questions were grouped to identify similar types of replies. RQ4 was answered by constructing linear regression models to investigate the effects of the five personal factors and one locational factor (predictor variables) on the five 'co-creation and social learning' variables and seven 'quality of outcome' variables mentioned above. We performed model selection by removing predictor variables that did not contribute to explaining variation in the response variable. Predictors were removed one at a time (starting from the least significant ones) until those left in the models had p values of < 0.1. All statistical analyses were performed using the R statistical software (R Core Team, 2020). A correlation analysis was performed using the R package psych (Revelle, 2021) and was applied between the 14 studied variables. For the statistical analyses, all pilot landscapes with<3 respondents were discarded.

During the second phase (see Fig. 2), the synthetic deduction of factors affecting network composition (RQ1), social learning and co-creation (RQ2), and outcomes quality (RQ3) was developed based on the quantitative results obtained from the analysis of the networks or the Likert questions of the survey; the qualitative answers to the open questions of the survey; and the authors' observations during the implementation of the project. These three sources of information were also used to evaluate the 'utility of the landscape concept' variable in CCA (RQ5).

Concerning the surveying process, once all the final deliverables, reports, and minutes of all the workshops were available on the project website (AELCLIC, 2019), the questionnaire was made available to all participants of the 15 local networks between March and April 2020 in Google Docs. As displayed in Fig. 1 and despite difficulties created by COVID19 lockdowns across the European Union at the time, the survey was answered by 77 respondents (excluding the organizers and facilitators), which constitutes 30 % of the 274 participants/stakeholders. Any person involved in any co-creation activity (workshops in pilot landscapes and/or the international meeting in Bologna) could answer the questionnaire regardless of their level of participation or type of connection with a pilot landscape.

4. Results

4.1. Composition and agency of local networks

Based on the criteria and results displayed in Table 2, 53 % of the AELCLIC networks were highly *representative* in terms of their composition since they included all types of stakeholders (governmental, societal, private economy, research). In 27 % of the networks, there was a dominance of governmental members, in 20 % of research institutions, in 13 % of private-economy actors, and in 13 % of societal organizations. In addition, 20 % of the networks did not have any private-economy actor, 20 % did not have any societal organization and 13 % did not have any governmental representative. Assuming a potential connection between the composition of networks and their capacity to promote and lead CCA initiatives (LACAP in this case) (Gerhardinger et al., 2018; Sandström et al., 2013; Virkkunen, 2006), 80 % of the networks had a high or medium *level of agency*, whereas 20 % of the networks had a low level of agency since they were lacking any governmental stakeholder or more than one type of stakeholder.

Furthermore, 53 % of the networks were able to identify connections between their activity and existing regional, local, and district planning; and in 80 % of the networks, regional and local authorities expressed their availability to take the lead. These two factors can be considered additional indicators of the level of agency of the networks and of their capacity to promote CCA.

4.2. Social learning within local networks and utility of the Landscape concept

The evolution of social learning for different variables and sub-variables is shown in Fig. 3. Concerning *Evolution in Knowledge and Motivation,* all sub-variables (*increases in interest, knowledge, feeling of urgency, and willingness for future involvement*) received scores of 3.7 out of 5 (moderate increase) and above. The Multilevel governance variable (*Role of administrations and stakeholders*) denotes that the perceived importance of all types of stakeholders increased moderately along the co-creation process, especially for local administrations, which scored over 4.0. Regarding the gain of *Interdisciplinary Skills,* participants agreed that the project gave them the opportunity to interact with other disciplines and sectors (score 4.1). Similarly, participants considered that their *Co-creation Skills* moderately increased during the AELCLIC activities (score 3.8) and that the *Landscape Concept* was useful for addressing CCA systemically (score 3.9).

4.3. Quality of co-produced outcomes

Self-assessment by members of each local network of the quality of their co-produced outcomes is shown in Fig. 4. All *Partial Outcomes* co-created in the pilot landscapes were positively valued with scores ranging between 'moderate agreement (3–3.9)' and 'agreement (4.0–4.5)' to the positive statements included in the survey. The co-identification of *Climate Change Impacts, Opportunities, and Barriers* received the highest scores (4.2, 4.0 and 4.1 respectively). In this regard, the use of available data (from European and National Agencies) made the detection of impacts particularly productive since local participants

Table 2
Main characteristics of the generated local networks for Landscape Adaptation to Climate Change. Percentage of types of stakeholders calculated from the data presented in Fig. 1. REPRESENTATIVENESS OF THE NETWORK: HIGH - all types of stakeholders in the network, MED - one type is missing, LOW - more than one type is missing; DOMINANCE: when one type of stakeholder contributes more than 40% to the total number of members of the network. COLLECTIVE AGENCY: HIGH - when all types of stakeholders are in the network, MED - when one type is missing, LOW - when more than one type or a governmental stakeholder is missing.

	MALMI DISTRICT (Helsinki, Finland)	HYYPPA RIVER VALLEY (Finland)	TORNIO-RIVER VALLEY (Finland-Sweden)	LOWLANDS-POLDERS (The Netherlands)	BERTRA DUNES (Ireland)	HAUTE TARANTAISE (France)	HUERTA OF VALENCIA (Spain)	RIU BESOS (Metro. Barcelona, Spain)	LA MATA-TORREVIEJA (Spain)	ALT PIRINEU Natural Park, (Spain)	SERRES ĎANCOSA (Spain)	BOLOGNA FRINGE, (Italy)	MANTOVA CENTER (Italy)	ETNA-GIARRE (Italy)	CAROL PARK DISTRICT (Bucharest, Romania)
TYPES OF STAKEHOLDERS IN THE FINAL NETWORKS	N = 9	N = 14	N = 14	N = 4	N = 4	N = 2	N = 9	N = 14	N = 11	N = 6	N = 10	N = 14	N = 11	N = 8	N = 5
Governmental (Gov) (%)	12	21	43	50	25	50	12	57	9	33	20	7	18	0	0
Civic society (Soc) (%)	44	36	21	0	25	0	33	29	0	17	20	27	18	62	40
Private economy sector (Pri) (%)	32	29	21	25	0	0	33	7	82	0	30	46	37	25	40
Research (Res) (%)	12	14	15	25	50	50	22	7	9	50	30	20	27	13	20
COMPOSITION															
REPRESENTATIVENESS OF THE NETWORK	HIGH	HIGH	HIGH	MED.	MED.	LOW	HIGH	HIGH	MED.	MED.	HIGH	HIGH	HIGH	MED.	MED
DOMINANCE of some types of stakeholders	Soc	—	Gov	Gov	Res	Gov/Res	—	Gov	Pri	Res	—	Pri	—	Soc	
MISSING STAKEHOLDERS	—	—	—	Soc	Pri	Pri/Soc	—	—	Soc	Pri	—	—	—	Gov	Gov
AGENCY															
COLLECTIVE AGENCY to start working on a LACAP	HIGH	HIGH	HIGH	MED.	MED.	LOW	HIGH	HIGH	MED	MED.	HIGH	HIGH	HIGH	LOW	LOW
SYNERGIES WITH REGIONAL, LOCAL AND DISTRICT PLANNING clearly identified and activated	YES	—	—	YES	—	—	YES	YES	YES	YES	YES	YES	—	—	—
AUTHORITIES DEEPLY INVOLVED AND READY TO TAKE THE LEAD	YES	YES	YES	YES	YES	—	YES	YES	YES	YES	YES	YES	YES	—	—

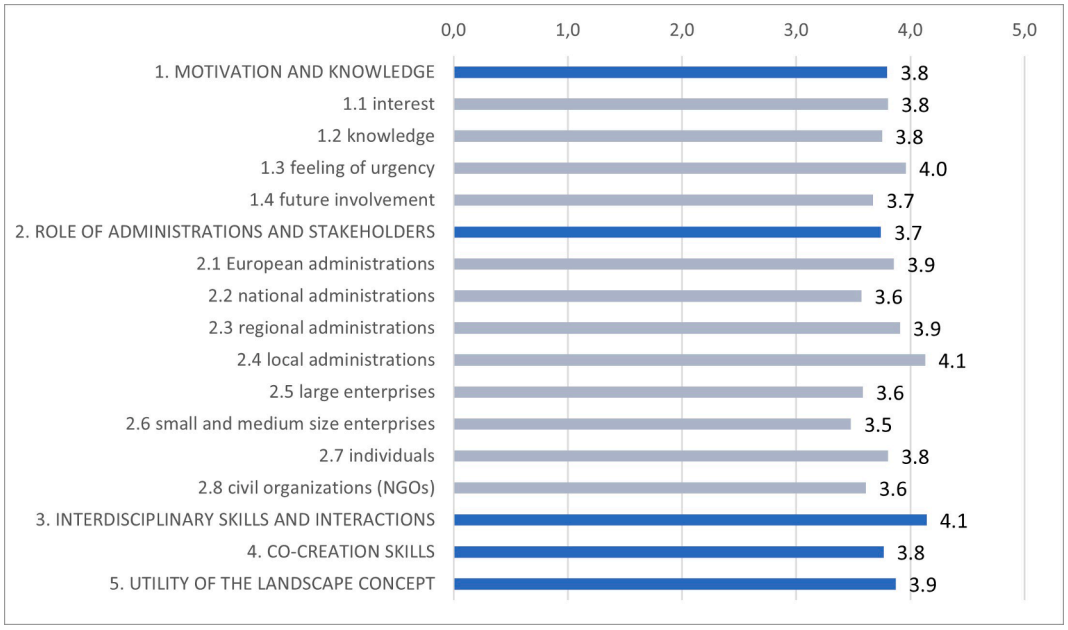

Fig. 3. Personal evolution of participants in the social learning and co-creation processes organized in the AELCLIC project (average results in the 15 pilot landscapes, for full results in each pilot landscape, see Appendix D, Table D.1). Blue bars represent the mean scores for variables and grey bars for their sub-variables (N = 77). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

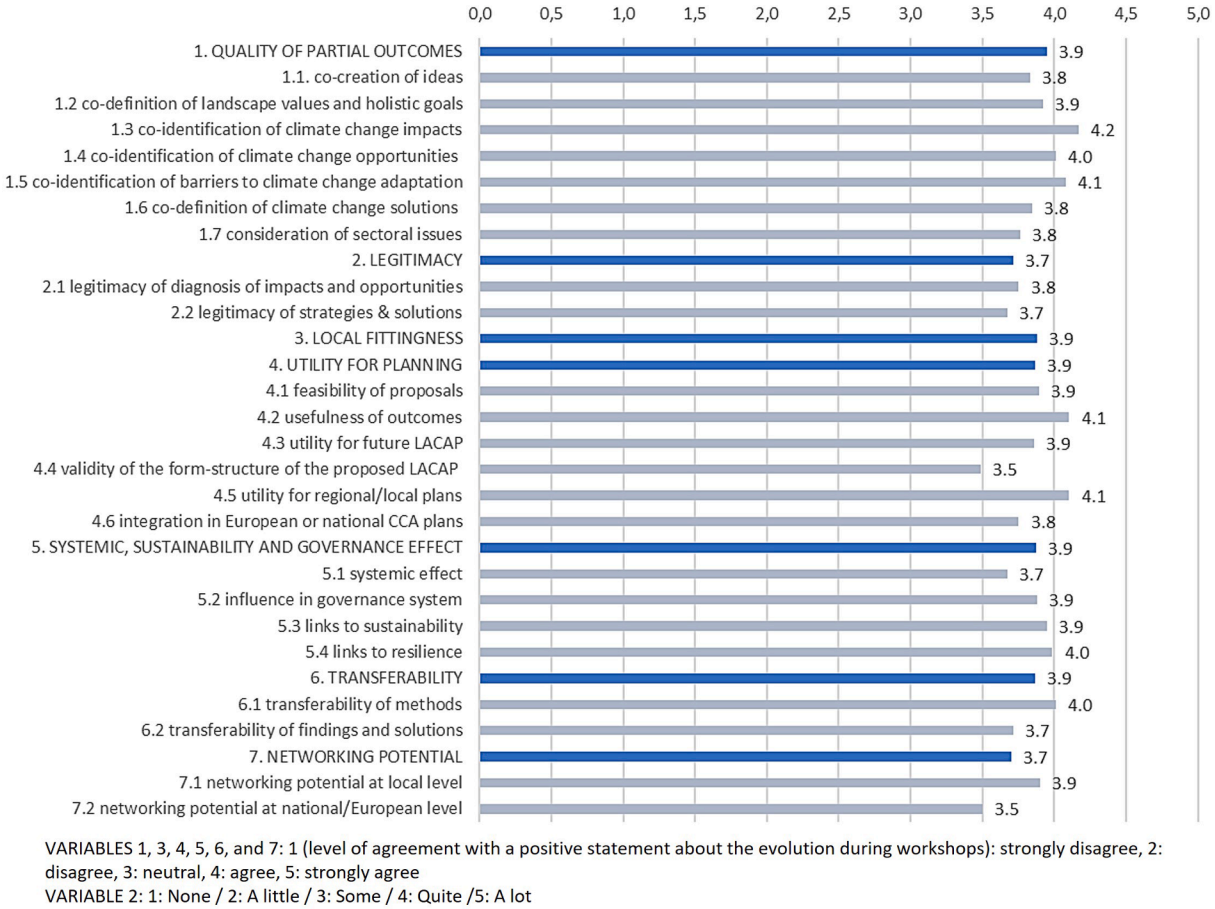

Fig. 4. Self-assessment of the quality of the co-produced outcomes in relation to a set of critical variables identified in the literature (overall results in the 15 pilot landscapes, for full results in each pilot landscape, see Appendix D, Table D.2). Blue bars represent the mean scores for variables and grey bars for their sub-variables (N = 77). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

tried to connect large-scale impacts with their own landscapes and daily lives. On the other hand, the detection of adaptation barriers benefited from the general interest of the participants in discussing obstacles affecting the development of their communities.

Concerning the other assessed variables, the *Legitimacy* of the co-produced outcomes was moderately positive both concerning the diagnosis of problems and the co-definition of proposals. The scores given to the *Local fittingness* of the outcomes (3.9) suggest that members of the local networks found their work moderately connected to the specific characteristics of their own landscapes. The *Utility of the outcomes for Planning* also received positive scores but with slight divergences between sub-variables. Thus, the general utility of the outcomes and their capacity to support local and regional planning were particularly valued (4.1 and 4.1 respectively), whereas the form and structure proposed by each local network for a future LACAP was less supported (3.5). The *Systemic, Sustainability, and Governance Effect* of the co-produced outcomes was positively valued, although their systemic potential scored lower (3.7) than their linkages to new models of governance, sustainability, and resilience agendas (3.9, 3.9 and 4.0 respectively). Regarding *Transferability,* the methods used in the project to foster participatory discussions and co-creation processes received higher scores than the specific solutions co-defined by each network, probably because the latter were more connected to the specific conditions of each landscape. Finally, the *Networking potential* of the co-creation process received a moderate score. The observed difference between the networking potential at a local or regional scale (3.9), and at a national or European scale (3.5), reflects the local character of most of the activities developed within the project.

4.4. Influence of personal and locational factors

The personal characteristics of the respondents are presented in Appendix A (Table A3). None of the personal characteristics showed a fully explanatory relationship with the answers that they gave to the questionnaire. This suggests that social learning and the quality of the outcomes co-produced in the pilot landscapes were similarly perceived by people with different personal backgrounds. This adds to the transferability of the results although some significant tendencies were detected (see Appendix E).

Regarding the influence of the locational factor, some differences were observed in different pilot landscapes across Europe (Appendix E). Answers from the Riu Besos pilot were higher in 5 out of 11 variables, Serres D'Ancosa higher in 4, Hyyppä River valley, Malmi District and La Huerta de Valencia higher in 3, La Mata-Torrevieja and Carol Park District higher in 2, and Bologna, Tornio River valley and Alt Pirineu Natural Park higher in 1. A specific analysis of the participants, networks, and activities reveals that most of the pilots with the following characteristics obtained higher scores (see Fig. 1 and Table 2):

- Networks with a high level of representativeness and agency
- Networks with more than 12 participants and 5 responses to the survey
- Networks where several workshops were organized.

4.5. Correlations between studied variables

A correlation analysis between the two network variables, five social

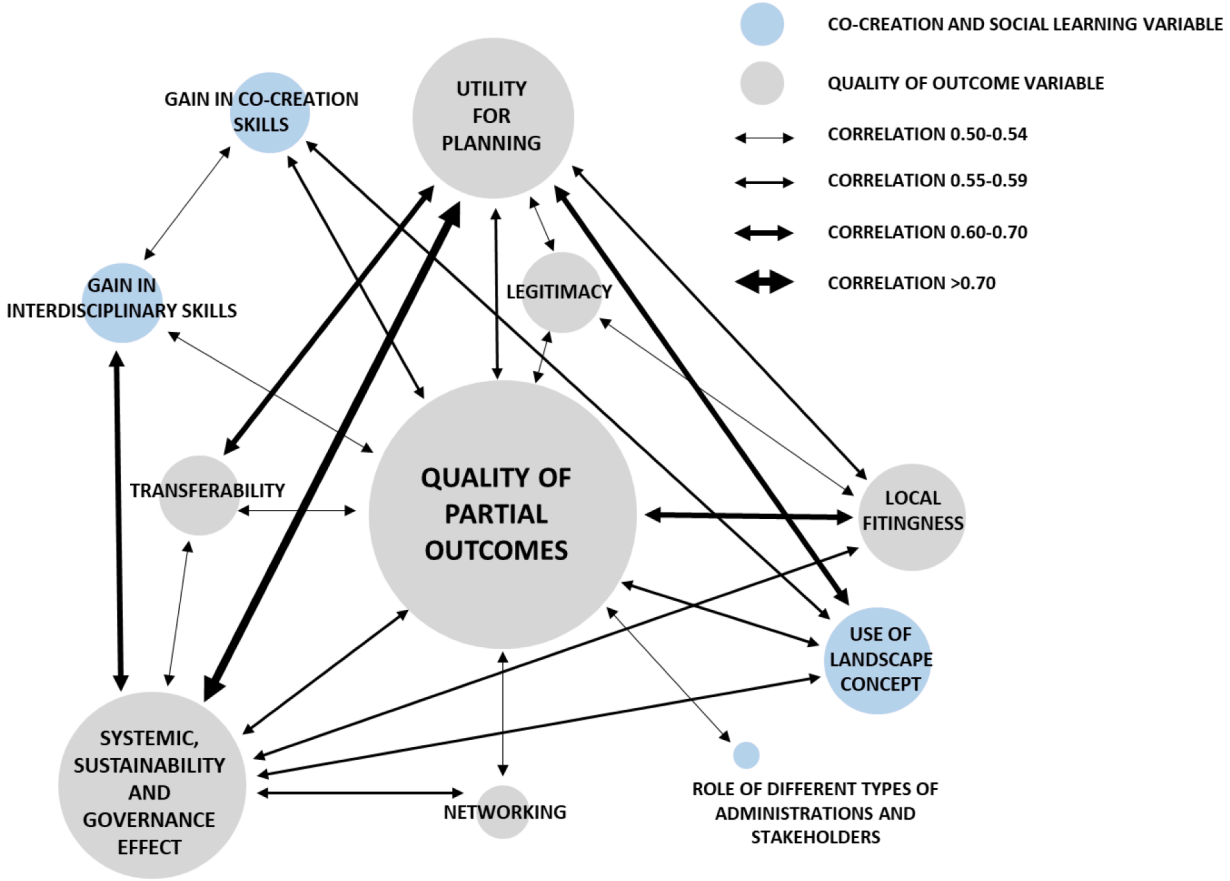

Fig. 5. Bubble diagram summarising the main detected correlations between the variables assessed. All correlations displayed are positive and significant ($p < 0.05$). Bubble size is proportional to the number of correlations for each variable, arrows connect correlated variables, the thickness of the arrows indicates the value of the correlation coefficient, and the colour of the bubble indicates whether it is a social learning (blue) or a quality of outcome variable (grey) (N = 68). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

learning and co-creation variables, and seven outcome quality variables revealed some convergent and divergent patterns of increase (or decrease) between them (Fig. 5, full results in Appendix F). These correlations do not necessarily imply an interdependence or causal link, but may indicate a certain level of association, perhaps due to external factors or variables.

Regarding social learning variables, the *Use of the landscape concept* as a facilitator for cross-cutting discussions was positively correlated with another social learning variable (*Gain of Co-creation skills*) and with three variables associated with the quality of the co-produced outcomes. Similarly, the *Gain of Co-creation skills* was positively correlated with the *Quality of Partial Outcomes* and with the acquisition of *Interdisciplinary Skills*, which was also connected with the production of outcomes with a *Systemic, Governance, and Sustainability effect*.

Concerning the quality of outcomes variables, the *Quality of Partial Outcomes* - that is, the co-identification of climate change impacts and barriers, the co-definition of goals, and the co-design of solutions, was positively correlated with all the other 'quality of outcomes' and 'co-creation and social learning' variables. This suggests that the quality of the partial works produced during the co-creation process had a close connection with all the other variables. In addition, the *Utility for Planning* of the co-produced outcomes and their *Systemic, Sustainability, and Governance* effect were strongly correlated with one another ($r = 0.75$, $p < 0.001$) and with many other variables. In fact, the triangle defined by the three most correlated variables: *Quality of Partial Outcomes* (the different tasks in which the networks were engaged), their *Utility for Planning*, and their *Systemic, Sustainability, and Governance* effect, illustrates the positive connections that can be achieved between co-creation activities within multi-sectoral networks (process), the planning value of their collaborative work (utility), and the systemic and governance impact of the co-produced outcomes (effect). These activities were also positively correlated with the *Local Fittingness* of the outcomes and with the *Use of the Landscape Concept*, which could in fact be perceived as two parallel expressions of a deep connection to the site. In addition, the *Legitimacy* of the co-produced outcomes was positively correlated with their *Utility for Planning*, *Local Fittingness,* and the *Quality of Partial Outcomes*.

4.6. Results from open questions of the questionnaire and from direct observations of the organizers during AELCLIC activities

Answers to the open questions included in the questionnaire (full list available in Appendix G), and authors' observations during their interactions with local networks, provided additional information about potential factors influencing the assessed variables. A synthetic analysis of these answers suggests that:

#1. Respondents were satisfied with the co-creation process and with the possibility of contributing with their personal or sectoral perspectives in local planning for CCA.
#2. More diversity of participants is needed in networks, especially from the economic sector.
#3. Governmental involvement is vital for legitimizing and operationalizing decisions of the networks.
#4. The adequate design of the co-creation process and the sufficient allocation of time and resources are essential to produce adequate outcomes and consolidate the network.
#5. Participants want to produce tangible outcomes that can lead to action and self-involvement.
#6. Communication and dissemination with adequate materials are critical to increase the networks and their impact.
#7. The process needs to have continuity and lead to follow-ups and further studies.
#8. CCA can be incorporated into all types of planning and in some existing tools (e.g., Environmental Impact Assessment, Landscape Impact Assessment, or Strategic Environmental Assessment).
#9. More local knowledge and research are required to inform local decisions.
#10. Cultural or mental barriers such as short-termism, denialism, pre-conceptions, lack of systemic and holistic thinking, or distrust need to be addressed.

5. Discussion

Our synthesis is based on three types of inputs: quantitative results obtained from the survey (Table 2, Figs. 3, 4, 5; appendices D, E, F); answers to the open questions of the questionnaire (list in section 4.6; Appendix G), and the authors' observations during activities in different pilot landscapes. This synthesis leads to the identification of factors influencing: (1) the creation of representative and operative local networks for CCA (RQ1), (2) social learning and co-creation processes within those networks (RQ2), and (3) the quality of co-produced outcomes (RQ3). These factors are explained below and listed in Fig. 6. In addition, the interconnections between these three types of factors are analysed, together with the possible effect of personal and locational factors (RQ4). The Discussion concludes with an analysis of the utility of the landscape concept in CCA (RQ5) and of the linkages between our research and the existing literature.

5.1. Composition of local networks for CCA (RQ1 and KG1).

Results suggest that the generation of '***representative/multi-sectoral***' and '***high-agency/operative***' local networks for CCA depends on the capacity to engage key local stakeholders representing the administrative, societal, economic, and scientific dimensions of the addressed landscape (Table 2). In addition, these two sub-variables are strongly correlated (Appendix F), although this can be the consequence of using similar criteria for their determination. The constitution of high-quality networks also seems to depend on the involvement of local/regional authorities (as highly legitimated and connected actors within their local communities), on the definition of action-oriented tasks that can lead to further initiatives, on the good dissemination of their activities, and on the definition of a well-managed co-creation process searching for true collaboration and community building (see open answers #3, #5, #7, #6 and #4 in subsection 4.6). In addition, the pre-existence of a participatory culture and multi-sectoral networks already working on environmental or landscape-related issues, together with the autonomy of the network to define their own agendas, might also have a positive effect on the creation of high-quality networks. These findings align with existing literature on the role and structure of local networks for CCA (García-Martín et al., 2016; Sandström et al., 2013; Amundsen et al., 2010). One of the main challenges affecting these variables is the difficulty of involving the many different actors representing the economic sectors and civil groups, whose diverging and even conflicting interests can be discussed and negotiated within local networks (#2).

5.2. Social learning and co-creation processes for CCA (RQ2 and KG2)

As presented in Fig. 3, we found that collaborative work in representative local networks can lead to an increase *in* ***motivation and knowledge*** (score 3.8), to the recognition of *the* ***role of different types of administrations and stakeholders*** on CCA multilevel governance (score: 3.7), and to the development of ***interdisciplinary*** *and* ***co-creation skills*** (scores: 4.1 and 3.8, and significant correlation displayed in Fig. 5). In agreement with the literature (Sprain, 2017; Sandström et al., 2013; Ayers and Dodman, 2010; Few et al., 2007) and as synthesized in Fig. 6, the achievement of these goals can be catalyzed by using adequate participatory methods (#4), by the internal diversity of the group (#2), by the availability of adequate local knowledge (#9), by linking the discussions on CCA to other societal and planning agendas concerning the local community (#8), and by ***using the landscape*** as a common

Fig. 6. Key factors affecting the generation of representative and operative local networks for CCA, the development of co-creation processes for social learning, and the co-production of high-quality outcomes.

ground in which all participants can recognize themselves and in which integrative solutions can be achieved (#8 and score 3.9). In relation to political-science studies on multilevel governance for CCA, results indicate that all levels were found relevant in the research conducted, but the two extremes of the governance chain (Europe and Region/Municipality/Individual) experienced higher increases during the co-creation process (scores 3.9, 3.9, 4.1 and 3.8 respectively). This last result aligns with the importance assigned by different authors to the local scale in climate change governance (Bernauer, 2013). In addition, the observed positive variations in the levels of motivation and future involvement (see Fig. 3) align with the positive effect that participatory techniques can have in connecting individuals with CCA through the generation of community and identity feelings (Bernauer, 2013).

5.3. Quality of co-created outcomes for CCA (RQ3 and KG2)

Concerning factors affecting the quality of co-created outcomes for CCA (RQ3), as presented in Fig. 6 and according to the scores displayed in Fig. 4, their ***legitimacy*** (score 3.7) seems to be connected to the participation of legitimized stakeholders (e.g., local authorities and other publicly elected actors, see open answer #3) and to the implementation of a consistent co-creation process fitting local conditions and

planning requirements (see correlations in Fig. 5 and #4). The ***utility for planning*** (score 3.9) is influenced by the extent to which the activity of local networks can be linked to the development of CCA-specific plans (LACAPs in this study) or to other types of plans (#8). In addition, and as displayed in Fig. 5, the ***utility for planning*** variable relates to many other variables affecting the quality of co-creation processes. Moreover, the use and generation of sound evidence and local knowledge seems to be crucial for the overall quality of the outcomes and for their integration into planning (#9).

Results also suggest that the ***systemic, sustainability, and governance effect*** of the outcomes (score 3.9) might depend on the networks' capacity to connect CCA to other cross-cutting planning agendas and on their potential to promote interdisciplinary thinking, long-termism, and new vertical and horizontal collaborations between social and political actors (see correlations in Fig. 5 and #10). ***Local fittingness*** (score 3.9) had a significant linkage to the utility for planning, legitimacy, systemic-sustainability-governance effect, and quality of partial outcomes (Fig. 5). In addition, the level of this variable might depend on the availability of local information (#9). The ***transferability*** of co-produced outcomes for CCA (score 3.9) could be affected by their didactic and visual quality, their level of generalization, and their capacity to support planning (#6 and correlations in Fig. 5), whereas their ***networking potential*** (score 3.7) might benefit from positive interactions within the network leading to its consolidation and expansion within the community (#4). Externally, the interaction with other networks or communities addressing similar challenges might lead to the creation of external alliances and the exchange of knowledge (see Appendix G). Finally, according to our results, the ***quality of the partial outcomes*** (score 3.9) elaborated by local networks through a sequence of articulated tasks (co-identification of impacts, opportunities, and barriers; co-definition of goals and visions; and co-design of solutions) is strongly and positively correlated with all the other quality variables (see Fig. 5). This suggests that the way in which the co-creation process is conducted and structured has a crucial effect on all other variables.

5.4. Connections between the composition of local networks, social learning, and co-produced outcomes for CCA and the potential influence of personal and locational/geographical factors (RQ4 and KG2)

The correlational analysis indicates a positive relation between many of the studied variables, especially those associated with the quality of co-produced outcomes, the acquisition of co-creation and interdisciplinary skills, and the utility of the landscape concept in CCA (see Fig. 5; Appendix F). This suggests that potential synergies can be generated between co-creation methods and adaptive instruments for CCA, and that further investigations might be needed to understand their mutual interdependencies. Conversely, the observed low correlations between the variables associated with representativeness and agency of local networks, and all the other variables, was an unexpected result that would require further research. An initial hypothesis is that the effective ways in which the co-creation process was conducted in some local networks could have counter-balanced some problems in their levels of representativeness or agency, and vice versa.

In addition, the linear regression analysis conducted for each personal or locational factor and each social learning or quality of outcomes variable (see Appendix E), reveals that none of these factors had an overarching predictive effect. Personal factors were rarely significant, suggesting that results can be transferred to other landscapes and communities. The locational factor had a certain influence on the assessed variables. For instance, the levels of representativeness/agency of the constituted local networks and the quality of the implemented social learning processes and of the co-created outcomes were higher in some pilot landscapes in which four characteristics concurred (see Table 2; Appendix D): (1) high number of participants from different sectors; (2) development of multiple workshops, (3) proactive involvement of local authorities in the activities, and (4) strong alignment between the organized activities and the objectives of the project (constitution of representative and operational local networks for CCA and development of collective works of diagnosis and planning). In practice, these four characteristics were highly interconnected, which suggests that the overall design and implementation of the recruitment process and of the co-creation activities (workshops) could have a strong influence on the assessed variables (see the nodal position of *Quality of Partial Outcomes* in Fig. 5).

5.5. Utility of the landscape concept for CCA (RQ5 and KG3)

The landscape concept was perceived as a suitable integrative platform to accommodate systemic discussions transcending disciplinary knowledge or personal interests (Opdam et al., 2013). Thus, when a direct question on the utility of 'landscape' was put to participants, it scored 3.9 out of 5 (Fig. 4). In addition, the linkages presented in Fig. 5 support the utility of the landscape concept in improving the quality of co-produced outcomes for the three most interconnected variables. In fact, and as claimed by Nassauer (2012), the emotional bonds generated through the landscape between people and places might strongly determine peoplés interest in promoting CCA, especially when they perceive that those landscapes are at risk. These results also denote that comprehensive planning can be promoted through the co-creation of landscape-based visions and the co-definition of landscape-based plans "*fulfilling the needs and reflecting the power balance between the actors involved within the context of the landscape system*" (Van Rooij et al., 2021, p. 10).

5.6. Additional reflections and limitations of our research

Results align with existing studies indicating the importance of promoting systemic adjustments and of increasing the transformative agency of society if CCA is to be achieved (Gerhardinger et al., 2018; Davoudi et al., 2013; Balbi and Giupponi, 2009). This alignment was confirmed by the support that members of local communities expressed for the possibility of getting involved in CCA integrative planning (see #1 and Figs. 3 and 4). Similarly, the possibility of combining CCA with sustainability, resilience, and local stewardship issues (Eriksen et al., 2011; Ayers and Dodman, 2010) was corroborated by the sustainability, resilience, and governance potential of the outcomes co-produced by local networks (score 3.9 in Fig. 4). The main types of barriers affecting CCA (see Table 1) were also identified by the local networks in their own pilot landscapes through a co-creation process, especially those affecting socio-cultural barriers, engagement, legitimacy, governance and institutional obstacles, local knowledge gaps, planning barriers, resource constraints and lack of systemic and long-term thinking (see #3, #8, #9 and #10 and reports in AELCLIC, 2019). Overall, we observed (see 'planning' and 'systemic' variables in Fig. 4) that co-produced outcomes might contribute to "*…integrate different adaptation and mitigation strategies with the overall development goals of the community through local government leadership, comprehensive planning, and prioritization*" (Laukkonen et al., 2009, p. 287).

In agreement with the literature, results suggest (see Fig. 4) the utility of local networks and co-creation processes to conduct legitimate community-based discussion on CCA and to generate visions and plans for CCA with a broader level of social support, and therefore of implementation potential (Sandström et al., 2013; Adger et al., 2005). Moreover, as claimed by Sandström et al. (2013), the special attention paid in this study to the structure, substance, and process of the constituted local networks through the integration of a wide variety of actors, the achievement of collective consensus, and the interaction between stakeholders, was key for their functioning and helped to overcome purely managerial, reactive, or consultancy approaches (Amundsen et al., 2010; Few et al., 2007). Results also agree with most of the conditions identified by Pahl-Wostl et al. (2007) for the consolidation of adaptive regimes and for the generation of dynamic and

flexible actor-networks for adaptive management: (1) availability and monitoring of adequate information over appropriate time scales, (2) implementation of transparent and open social learning processes in which actors are able to process the available information and draw meaningful conclusions, (3) generation of decisions which are evidence-based, and combine flexibility and continuity, (4) development of trust and social capital for problem-solving and collaborative governance, and (5) creation of space for collaborative, creative, and out-of-the-box thinking to unblock lock-ins and counteract entrenched positions.

A critical analysis of our research reveals some limitations. From a methodological perspective, the deduction of factors displayed in Fig. 6 could have been based on a more systematic definition of variables in the initial phases (e.g., through an external Delphi process) and another type of triangulation (e.g., post-case survey, evaluation of processes and outcomes by external experts, and interviews with participants and organizers). Based on the existing literature, we would also recommend considering in further studies the influence of other personal factors such as economic status, race or ethnicity, political and ideological views, etc. (Schuldt and Pearson, 2016; Bliuc et al., 2015). In addition, the number of participants was adequate for the development of co-creation activities, but the incorporation of more stakeholders could have added additional perspectives, enriched the discussions, and strengthened the findings.

6. Conclusions

In answer to existing knowledge gaps affecting the development of social learning processes for climate change adaptation at the local level, this study reveals the importance of generating highly representative and operative networks in which stakeholders with different interests, types of knowledge, worldviews, and expectations can openly co-identify climate change impacts and co-design systemic solutions. Thus, adequately designed co-creation processes on CCA can lead to social learning, increased motivation and knowledge, recognition of other stakeholders and planning levels, development of interdisciplinary and co-creation skills, and the adoption of the landscape as a platform for systemic and integrative thinking.

These co-creation processes can crystallize in the co-production of outcomes embodied with sufficient levels of legitimacy, local fittingness, feasibility for planning, and transferability. They can generate networking possibilities at different scales and promote local sustainability, resilience, and governance. Moreover, the positive correlations detected in our study between different *quality of outcomes* and *co-creation and social learning* variables suggest that they may well be interconnected and that positive synergies may be generated between them.

Our results were shared across 15 different European landscapes, which indicates their potential transferability to other landscapes. However, observed differences between pilot landscapes suggest that specific arrangements during the recruitment and co-creation processes can affect the final composition of local networks and the quality of social learning and co-produced outcomes.

Although the effectiveness of multilevel governance and participatory processes on CCA is not self-evident (Nalau et al., 2015; Carina and Keskitalo, 2010), our study confirms the importance of the local scale in multi-scalar climatic regimes and in the legitimation and implementation of climate policies at the domestic level (Bernauer, 2013). Co-creation activities in multi-stakeholder networks can thus be perceived as a specific tool to develop collective diagnoses, visions, and solutions, but also to internalize and signify climate change challenges within local communities. In addition, the effectiveness of the local and community-scale commitment to CCA seems to be a powerful argument to counteract potential conflicts between the predominant large-scale planning for climate change mitigation and adaptation (e.g., New Green Deal in the USA or European Green Deal), and social justice at the local level (Goh, 2020).

The presented methods and results might be perceived as part of the much-needed actionable knowledge required to support sustainable and adaptive transitions (Mach et al., 2020) and to achieve the alignment advocated by Epstein et al. (2015) between policies, governance systems, and the socio-ecological context of environmental or landscape problems. In essence, they constitute potential instruments for decision and policymakers interested in exploring new ways of progressing in sustainable and resilient development and management through the activation and coordinated involvement of local communities in CCA.

Our results suggest that climate change can become a catalyst for the holistic management of the various dimensions of the landscape (ecological, cultural, social, political, and economic) and for solving today's adaptive planning problems. This finding constitutes an invitation to use the potential of co-participated processes and the landscape concept to foster integrated visions and solutions based on collaboration and dialogue, and to promote systems thinking, open governance, and the re-connection between people and places as basic preconditions to address CCA and other critical global challenges.

Funding Source

This work was supported by EIT-CLIMATE-KIC [grant number TC_2.1.5_190294_P018-1A, 2019]. The sponsor was not involved in the preparation of the article.

CRediT authorship contribution statement

Juanjo Galan: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – review & editing, Supervision, Visualization, Writing – original draft. **Francisco Galiana:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **D. Johan Kotze:** Data curation, Formal analysis, Methodology, Resources, Writing – review & editing. **Kevin Lynch:** Conceptualization, Investigation, Methodology, Resources, Writing – review & editing. **Daniele Torreggiani:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing. **Bas Pedroli:** Conceptualization, Funding acquisition, Investigation, Methodology, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank all members of the AELCLIC local networks and all participants of the AELCLIC project activities, with special reference to those who kindly answered the final questionnaire.

Appendices A–G. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2022.102627.

References

Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. Econ. Geogr 79 (4), 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x.

Adger, W.N., Arnell, N.W., Tompkins, E.L., 2005. Successful adaptation to climate change across scales. Glob. Environ. Chang. 15 (2), 77–86. https://doi.org/10.1016/j.gloenvcha.2004.12.005.

AELCLIC (2019). Adaptation of European Landscapes to Climate Change. Available from: https://aelclicpathfinder.com/ [Accessed 08th June 2021].

Albert, C., Zimmermann, T., Knieling, J., von Haarena, C., 2012. Social learning can benefit decision-making in landscape planning: Gartow case study on climate change

adaptation, Elbe valley biosphere reserve. Landsc. Urban Plan. 105 (4), 347–360. https://doi.org/10.1016/j.landurbplan.2011.12.024.
Amaru, S., Chhetri, N.B., 2013. Climate adaptation: Institutional response to environmental constraints, and the need for increased flexibility, participation, and integration of approaches. Appl. Geogr. 39, 128–139. https://doi.org/10.1016/j.apgeog.2012.12.006.
Amundsen, H., Berglund, F., Westskog, H., 2010. Overcoming barriers to climate change adaptation—A question of multilevel governance? Eviron. Plann. C. Gov. Policy 28 (2), 276–289. https://doi.org/10.1068/c0941.
Ayers, J., Dodman, D., 2010. Climate change adaptation and development I. Prog. Dev. Stud. 10 (2), 161–168. https://doi.org/10.1177/146499340901000205.
Balbi, S., Giupponi, C., 2009. Reviewing agent-based modelling of socio-ecosystems: A methodology for the analysis of climate change adaptation and sustainability. SSRN Electron. J. https://doi.org/10.2139/ssrn.1457625.
Bernauer, T., 2013. Climate change politics. Annu. Rev. Polit. Sci. 16 (1), 421–448. https://doi.org/10.1146/annurev-polisci-062011-154926.
Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., McNeeley, S.M., 2014. A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. Glob. Environ. Chang. 25, 97–108. https://doi.org/10.1016/j.gloenvcha.2014.01.003.
Biesbroek, G.R., Klostermann, J.E.M., Termeer, C.J.A.M., Kabat, P., 2013. On the nature of barriers to climate change adaptation. Reg. Environ. Chang. 13 (5), 1119–1129. https://doi.org/10.1007/s10113-013-0421-y.
Bliuc, A.-M., McGarty, C., Thomas, E.F., Lala, G., Berndsen, M., Misajon, R., 2015. Public division about climate change rooted in conflicting socio-political identities. Nat. Clim. Chang. 5 (3), 226–229.
Bryman, A. (2004). Triangulation and measurement. Retrieved from Department of Social Sciences, Loughborough University, Loughborough, Leicestershire: www.referenceworld.com/sage/socialscience/triangulation.pdf. In Lewis-Beck, M.S, Bryman, A. Liao, T.F. (eds) *Encyclopedia of Social Science Research Methods,* Thousand Oaks: SAGE Publications, Inc. 1143-1144. 10.4135/9781412950589.n1031.
Carina, E., Keskitalo, H., 2010. Introduction – adaptation to climate change in Europe: theoretical framework and study design. In: Carina, E., Keskitalo, H. (Eds.), Developing Adaptation Policy and Practice in Europe: Multi-level Governance of Climate Change, 1st ed. Springer:, Heidelberg, pp. 1–38. https://doi.org/10.1007/978-90-481-9325-7_1.
Carter, J.C. (2011) Climate change adaptation in European cities. *Curr. Opin. Environ. Sustain.*, 3(3), 193-198, DOI.
Davoudi, S., Brooks, E., Mehmood, A., 2013. Evolutionary resilience and strategies for climate adaptation. Plan. Pract. Res. 28 (3), 307–322. https://doi.org/10.1080/02697459.2013.787695.
Denzin, N. K. (2007). *Triangulation.* The Blackwell Encyclopedia of Sociology. doi.org/10.1002/9781405165518.wbeost050.pub2.
Duguma, L.A., Minang, P.A., van Noordwijk, M., 2014. Climate change mitigation and adaptation in the land use sector: from complementarity to synergy. Environ. Manag. 54 (3), 420–432. https://doi.org/10.1007/s00267-014-0331-x.
ELC (2000). European Landscape Convention. Available from: http://www.coe.int/en/web/landscape/text-of-the-european-landscape-convention/ [Accessed 08th June 2021].
Epstein, G., Pittman, J., Alexander, S.M., Berdej, S., Dyck, T., Kreitmair, U., Rathwell, K. J., Villamaypr-Tomas, S., Vogt, J., Armitage, D., 2015. Institutional fit and the sustainability of social–ecological systems. Curr. Opin. Environ. Sustain. 14, 34–40. https://doi.org/10.1016/j.cosust.2015.03.005.
Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D., Molefe, J.I., Nhemachena, C., O'brien, K., Olorunfemi, F., Park, J., Sygna, L., Ulsrud, K., 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. Clim. Dev. 3 (1), 7–20.
Few, R., Brown, K., Tompkins, E.L., 2007. Public participation and climate change adaptation: avoiding the illusion of inclusion. Clim. Pol. 7 (1), 46–59. https://doi.org/10.1080/14693062.2007.9685637.
Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., Rockström, J., 2010. Resilience thinking: integrating resilience, adaptability and transformability. Ecol. Soc. 15 (4) https://doi.org/10.5751/es-03610-150420.
Galan, J., Bourgeau, F., Pedroli, B., 2020. A Multidimensional Model for the Vernacular: Linking Disciplines and Connecting the Vernacular Landscape to Sustainability Challenges. Sustainability 12 (16), 6347. https://doi.org/10.3390/su12166347.
García-Martín, M., Bieling, C., Hart, A., Plieninger, T., 2016. Integrated landscape initiatives in Europe: Multi-sector collaboration in multi-functional landscapes. Land Use Policy 58, 43–53. https://doi.org/10.1016/j.landusepol.2016.07.001.
Gerhardinger, L.C., Gorris, P., Gonçalves, L.R., Herbst, D.F., Vila-Nova, D.A., De Carvalho, F.G., Glaser, M., Zondervan, R., Glavovic, B.C., 2018. Healing Brazil's Blue Amazon: The role of knowledge networks in nurturing cross-scale transformations at the frontlines of ocean sustainability. Front. Mar. Sci. 4 https://doi.org/10.3389/fmars.2017.00395.
Goh, K., 2020. Planning the green new deal: Climate justice and the politics of sites and scales. J. Am. Plann. Assoc. 86 (2), 188–195.
Hallegatte, S., 2009. Strategies to adapt to an uncertain climate change. Glob. Environ. Chang. 19 (2), 240–247. https://doi.org/10.1016/j.gloenvcha.2008.12.003.
Klein, R.J.T., Schipper, E.L.F., Dessai, S., 2005. Integrating mitigation and adaptation into climate and development policy: three research questions. Environ. Sci. Policy 8 (6), 579–588. https://doi.org/10.1016/j.envsci.2005.06.010.
Laukkonen, J., Blanco, P.K., Lenhart, J., Keiner, M., Cavric, B., Kinuthia-Njenga, C., 2009. Combining climate change adaptation and mitigation measures at the local level. Habitat Int. 33 (3), 287–292. https://doi.org/10.1016/j.habitatint.2008.10.003.
Mach, K.J., Lemos, M.C., Meadow, A.M., Wyborn, C., Klenk, N., Arnott, J.C., Ardoin, N. M., Fieseler, C., Moss, R.H., Nichols, L., Stults, M., Vaughan, C., Wong-Parodi, G., 2020. Actionable knowledge and the art of engagement. Curr. Opin. Environ. Sustain. 42, 30–37.
Mathis, E.F., Kim, H., Uysal, M., Sirgy, J.M., Prebensen, N.K., 2016. The effect of co-creation experience on outcome variable. Ann. Tour. Res. 57, 62–75. https://doi.org/10.1016/j.annals.2015.11.023.
Mauser, W., Klepper, G., Rice, M., Schmalzbauer, B.S., Hackmann, H., Leemans, R., Moore, H., 2013. Transdisciplinary global change research: the co-creation of knowledge for sustainability. Curr. Opin. Environ. Sustain. 5 (3–4), 420–431. https://doi.org/10.1016/j.cosust.2013.07.001.
McLaughlin, P., 2011. Climate change, adaptation, and vulnerability: reconceptualizing societal-environment interaction within a socially constructed adaptive landscape. Organ. Environ. 24 (3), 269–291. https://doi.org/10.1177/1086026611419862.
Measham, T.G., Preston, B.L., Smith, T.F., Brooke, C., Gorddard, R., Withycombe, G., Morrison, C., 2011. Adapting to climate change through local municipal planning: barriers and challenges. Mitig. Adapt. Strat. Glob. Chang. 16 (8), 889–909.
Moser, S.C., Ekstrom, J.A., 2010. A framework to diagnose barriers to climate change adaptation. PNAS 107 (51), 22026–22031.
Nalau, J., Preston, B.L., Maloney, M.C., 2015. Is adaptation a local responsibility? Environ Sci Policy 48, 89–98. https://doi.org/10.1016/j.envsci.2014.12.011.
Nassauer, J.I., 2011. Care and stewardship: From home to planet. Landsc. Urban Plan. 100 (4), 321–323. https://doi.org/10.1016/j.landurbplan.2011.02.022.
Nassauer, J.I., 2012. Landscape as medium and method for synthesis in urban ecological design. Landsc. Urban Plan. 106 (3), 221–229. https://doi.org/10.1016/j.landurbplan.2012.03.014.
Newig, J., Fritsch, O., 2009. Environmental governance: participatory, multi-level - and effective? Environ. Policy Gov. 19 (3), 197–214. https://doi.org/10.1002/eet.509.
Nordgren, J., Stults, M., Meerow, S., 2016. Supporting local climate change adaptation: Where we are and where we need to go. Environ Sci Policy 66, 344–352. https://doi.org/10.1016/j.envsci.2016.05.006.
Opdam, P., Nassauer, J.I., Wang, Z., Albert, C., Bentrup, G., Castella, J.-C., McAlpine, C., Liu, J., Sheppard, S., Swaffield, S., 2013. Science for action at the local landscape scale. Landsc. Ecol. 28 (8), 1439–1445.
Pahl-Wostl, C., Sendzimir, J., Jeffrey, P., Aerts, J., Berkamp, G., Cross, K., 2007. Managing change toward adaptive water management through social learning. Ecol. Soc. 12 (2) https://doi.org/10.5751/es-02147-120230.
Pielke, R.A., 1998. Rethinking the role of adaptation in climate policy. Glob. Environ. Chang. 8 (2), 159–170. https://doi.org/10.1016/s0959-3780(98)00011-9.
Plummer, R., Crona, B., Armitage, D.R., Olsson, P., Tengö, M., Yudina, O., 2012. Adaptive comanagement: a systematic review and analysis. Ecol. Soc. 17 (3) https://doi.org/10.5751/es-04952-170311.
R Core Team, 2020. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria https://www.R-project.org/.
Raymond, C.M., Brown, G., 2011. Assessing spatial associations between perceptions of landscape value and climate change risk for use in climate change planning. Clim. Change 104 (3–4), 653–678. https://doi.org/10.1007/s10584-010-9806-9.
Revelle, W., 2021. psych: Procedures for Psychological, Psychometric, and Personality Research. Northwestern University, Evanston, Illinois. R package version 2.1.3.
Sandström, A., Crona, B., Bodin, Ö., 2013. Legitimacy in co-management: the impact of preexisting structures, social networks and governance strategies. Environ. Policy Gov. 24 (1), 60–76. https://doi.org/10.1002/eet.1633.
Schuldt, J.P., Pearson, A.R., 2016. The role of race and ethnicity in climate change polarization: evidence from a U.S. national survey experiment. Clim. Change 136 (3–4), 495–505. https://doi.org/10.1007/s10584-016-1631-3.
Smit, B., Pilifosova, O. 2001. Adaptation to Climate Change in the Context of Sustainable Development and Equity. In *Climate Change 2001: Impacts, Adaptation, and Vulnerability (chapter 18)*, IPCC.
Sprain, L., 2017. Paradoxes of public participation in climate change governance. Good Soc. 25 (1), 62–80. https://doi.org/10.5325/goodsociety.25.1.0062.
Tschakert, P., Dietrich, K.A., 2010. Anticipatory learning for climate change adaptation and resilience. Ecol. Soc. 15 (2) https://doi.org/10.5751/es-03335-150211.
Urwin, K., Jordan, A., 2008. Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. Glob. Environ. Chang. 18 (1), 180–191. https://doi.org/10.1016/j.gloenvcha.2007.08.002.

Van Rooij, S., Timmermans, W., Roosenschoon, O., Keesstra, S., Sterk, M., Pedroli, B., 2021. Landscape-based visions as powerful boundary objects in spatial planning: lessons from three Dutch projects. Land 10 (16). https://doi.org/10.3390/land10010016.

Virkkunen, J. (2006) Dilemmas in building shared transformative agency, *Activités* [Online], Available from: https://journals.openedition.org/activites/1850 [Accessed 08th June 2021]. 10.4000/activites.1850.

Wheeler, S.M., 2002. The new regionalism: Key characteristics of an emerging movement. J. Am. Plann. Assoc. 68 (3), 267–278. https://doi.org/10.1080/01944360208976272.

Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E. R.M., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Glob. Environ. Chang. 28, 325–336. https://doi.org/10.1016/j.gloenvcha.2013.12.002.

Young, O.R., Berkhout, F., Gallopin, G.C., Janssen, M.A., Ostrom, E., van der Leeuw, S., 2006. The globalization of socio-ecological systems: An agenda for scientific research. Glob. Environ. Chang. 16 (3), 304–316. https://doi.org/10.1016/j.gloenvcha.2006.03.004.

Zhang, X., Chen, R., 2008. Examining the mechanism of the value co-creation with customers. Int. J. Prod. Econ. 116 (2), 242–250. https://doi.org/10.1016/j.ijpe.2008.09.004.