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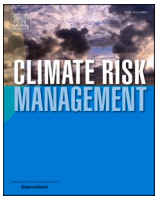

Unattended gap in local adaptation plans: The quality of vulnerability knowledge in climate risk management

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ABSTRACT

A risk-based management approach to climate change is dominant in local adaptation plans integrating climate-science data with place-based vulnerability assessments. While the former has a regional character and uncertainty is approached by means of probabilities and confidence, the latter is context-specific, relies on local knowledge and uncertainty is barely assessed. The objective of this paper is to highlight the relevance of uncertainty analysis in the vulnerability assessment of local adaptation plans by enhancing the Knowledge Quality Assessment tool. This analytical proposal differs from technical uncertainty analysis because it addresses both the social context and the process of knowledge production. Next, the advanced uncertainty dimensions have been applied in the vulnerability assessment used in two Mediterranean adaptation plans. Findings show that institutional arrangements and the role of intermediate parties (contextual dimension) shape the knowledge used, produced, and reproduced (substantive dimension) and hamper community-engaged assessments (procedural dimension). Resulting vulnerability representations, which are poorly grounded on context-sensitive knowledge, compromise the relevance of risk-assessment outputs and local agency in adaptation governance. The present research contributes to the academic study of plans evaluation and of the adaptation science-governance interface at the local scale.

1. Introduction

A climate-adaptation plan should detail how global climate change (CC) is projected to impact a target community, and identify adaptive local responses (Preston et al., 2011a). Within the standardized risk-based assessment workflow of local adaptation plans (hereafter, plans), vulnerability assessment is commonly articulated through local knowledge (Kettle et al., 2014). However, local authorities remain financially and technically ill-equipped for assessing local exposure and vulnerability linked to climate risk assessment and management (Fünfgeld, 2010; Räsänen et al., 2017).

There is an increased awareness of the need to address uncertainty in CC adaptation policies (Kunreuther et al., 2014; Patt & Weber,

Abbreviations: CC, Climate Change; KQA, Knowledge Quality Assessment; SES, Socioecological System.

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2014; van Bree & van der Sluijs, 2014). To date, strategies to account for uncertainty in adaptation decision-making have mostly relied on quantitative and statistical analysis of the climate-system information (Dessai & van der Sluijs, 2007). Uncertainties exist when trying to understand current and projected place-based vulnerabilities of target socioecological systems (SES) for the purpose of identifying local risks and impacts on CC. Moreover, uncertainties in context-specific knowledge and societal responses to global CC can potentially be quite large (Adger & Vincent, 2005; Moser, 2005; Patt et al., 2005). However, those uncertainties have so far been relatively unattended (Dessai et al., 2007; Preston, Yuen, et al., 2011). This might partly be explained by the standardized approach grounded on the positivistic paradigm that inhibits the social dynamics of environmental change (Lövbrand et al., 2015; O'Brien & Leichenko, 2019); the context-specific nature of vulnerability assessments; the qualitative nature of many vulnerability assessments and their challenging validation process (Preston et al., 2011b). The consequences of under addressing those uncertainties undermine the role of vulnerability assessments in supporting informed decisions in the policy arena (Preston et al., 2011b). Since local adaptation policies are aimed at reducing vulnerability (Ribot, 2011), there is a need to address uncertainty in local vulnerability assessments and to reinforce the role of the context-specific knowledge of plans.

To this end, this paper advances and tests an analytical uncertainty framework to evaluate the quality of local vulnerability assessments and inform adaptation practitioners. Grounded on the complex (Gallopín, 2006; Turner et al., 2003) and contested nature (Eriksen & Selboe, 2015; O'Brien & Wolf, 2010) of vulnerability characterization and its policy implications, we draw on the post-normal view of uncertainty (Funtowicz & Ravetz, 1990). A broad conception of uncertainty allows us to address quality criteria specific to the properties and roles of this knowledge within the political, social, and economic context. Additionally, the present paper advances the original Knowledge Quality Assessment (KQA) framework (Maxim & van der Sluijs, 2011) by integrating knowledge governance as a novel source of knowledge quality. We refer here to the institutional rules and knowledge management practices that shape the possibilities and choices for producing and reproducing relevant actionable knowledge (Van Kerkhoff, 2014) and social learning (Gerritsen et al., 2013) in the context of CC adaptation strategies.

In the following sections, we apply this analytical framework by evaluating the quality of knowledge within the vulnerability indices developed by local adaptation polices for two cities located within the metropolitan area of Barcelona (Spain). Both plans were developed under the Covenant of Mayors Initiative on Adaptation to Climate Change (Mayors Adapt, 2014). The Covenant of Mayors (hereafter, the Covenant) is a transnational climate network of cities based on a multilevel-governance model and is a determinant driver in boosting the adaptation plans of small agglomerations (Reckien et al., 2018). Our approach raises the question of whether the transfer and alignment of assessment procedures (i.e., vulnerability and risk identification) can result in influential assessments in concrete policy-making processes that are highly conditioned by specific geographical, political, and cultural contexts. We argue that this will depend largely on the quality of the context-specific knowledge used. Subsequently, we advance a qualitative uncertainty analysis of risk-based management in urban adaptation policy. Transcending traditional approaches of technical uncertainty, we highlight the role of reflexivity in rethinking institutional settings and facilitating the processing of knowledge for complex issues at the local scale.

2. Conceptual framework

2.1. Vulnerability analysis under complexity and uncertainty

Vulnerability emerges from the dynamic interplay between biophysical and social processes operating at different spatiotemporal and functional scales (Adger, 2006; Turner et al., 2003). Vulnerabilities within an SES evolve and redistribute (Bousquet et al., 2021). Explicative factors (climatic-induced and non-climatic determinants) consist of a web of causalities which cannot be commensurate with linear phenomena (Gallopín, 2006; Turner et al., 2003). Adaptive capacity can occur through dynamic interaction and feedback relationships that generate novel behaviour or emerging properties which cannot be predicted or understood simply by examining the system's parts (Berkes et al., 2003; Folke, 2006; Gallopín, 2006).

Simplifying complexity is necessary in producing information that can be used for governance. However, in contrast to simple systems, a complex system cannot be adequately captured using a single perspective or analytical choice. Within vulnerability research, different traditions (hazard approach, political ecology, entitlements approach or SES resilience approach) have addressed place-based vulnerability representations from different analytical choices (Eakin & Luers, 2006). Each analytical choice not only prioritizes different types of knowledge but also embraces complexity differently and emphasizes different types of responses (O'Brien et al., 2007). Resulting vulnerability representations of the same system under study from different analytical choices and/or scales might be non-equivalent (Kovacic, 2017; Nightingale, 2016; O'Brien et al., 2004). Consequently, complexity is by default a source of uncertainty.

The approach proposed in this paper addresses uncertainties that are the result of "forcing the complex observed system into the theoretical boxes provided by the formal method of representation used" (Kovacic, 2015, p.10); for example, measurements of theoretical concepts (Hinkel, 2011) through the development of composite indicators praxis (Barnett et al., 2008). Proxy indicators are generally employed in constructing indices of vulnerability dimensions to different stressors. Different model structures linking exposure, sensitivity, and adaptive capacity have been advanced in the literature (Thiault et al., 2021). Vulnerability indicators range from the biophysical to the socioeconomic and institutional (Füssel, 2007). Practical challenges and limitations of methodological approaches, such as aggregation methods or weight estimation, have been identified as sources of uncertainty (Tate, 2013; Tonmoy et al., 2014), and alternative methodological proposals to deal with nonlinearity and incommensurability have been made (El-Zein & Tonmoy, 2017).

We argue that difficulties encountered in defining, measuring, or evaluating vulnerabilities of complex SES are sources of

uncertainty, but do not necessarily impede good quality assessments in addressing specific decision-making processes. Therefore, this paper proposes moving from scientific research to specific vulnerability assessments framed by the domain of policy analysis that involves both facts and values (Patt et al., 2012).

2.2. Quality of knowledge for governance

The knowledge used in CC adaptation policies influences decision-making in the effort to reduce vulnerability. Therefore, policymakers and resource managers should be aware of knowledge uncertainties in making informed decisions. In that regard, three challenges should be highlighted:

1. Not all uncertainties can be resolved by gathering more data (i.e., irreducible uncertainty); nor can all uncertainties always be expressed quantitatively.
2. Vulnerability measures do not only respond to "stating facts" but also to how a system is likely to function in the future, which cannot be developed through strict reliance on predictive logic.
3. "Positivistic" uncertainty analysis (i.e., accounting for the deviation from deterministic knowledge) refers exclusively to scientific content and is suited specifically to the scientists' view (or to the modellers' view), with low relevance within the socio-political sphere (Maxim & van der Sluijs, 2011).

Challenges found in the assessment of science for policy are addressed through the lens of post-normal science by transcending the classical concept of 'technical uncertainty' for 'quality' approached as a function of context. There is no direct relationship between quality and uncertainty, i.e., high-quality knowledge is not equivalent to low uncertainty. The quality criterion for evaluating the knowledge used and produced for informing societal and political debates is *fitness for function*. As such, "quality is not only about the product but also includes process, people, and purposes when information is to be fit for sustainable decision-making" (Funtowicz and Ravetz, 1993 quoted by Kønig et al., 2017, p.13) or is intended to enhance local governance capacities.

Practical tools for quality evaluation aim to promote transparency by divulging the constraints found and the decisions taken on dealing with stochastic and nonlinear processes, and the limits of scientific knowledge for policy demands. These tools include quantitative approaches (such as Monte Carlo), mixed approaches capturing both quantitative and qualitative (NUSAP, i.e., Numeral, Unit, Spread, Assessment and Pedigree), and qualitative approaches (KQA, Uncertainty guidance, extended peer-review, model quality checklist) (van der Sluijs et al., 2006). These methods have been applied to specific case studies in exploring the quality of environmental indicators for governance, such as beach quality indexes (Bombana & Ariza, 2018, 2019) or the quality of CC adaptation projects (Haque et al., 2017). However, the academic literature on KQA has mostly focused on theoretical terms within the ambit of the philosophy of science, and less effort has been dedicated to assessing its practical applicability.

There is a lack of consensus on vulnerability metrics in the academic literature, and the international climate network of cities promotes a standardized approach based on descriptive measures by aggregating environmental and social attributes (Abarca-Alvarez et al., 2019). But how can these descriptive measures be validated? This paper applies a KQA tool to address the unattended uncertainty characterization of the context-specific knowledge required in the risk equation. By context-specific knowledge we refer to scientific, local and managerial–political knowledge. Therefore, this uncertainty approach adds to Ziervogel et al., (2016) knowledge-policy interface of climate change adaptation planning. The analytical proposal differs from technical uncertainty analysis by addressing both the social context and the process of knowledge production. The inclusion of the social dimensions of uncertainty (instead of the ideal of *truth* knowledge) is justified by the inherent epistemic uncertainty surrounding vulnerability characterization, as well as by its political implications.

The term 'knowledge quality' in this paper is consistent with 'usable science', since both are explicitly conceived to contribute to a decision-making process (Clark & Majone, 1985). The vulnerability KQA framework, which we explore in the following sections, is —like the climate science usability approach—a "function both of the context of potential use and of the process of scientific knowledge production itself" (Dilling and Lemos, 2011, p. 680). Both approaches contribute to enhancing the relevance of science for policy in a context of environmental change. The usability approach has predominantly focused on the relevance of climate information for decision-making (Kirchhoff et al., 2013; Lemos et al., 2012) or the effectiveness of research programmes for informing decision-making (Ford et al., 2013). Less attention has been given to the usability of context-specific knowledge used in communicating CC vulnerabilities to local councils. Unlike the usability approach, the KQA looks through the lenses of knowledge uncertainty in managing complex SES. Accordingly, this paper contributes to science for policy by linking local vulnerability assessment with qualitative approaches of uncertainty, and explores its implications in the policy sphere.

3. Methodology

3.1. Study area

Located in the south of Barcelona's metropolitan area, the Llobregat delta has historically played a strategical role in the city of Barcelona's economic development (Breton et al., 2000; Paül & Tonts, 2005). Successive expansions of Barcelona's airport, port and logistic platforms since the mid-1960s have turned the deltaic natural system into a channelled estuary disconnecting the river from the evolution of the delta (Gracia & Calafat, 2019). Fluvial and marine flooding episodes are constitutive elements of the Delta (Codina, 1966), but human alteration of the deltaic system's dynamics adds uncertainty to its predicted behaviour under extreme events.

The deltaic land, covering only 100 km^2, is made up of a highly heterogeneous mosaic of land uses (Fig. 1). Competing interests, values, and place attachments in the area generate different narratives with respect to resource management (De Roa & Esteban, 2018). Risk and environmental problems are individually addressed by means of expensive and controversial instrumental interventions. As a result, the Llobregat delta faces the challenge of dealing with accumulated threats due to local historical process, aggravated by global environmental change (Marcé et al., 2012).

Two coastal municipalities of this deltaic region, El Prat del Llobregat and Viladecans (case study - Fig. 1), approved a local adaptation strategy in 2015 (AMB, 2015b, 2015a). Driven by the commitment of the Covenant of Mayors, both plans are the first generation of CC adaptation strategies for small agglomerations (less than 100,000 inhabitants) in the region. Additionally, the two cases are also relevant because, first, they capture the features of many other middle-size Mediterranean municipalities engaging with the Covenant mandates; and second, by being located in a metropolitan delta, they capture the contested values, SES complexities and uncertainties of flooding *peri*-urban areas. Furthermore, these municipalities show a historical coexistence with flood risk and management that highpoint the relevance of the need to take local knowledge into account.

The plans were promoted by the Barcelona metropolitan agency acting as a Covenant regional coordinator of both municipalities. Covenant intermediate coordinators are those public administrations (provinces, regions, etc.) providing financial and technical support to municipalities signing up to the Covenant. Accordingly, these regional parties are key determinants of the multilevel-governance boosted by the European Commission.

The documents produced are action plans—in some cases with referrals to intervention sectors—but of a non-binding character. They are conceived as a preliminary screening of most prominent climate risks based on a standardized approach (EC and EEA, 2019). Consequently, the analytical framework of the vulnerability assessment is operationalized and subordinated to obtaining a ranking of the most prominent climate risks that guide the actions programme. However, we have focused exclusively on the vulnerability assessment of coastal inundation risk. The plan structure is as follows: (i) geographical characterization of the municipality and review of local competences; (ii) regional climate projection; (iii) risks prioritization (includes a vulnerability assessment); (iv) programme of actions (horizon 2016–2020); and (v) monitoring/review.

3.2. Methods: The vulnerability KQA tool

The critical assessment of knowledge quality is performed by submitting and scrutinizing the content of the plans as shown in the KQA analytical framework (Table 1) below. Conceived as a friendly evaluative approach, the framework links qualitative uncertainty assessment theory with vulnerability guidance for planning process adaptation. The present analytical framework is the result of a synthesis from a previous work: the uncertainty matrix of quality assessments of environmental science for policy (Maxim and van der Sluijs, 2011), which incorporates common uncertainty typologies to assess the knowledge base (Walker et al., 2003), jointly with qualitative sources of uncertainty (Pereira & Funtowicz, 2009).

While the structure of Table 1 is the same as the original version (in the *x* axis, the knowledge production phases; in the y axis, the knowledge dimensions), we have reformulated the set of uncertainty typologies into fields of inquiry through nine guiding questions. Thus, it offers a more comprehensible framework of analysis than its predecessor and is tailored and extended to adaptation science for policy. The main contribution of the reformulated KQA tool with respect to the original version is the inclusion of a pivotal issue affecting environmental science for policy: the institutional arrangements and organizational practices that articulate knowledge-

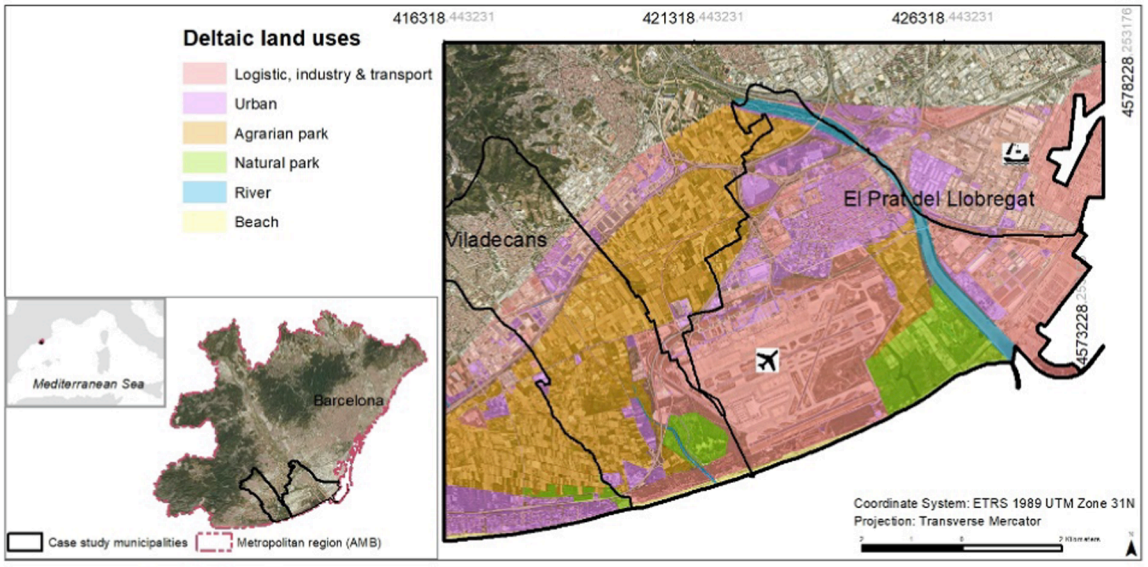

Fig. 1. Study area location map.

Table 1
The vulnerability KQA framework reformulated.

		KNOWLEDGE PRODUCTION PHASES		
		Problem framing	Knowledge production	Knowledge communication and use
UNCERTAINTY DIMENSIONS	Contextual	Why carry out the assessment at all?	What kind of institutional arrangements govern knowledge-based plans?	Is it relevant to the problem addressed?
		Analytical choices influenced by socioeconomic & political context	*Pertinence of knowledge management process & knowledge governance*	*External quality (fitness for purpose)*
	Procedural	Who defines/how to define the problem?	By whom/how is the knowledge produced and validated?	Who communicates/how to communicate?
		Shared vision, legitimacy	*Competences & validation (extended peer review)*	*Accountability, transparency, reflexivity*
	Substantive	What to assess?	Is it scientifically robust?	Is it precise in reporting outcomes & uncertainties?
		Epistemic uncertainty in contextual understanding and by the simplification of knowledge claims	*Technical, methodological and epistemic uncertainty*	*Internal quality*

based processes with decision-making. This contribution fills a gap in the original version of the KQA tool (Maxim and van der Sluijs, 2011, p. 487), which leaves blank the central quadrant of the matrix without any uncertainty typology (knowledge production-contextual dimension). The inclusion of knowledge governance in Table 1 aims to point to relevant institutional and organizational challenges in adaptation strategies, that is, strengthening relationships between knowledge and action.

Problem framing refers to the process of defining the question to be addressed ("what is" vulnerable and "to which stressors".

1. *Why carry out the assessment at all,* refers to what has motivated the assessment and under what kind of conditions. This places attention onto the influence of normative, political and socioeconomic priorities in the framing phase of the assessment (Hinkel, 2011; Schneider et al., 2019).
2. *Who defines/how to define the problem?* is indicative of the legitimacy reached in the framing process (Cash and Clark, 2001) based on the sensitivity towards integrating divergent stakeholders' interests, values, beliefs, or risk perceptions. It is thus related to the inclusiveness and representativeness of vulnerable population groups (Mitrofanenko et al., 2018).
3. *What to assess,* entails making decisions on framing the system boundaries based on several assumptions. The quality of those assumptions (epistemic uncertainties) stem from incomplete knowledge of processes generating vulnerability (El-Zein & Tonmoy, 2015).

Knowledge production involves the process of measuring exposure, sensitivity, and adaptive capacity. This step, commonly developed through scoring indices/indicators, can encompass the selection of indicators, weight estimation and the aggregation methods used.

4. *What kind of institutional arrangements govern knowledge-based plans?* addresses patterns of knowledge governance influencing the quality of context-specific knowledge used and reproduced. Good quality in this field of inquiry can be identified by questioning whether identified institutional arrangements have been helpful in connecting context-specific knowledge and action (Van Kerkhoff & Lebel, 2006; West et al., 2019). As the development of the plans is in itself an adaptive capacity enhancement, this approach highlights the importance of social learning as a fundamental knowledge process (Gerritsen et al., 2013).
5. *By whom/how is the knowledge produced and validated*, ranges from expert competences of knowledge producers to value-*ladenness* or value orientations in shaping the way questions are framed, data included and interpreted, data excluded, etc., and, who has validated the outcomes, and how (peer review, extended peer communities review) if applicable.
6. *The scientific robustness* of vulnerability-index development includes an evaluation of the technical (i.e., inexactness), methodological (i.e., unreliability) and epistemic (i.e. ignorance) sources of uncertainty (Funtowicz & Ravetz, 1990).

Communication and use of the assessment outputs points to the reporting process of knowledge and uncertainties.

7. *Is it relevant to the problem addressed?* This question critically assesses whether the knowledge produced and communicated is well contextualized for its intended use, and is thus more likely to be influential in the governance sphere. This includes the scale of assessment outputs, the environmental and socioeconomic stakes addressed and the options for action (suited to the available competences and/or capacities of end-users).
8. *Who communicates/how to communicate* refers to the accountability reached in reporting assessment outcomes. Good quality is evaluated by identifying within the assessment-explicit argumentations reflecting existing alternative scientific evidence, data gaps or approaches excluded from the analysis and its impacts in results obtained.

9. *Is it precise in reporting outcomes & uncertainties* refers to both the quantity (completeness-selective reporting) and the quality (accuracy-vagueness) attained. It also covers accuracy in making uncertainties explicit, as well as the potential implications of those uncertainties with respect to the policy addressed (Petersen et al., 2013).

3.3. Data sources

The analytical framework applicability confronts the context-specific knowledge of plans with local qualitative data gathered in the study area (documentary and fieldwork).

3.3.1. Documentary analysis

As a first step, we reviewed local documents concerning the region's geography and its evolution. To gain a better understanding of the local territory, and its institutional and political dynamics, the review included local news reports, newspaper articles, laws, regulations, and political and economic agreements. To gain knowledge about accumulated environmental impacts affecting the region, case-specific scientific studies related to geomorphological coastal dynamics, flood risk, groundwater governance and pollution were revised. Additionally, documents of past Environmental Impact Assessments for each of the supra-municipal infrastructures built in the study area were scrutinized with special attention to ongoing redemptive measures. This was crucial to identifying divergences in the vulnerability state described in the plans (substantive dimension). Another thematic pillar of material analysed included local CC adaptation within academic papers and grey literature on adaptation guidance for local practitioners, which became determinant in analysing the procedural quality of knowledge.

3.3.2. Field work

As a second step, and as a primary data source, a total of 22 semi-structured interviews were held with regional practitioners (including Covenant territorial coordinators), members of municipal institutions, water managers, coastal managers, officials of large infrastructure, and transport-logistics facilities, members of the water users' community, agrarian park farmers, natural park managers, environmental law experts and interest groups. The snowball sampling technique was used to identify these practitioners. An important source of bias in the representativity of our sample was the fact that we were not able to interview either a representative of the International Airport or any agent from large operators through to medium and small enterprises. Participants were asked to comment: present challenges faced by the target system (by them as individuals and/or as representatives of an institution, entity or collective), integration of climate risks into planning documents, and constraints/facilitators of local capacities.

Additionally, three workshops were organized from November to December 2019 to provide a platform for interaction among local political, economic, and civil society agents so as to discuss current and expected future problems. Most of the interviewed agents participated in the workshops, which were attended by a total of 24, 33 and 20 people respectively. The workshops were organized using the World Café methodology promoting intersectoral discussions of the complex societal challenges tackled. A total of 9 group discussions were held in each workshop. Workshop 1 perused discussion on present sensitivities aggravating local vulnerabilities. Workshop 2 focused on linking current vulnerabilities with projected climate pressures, placing emphasis on available local responses. And Workshop 3 included social platforms and interest groups that could not attend the previous two workshops. The purpose was not to perform an analysis of narratives on the legitimacy of the plans. Accordingly, participants were not asked to comment on plan content, or on the veracity of the knowledge used for vulnerability indices. Rather, plans' quality assessment was performed indirectly through knowledge acquired in the rich qualitative material of the fieldwork (i.e., notes and transcripts).

To sum up, primary source of data was collected, analysed, and contrasted with the knowledge contained in the plans (descriptive, purposive, and normative) referred to coastal inundation risk. The vulnerability KQA tool structured such evaluation by the occurrence of, and reference to, the nine guiding questions. The purpose was to interrogate the significance and usability of the vulnerability knowledges used/produced in attaining the goals of the plans (risk identification and vulnerability reduction).

4. Results

In line with the analytical framework, we adopted a reflexive stance in relation to the inadequacies of knowledge that hinder a useful representation of the system. As mentioned previously, quality assessment exclusively includes the local vulnerability knowledge used in plans; consequently, the regional climate projections or adaptation measures proposed are beyond the scope of our analysis.

4.1. Contextual

4.1.1. Why carry out the assessment at all?

Municipalities are encouraged to engage with the Covenant's European call through the assistance of an intermediate territorial coordinator, in this case, the metropolitan agency. Local authorities agree on the development of the adaptation plan executed by an external consulting firm, but without specific local resources, either for knowledge production or for implementation. Proposed adaptation measures do not have a specific financial budget that needs to be executed. In fact, most of the listed adaptation actions are not new, but the measures already implemented by other municipal or sectorial policies. As quoted in an interview with a local authority, "are simply reused as adaptation measures in the plans". This represents a pivotal limitation from the outset.

A second limitation is due to jurisdictional competences. The spatial boundaries of the plans are compromised by the presence of

supra-municipal large infrastructures excluded from the assessment (e.g., 50 % of the total area of El Prat del Llobregat) while most of the environmental problems aggravating the vulnerability condition of the system are caused by the presence of those same infrastructures (De Roa & Esteban, 2018; Marcé et al., 2012). According to the fieldwork conducted, we identified a need to reach a shared understanding of interests and capacities in managing conflicting and contested uses, a situation reinforced by global environmental change. The fieldwork data exemplifies the extent to which plans are framed by a prescribed normative objective that is poorly aligned with case-specific needs and real-life concerns.

4.1.2. What kind of institutional arrangements govern knowledge-based plans?

When officially joining the Covenant of Mayors, signatories commit to developing a Sustainable Energy and Climate Action Plan within two years. As regards adaptation, local councils must report a risk and vulnerability assessment, as well as commit to a programme of actions to reduce CC vulnerability. Additionally, signatories are requested to submit a monitoring report every second year after the adoption of its action plan.

Institutional arrangements governing the knowledge base for CC adaptation at the municipal scale are based on consulting services commissioned by the metropolitan agency and financed by public grants. This has been a well-established procedure, since the first international call at the Rio Earth Summit in 1992, for local authorities to voluntarily engage with the action plan for sustainable development (LA21), followed by the CC mitigation plans (called the *sustainable energy action plan*).

As such, the plans are conceived as an externally driven outcome "given" to the municipalities involved to fulfil the Covenant mandate. As mentioned by a regional Covenant coordinator during our fieldwork, "this procedure has quantitatively promoted a significant number of local plans from small agglomerations. But qualitatively those plans, too standardized, have been less helpful in advancing towards climate-change adaptation at the municipal scale". The plans produced by environmental consultancy firms have taken place without deliberative involvement among assessment producers, experts, local practitioners and affected local population. The role of local authorities is limited to residual consultation. In practice, the implementation of this multilevel-governance ends up conceiving local plans as a product and not as a process, which reduces social learning opportunities and context-specific knowledge used, producing local plans that are strongly biased by the metropolitan CC adaptation plan developed at an early stage.

4.1.3. It is relevant to the problem addressed?

Although informative, the relevance of the plans' vulnerability outputs for local authorities is insufficient to effectively influence a real decision-making process. In the words of an interviewed local authority, "the plan sits on a shelf". Local exposure and vulnerability data contained in revised plans are not "actionable" knowledge to reduce vulnerability, due to several factors. First, the low precision of areas exposed to coastal risks of flooding (e.g., through concrete representational metrics) inhibits a tailored comprehension of place-based sensitivities. Second, sensitivity representation is additionally hampered by a low examination of the social and ecological states of territorial entities and trade-offs among them. Third, the procedural design neglects self-exploration of local capacities by the affected population; therefore, there is no space for self-improving the adaptive capacity throughout the process of carrying out the plans (i.e., in which local governance can effectively contribute). Thus, vulnerability assessment falls short of the intended goal of informing decision making and enhancing the adaptive capacity of the local jurisdictional area.

4.2. Procedural

4.2.1. For whom and how is the assessment framed?

Framed by external actors, the procedural dimension is designed and operationalized as a technical process and is not open to debate. Therefore, the transfer process (from formal guidelines to the specific case study) does not involve a participatory process oriented toward framing the problem in the territorial context. The framing process is conceived through abstract knowledge unlinked to case-specific knowledge, introducing an epistemic uncertainty source from the outset. For example, under CC adaptation mandates and sustainable development precepts, decisions in the framing phase do not consider the existence of different priorities and values as evidenced in our fieldwork. Differences in the perceptions of local conflicts or risk aversion among stakeholders are not addressed either by encouraging stakeholders to self-identify as interested parties or by reflecting their views and disagreements through secondary sources of information. Using the aquifer subsystem to illustrate this, high levels of groundwater are required to impede seawater intrusion and to reach the levels of quantity and quality required by the EU Water Framework Directive; however, a high phreatic level is incompatible with the optimal functioning of existing transport infrastructures (e.g., the international airport or subway train networks) due to flood risk. This is an example of a non-equivalent representation of the system co-identified with participants in the second workshop. Both high and low levels for the groundwater aquifer can be computed as vulnerability-reduction measures according to a specific pre-analytical choice (epistemic and normative).

4.2.2. By whom and how is the knowledge produced and validated? Is it credible?

The process of scoring exposure, sensitivity, and adaptive capacity by means of qualitative indices (high-low) to risk of coastal inundation is exclusively executed by the consultancy technicians. As such, neither scientific nor lay knowledge is mobilized. The exposure of the deltaic region to coastal inundation is approached without specialized biophysical knowledge or modelling expertise in the field. Furthermore, characterization of sensitivity and adaptive capacity is addressed without specialized or academic knowledge in the social sciences. Overall, there is a lack of expert competence in ambits of local knowledge (local history, social relations, subordination, governance, etc).

The plans' narrative is external to the target system. A strong reliance on a metropolitan vision of the deltaic zone influences the

results of the scoring process. A managerialist bias to approaching adaptive capacity targets protection engineering works as the only inclusion criteria to qualify local adaptive capacity to coastal inundation risk. Other essential factors of the adaptive capacity, such as local governance capacities, as identified in our fieldwork, are not considered. Farmers expressed that their decision-making capabilities were diminished due to their low representativeness within the agrarian park-managing entity (focal group discussion, workshop 2). Similarly, natural-park managers suggest that there are communication concerns with airport authorities (absent interlocutors) generating difficulties in managing everyday situations. In short, the affected population perceived local agency as compromised by the strategic and economic role of the region and its overlapping jurisdictional competence. Additionally, the omission of the negative impact of large infrastructures on local sensitivities, or the non-recognition of vulnerability transfer exerted by large engineering works (e.g., coastal erosion) misrepresents local sensitivity and adaptive capacity states. Consequently, value-*ladenness* results from including only the positive impacts of large infrastructures, while, according to a lecturer in environmental law (workshop 1), environmental redemptive measures stipulated for each large infrastructure need to be revised from and merged into a strategic environmental-impact assessment.

Finally, there is an absence of a validation process, and neither the process nor the outputs (i.e., vulnerability indices) are subject to a peer or extended review, compromising their legitimacy and scientific robustness.

4.2.3. To whom and how is it communicated?

The plan has led to a poor dissemination of the initiative to citizens (based on workshop 3 participants). Additionally, the information contained in both plans is weakened by the low accountability of the shortcomings found in the procedural dimension (e.g., data gaps, non-existence of a validation process, dissenting views, etc.), and the reflexion on their potential impact on disseminated results.

Furthermore, the low accountability of context-sensitive knowledge addressing how vulnerability is produced leads to an institutional *status-quo*-driven plan, reducing opportunities for critical social inquiry and community engagement on vulnerability reduction.

4.3. Substantive

4.3.1. What to assess?

Decisions taken in the process of establishing system boundaries to describe the local reality in relation to CC embody several assumptions. The quality of those assumptions is evaluated in relation to their suitability to reach a realistic representation of the system and to capture the current place-based vulnerability condition.

Decisions and underlying assumptions:

1. The temporal boundary of risk assessment is based on the timeframe stipulated by climate projection models (i.e., time-horizon 2050 and 2100).

Assumption 1. *Climate risk occurrence is expected to begin in* 2050.

2. Climatic determinants identified according to levels of confidence.

Assumption 2. *Outputs from a regional climate model predict* "*what climate hazards*" *a locality is vulnerable to*.

3. The spatial boundary of "what is" vulnerable is conducted through a territorial sectorization of the local jurisdictions according to land use categories.

Assumption 3. *Each territorial entity* (*i.e., land use*) *behaves with homogeneity under specific climate risks*.

4. The current vulnerability condition is used to estimate 2050 and 2100 climate risks. **Assumption 4**: Vulnerability is a static state within the target system.

5. Adaptive capacity is exclusively equated to the protection capability of the engineering infrastructures.

Assumption 5. *The over-engineered Delta* (*and watershed*) *enhance the adaptive capacity of the region to coastal inundation*.

The main implication of assumptions 1 and 2 is that coastal inundation risk should be approached by means of permanent sea-level-rise inundation (2050–2100 timeframe horizon). This omits current and near-future climatic determinants of coastal inundation, even though the deltaic region is periodically affected by levant storms causing coastal erosion and flooding. Storms from the east (a frequent meteorological situation on the NW Mediterranean coast) is characterized by acute sea-storms (extreme-height waves), short-term convective rainfall affecting the littoral fringe and usually coupled with a situation of low atmospheric pressure, raising mean sea level by up to 0.6 m–1 m. Storm Gloria, impacting the study area in January 2020, left a third of the delta plain flooded. Moreover, historic meteorological and oceanographic data indicate a change in the frequency and intensity of eastern storm events (Pintó et al., 2020). Episodic events are more difficult to predict with high levels of confidence by global climate models. Consequently, the plans do not include behavioural storm changes as a local manifestation of global CC. Neither do they inquire into the potential of sea-level-rise to aggravate short-term hazards. The result is a low fitness of the hazard definition in the framing phase to current signals of changes perceived at the local scale.

Presuming a homogenous impact within each exposure unit (Assumption 3) leads to an oversimplified sectorial vulnerability approach incapable of identifying the most vulnerable actors. For example, Storm Gloria demonstrated a differential exposure of the deltaic farmers. The assumption that all farmers from the agrarian park are equally vulnerable to coastal inundation risk is an

epistemological framing error as identified in our fieldwork, and is a source of uncertainty in the effort to diminish local actors' vulnerability.

The static conception of the target system (Assumption 4) leads to an insufficient awareness of historical and projected economic development in the area and how these processes relate to smaller and larger scales. This results in an important data gap to conceptualize the place-based causal model of vulnerability (i.e., strength of interactions linking causal factors) needed to draw a realistic representation of the system sensitivity as well as the identification of possible opportunities and constraints to reducing current and future vulnerability. For example, channelled sections of the Llobregat river have normalised urban expansion occupying and stretching the river floodplain (Martín-Vide et al., 2020). According to social platforms interviewed, the apparent gain in sensitivity of river canalization contributes to the undermining of historical climatic memory and thus diminishes local capacities to react against extreme flash-flood events.

Assumption 5 impacts the quality of the place-based adaptive capacity representation. Metropolitan and regional capacities are biased by large engineering works. The plans ignore current local strategies in preventing flooding, as identified in our workshops, such as the water-crew system managed by farmers to pump water into the sea. Nor is existing differential drainage capacity between different sectors of the coast addressed, a key factor in identifying the most vulnerable targets of flooding. The epistemic uncertainties identified in the problem-framing phase illustrate the inability to reach a realistic SES assessment by underestimating system-based knowledge and lay perspectives.

Is it scientifically robust?

Input data used to characterize vulnerability parameters are based on secondary sources of information: sectorial and regional administrative reports. Primary data and scholarly journals or local documentary sources such as official archival documents (e.g., Environmental Impact Assessments, etc.) are not used. Accordingly, the discordance between the scale of the analysis (local jurisdiction) and the scale of the knowledge used (metropolitan and regional/sectorial scale) is a source of technical uncertainty. Input data on local exposure, and vulnerability to coastal inundation risk, are in most cases partial and filled by proxies with low evidence-based information. Specific attributes and parameters to assess exposure, sensitivity and adaptive capacity to coastal-inundation risk are unidentified. No modelling or mapping techniques and no ethnographic research are used. Each vulnerability compound receives a qualitative score for coastal-inundation risk. As a result, piecemeal argumentation is the only basis to support decisions made. For example, exposure to marine flooding is qualified as high in the coastal fringe due to the flatness of the delta. The adaptive capacity of coastal-erosion risk is qualified as high, assuming that the annual injection of sand by Barcelonás Port Authority is enough to reverse the erosion process affecting the region. However, according to evidence-based empirical data (Perelló et al., 2019), and to lay knowledge, the erosion process has accelerated since the measure was put in place in 2005. Each vulnerability compound, including exposure, is aggregated to an overall qualitative indicator based on a geometric aggregation method.

Is the report of outcomes and uncertainties precise?

The communication of exposure, sensitivity and adaptive capacity is performed through general messages that avoid precision. A number of key questions are simply not addressed. These include the following: *What are the main spatial vulnerability hotspots detected in relation to coastal inundation risk? Who is vulnerable and to what extent?* and *What are the main local capacities and/or barriers to foster vulnerability reduction?* Reported vulnerability outputs are used only to establish a ranking of the most prominent risks, with minimal reference to local features. Uncertainties of place-based vulnerability outputs are unreported, and the reliability of the results goes unquestioned. While statistical uncertainty (measuring the probabilities in a stochastic climate model) is used to identify the likelihood of occurrence for a potential climate hazard, deltaic SES behaviour is treated as if it could be predicted with certainty. Deficiencies in communicating the inherent variability of the SES under observation is a source of low reliability for the results obtained.

5. Discussion

Commonly cited barriers to adaptation implementation at the local scale constraining local authorities' capacities are lack of resources, technical and institutional limitations, cognitive aspects, lack of information or uncertainty of available scientific knowledge (Aguiar et al., 2018; Measham et al., 2011; Moser & Ekstrom, 2010; Simonet & Leseur, 2019). Focusing on uncertainty as a barrier, most references point to climate data and its predicted behaviour at the local scale. By focusing on the quality of context-specific knowledge, this current work enhances the relevance of local vulnerability assessment in climate risk-based management.

Local authorities are aware of the vulnerabilities of their jurisdictional territories but understanding how these vulnerabilities are related to CC risk and impacts is less clear. This can therefore represent an important challenge for small agglomerations and may generate a knowledge gap when carrying out local risk-based assessments. In fact, "knowledge of vulnerabilities and CC impacts on human well-being is less advanced than the knowledge of climate systems" (Goosen et al., 2014; quoted by Räsänen et al., 2017, p.31).

This research is grounded on the argument that the predicted SES response for specific places is complex and uncertain, as is the climate system. Therefore, (i) awareness of contextual complexities in place-based vulnerability knowledge is a critical component in effective adaptation plans and, consequently, (ii) uncertainty evaluation is also needed in the vulnerability component of the risk equation. But, at the same time, (iii) wider views of uncertainty able to include the human dimension of uncertainty are needed to address vulnerability assessments. The approach adopted here focuses on the process through which the assessment is generated, by revising quality criteria specific to each knowledge-production phase and knowledge dimension. Far from trying to evaluate or judge the truth of a vulnerability assessment, we question its usefulness within a particular decision-making process. Evaluating the quality of context-specific knowledge adds to science for policy and adaptation practice at the local scale. By ground-testing a KQA tool and building on extensive documental sources and fieldwork, first we observe that the "low quality" of the local vulnerability knowledge reviewed in two Mediterranean plans is a key driver of the limited impact of those plans on influencing an urban development pathway

aligned to tangible adaptation efforts. By "low quality" we mean deficiencies in the vulnerability assessment in achieving the objectives pursued (i.e., local risks identification) as a function of its context of application, its procedural design, and the content of the knowledge used and produced.

Low fact-based data and the credibility of vulnerability assessments have been partially identified in the academic literature on plan evaluation (Baker et al., 2012; Guyadeen et al., 2019; Olazabal et al., 2019; Woodruff and Stults, 2016). The novelty of this current research is to address plan evaluation by focusing on the quality of the context-specific knowledge used within climate risk approaches. The relative lack of geographical sensitivity reflected in the understanding of local vulnerability reduces the detailed awareness of local risk required by local authorities. This, in turn, diminishes local-governance capacity for climate adaptation in the policy arena (low implementation) and, indeed, more broadly in the advocacy arena (lessening collective response-ability awareness). Major gaps detected in the plans reviewed are understanding how CC might affect the everyday life of target populations (Hackmann et al., 2014) or produce awareness of the diverse and dynamic response possibilities of a specific community (Lövbrand et al., 2015). Often, context-specific knowledge is replaced with broad descriptions from a regional perspective, omitting a lay critique of expertise. Adding insight from the contextual and procedural dimensions of knowledge reveals how the vulnerability assessment of the plans reviewed is lessened by a process of information transfer within adaptation plans from a higher administrative level. The same approach used in the metropolitan region of Barcelona is transposed to the municipality scale with minor changes of purpose, procedural design, and data sources. While the scale of the assessment (municipality boundaries) matches the scale of decision-making (Cash & Moser, 2000), the knowledge base mobilized to undertake such assessment is not pertinent to the scale of the assessment, leading to an insufficient relevance in the advocacy arena.

Second, we identify that this situation is mainly explained by the dominant governance setting that shapes the production and dissemination of the knowledge needed by local authorities to comply with Covenant mandates. As a Covenant signatory, both municipalities receive support from their territorial coordinator to develop their corresponding plan (Sauer et al., 2021). Even if it is helpful to report climate hazard data for the same climate region (Hernandez et al., 2020), local authorities still face the challenges of reporting vulnerability and risk assessments for their jurisdictional territories. In the case studies analysed here, this is solved by the metropolitan agency acting as an intermediate level of government with the Covenant through the promotion of a standardized vulnerability assessment authored by consultancy firms. However, the normalization of procedures is produced in isolation from their social context. The analysis of the institutional setting for conducting adaptation research at the municipal scale detects that organizational support has not promoted a genuine community engagement with Covenant mandates. Vulnerability assessments are unsupported by place-based participative or transdisciplinary approaches of knowledge production, and as such they exclude a shared vision, negotiation, and exploration.

Consequently, revised plans reproduce vulnerability representations that are rooted in global climate narratives and are biased against context-sensitive knowledge and local concerns. The instinct to reproduce global kinds of knowledge in climate-change research (Hulme, 2010) is also present in revised policy documents. Evidence for this bias is the low contribution of academic skills in the production of local vulnerability assessments. This is also marked by paying scant attention to cultural and place-based narratives of change (Krauß and Bremer, 2020), insufficient identification of social values at risk (Meo et al., 2021) or an inadequate appreciation of individuals' emotional attachments and risk perceptions (Bousquet; et al., 2022). This knowledge bias found in the plans diminishes local agency in climate risk governance. The relevance of these findings embraces the prominent role of intermediate regional parties in the development of plans for towns engaged in a global multilevel climate governance, such as the Covenant. Melica et al., (2018) highlights how the collaboration between Covenant regional coordinators and local governments has received scarce academic attention in mitigation-plan development. We add that, to a lesser extent, research has focused on the assisting role of those intermediate parties in reporting local socioenvironmental complexities (and associated uncertainties) to effectively ground the adaptation processes of smaller agglomerations.

The approach proposed in this paper is not about a demolishing critique of local adaptation plans, nor of the producers of those plans. Instead, it recognizes the challenges involved in mobilizing local knowledge in the risk-based management of towns, and, consequently, the need to articulate technical support in a co-production knowledge praxis (Moser & Dilling, 2012; Raymond et al., 2010). We suggest that the role of the Covenant regional coordinators in smaller agglomerations could be extended to organize and support a stable institutional setting that facilitates a pool of participative processes and an ongoing local science-policy exchange. We also advocate that the role of the scientific community be more involved in pursuing local jurisdictions' processes of adaptation. This has become especially relevant since the Paris Agreement, whereby a proliferation of local jurisdictions is committing and will commit to municipal climate adaptation for the first time.

Third, the KQA vulnerability framework also helps to examine how uncertainties are reported. Findings from the reviewed case studies detect a low confidence of vulnerability measures used to identify prominent local risks. The poor treatment and communication of uncertainties reflects the knowledge bias mentioned above, as well as the expected low impact of those adaptation strategies on influencing a local development pathway. Similar to findings by Millard-Ball, (2013), revised plans recodify existing local sustainable strategies into adaptation measures. Based on a managerial approach, the plans scrutinized are commended and shaped by the societal inertias of governmental environmental research agendas. Thus, in line with Eriksen et al., (2015), the approaches and knowledge used in the plans examined simply reproduce subjectivities, thereby serving to protect current development patterns and processes and, in fact, closing down opportunities for transformational adaptation.

Fourth, considering that "assumptions and biases not only determine findings but also tend to reinforce areas of ignorance" (Moser, 2005, p. 357), quality assessment embodies a reflexive stance that openly deals with the deeper dimensions of uncertainty, such as underlying assumptions and value loadings found in the process of knowledge production. Reflexivity entails scrutinizing the "things usually taken for granted, in such a way that their historically grown self-evidence is challenged" (Loeber et al., 2007; quoted by Fazey

et al., 2018, p. 66). A reflexive approach to uncertainty could become "a resource contributing to processes of institutional change instead of just being considered a problem for decision making" (van der Sluijs et al., 2006, p. 6). In this sense, the KQA endorsed in this paper performs a double-loop exercise (Argyris & Schön, 1978) or "knowing about knowing" (Bawden, 1997; quoted by Sterling, 2003, p.131) both based on Bateson's second learning level (Bateson, 1972).

6. Conclusion

The inadequate treatment of uncertainties in place-based exposure and vulnerability assessments within CC adaptation strategies generates a false sense of objectivity and certainty, as if climate behaviour were the only unstable factor of the risk equation. By addressing these, we emphasise the importance of context-specific knowledges within climate risk-based approaches. Beyond the known challenges of vulnerability-metrics validation, the present research establishes that a knowledge quality approach is suited to vulnerability assessments within the domain of policy analysis. In contrast with technical uncertainty assessments, the KQA evaluates context-specific knowledge used to develop vulnerability indices. But additionally, its role within socioeconomic and political process makes it possible to critically assess the usefulness of the knowledge base used for vulnerability reduction strategies in specific contexts. Addressing the procedural and contextual dimensions of knowledge has permitted a critical interrogation of how established concepts and vulnerability representations come about, to what extent they are designed in accordance with problem-focused knowledge strategies, and how they are shaped by existing economic and political institutional arrangements.

We do not expect this framework to be reproduced by a specific entity, but rather we hope to help identify a lack of consideration of context-specific knowledge used in the climate risk governance of small agglomerations. Empirical findings of the present vulnerability KQA operationalization in two municipalities committed to a transnational climate network provide evidence of the prominent role of intermediate institutional actors in shaping local vulnerability and risk assessments, a field of research that has been poorly addressed in the academic literature. Moreover, this has permitted detection of how knowledge governance that sustains the adaptation plans in small agglomerations is anchored to traditional procedures and insights that are poorly aligned with collaborative knowledge construction in a context of accelerated threats and uncertainty.

This proposal highlights qualitative sources of uncertainty and the crucial role of reflexivity in rethinking institutional settings and in facilitating the knowledge processing of complex issues at the local scale. Outputs from the qualitative analysis provide a wider contribution beyond the target study area, since the knowledge process that governs plan development is shared by all the municipalities in the region committed to the Covenant mandates. Therefore, we suggest that the role of intermediate regional actors should move from being plan providers to being companions in participative local processes and in the ongoing local science-policy exchange.

This paper adds to the academic literature on the theory and practice of KQA tools by, first, advancing a practical application of knowledge quality in the policy field of climate change adaptation. And second, by conceptually enhancing the KQA framework of analysis through the integration of a pivotal issue affecting environmental science for policy: the role of knowledge governance in local environmental management.

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.

Data availability

Data will be made available on request.

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