Combining Quantitative and Qualitative Aspects of Indicators for Assessing Community Resilience

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1 Potential and constraints of indicators for assessing community resilience

Indicators are regarded as important tools to benchmark, target and monitor performance. They also play a crucial role for assessing and evaluating changes and transformation, in particular in the interface between science and policy, since they provide simplified information about complex circumstances for the decision-making process.

Likewise, current approaches to assessing resilience – whether driven by research or practitioner interests – draw upon indicators. They are used to understand the most relevant aspects shaping a community's resilience and to reveal major weaknesses or drawbacks of resilience (cf. for example Twigg 2007, UNISDR 2014). When evaluated at regular intervals, indicators enable measuring changes over time and space (cf. for example Cutter et al. 2014, Burton 2015). In terms of assessing community disaster resilience (henceforth, community resilience), indicators help setting policy priorities, allocating resources – financial, personal, technical, etc. – before and after a hazard event and in evaluating the effectiveness of risk reduction efforts or emergency activities (OECD 2008, Gall 2013).

However, despite their popularity, indicators often remain ambiguous and imprecisely used, which is partially due to different definitions and applications of indicators in many scientific fields. It is crucial in the first place to define the term indicator, its function and objectives for the specific assessment approach. We use the definition of Freudenberg and approach an indicator as a "quantitative or qualitative measure derived from observed facts that simplify and communicate the reality of a complex situation" (Freudenberg 2003 in Burton 2015: 4).

The distinction between quantitative and qualitative indicators is common in research, however it is not as straightforward as it might seem, since there is no clear definition of 'quantitative data' or 'qualitative data' upon which an indicator can rely. Rather, we can distinguish quantitative and qualitative indicators according to the level of measurement, which is generally classified in nominal, ordinal, interval (and sometimes ratio) scales (cf. Meyer in Stockmann 2011). This classification allows us to distinguish different parameterisations of indicators and subsequently different functions. For example, quantitative indicators allow for repeatable comparisons of changes of resilience through numerical metrics, qualitative indicators allow for case- and context-specific assessments that detect important inherent characteristics of a resilient community.

Until now, no single or widely accepted indicator-based approach exists for assessing resilience. Whilst research efforts – on vulnerability for example – have increasingly provided useful indicators that are being applied in different fields of application, such as climate change vulnerability, food security, hazard mitigation planning or social vulnerability (cf. for example Adger et al. 2004), assessing resilience by means of indicators is still in its early stages of development (Cutter et al. 2014). This is particularly the case for community resilience to disasters, since this concept raises not only questions related to the measurement of resilience, but also related to the definition and conceptualisations of communities.

The emBRACE research activities emphasised that community resilience is a multidimensional concept that integrates transformative aspects such as learning, critical reflection or re-organisation. However,

exactly these dynamic aspects seem to be difficult to measure. Armitage et al. noted that "resilience is complex, context-specific, and highly dynamic – all characteristics that make it hard to operationalise and measure through simple proxies" (Armitage et al. 2012: 6). Developing a comprehensive, standardised set of resilience indicators is obviously very difficult for such a constantly amorphous and context-dependent concept.

Thus, key challenges concern not only the dynamic conceptualisations of resilience, but also the complexities of operationalisation of the concept. A major prerequisite for operationalising community resilience is the existence of sound analytical frameworks, which encompass all the relevant constituent components. Frameworks allow the derivation of conceptually grounded indicators, which in turn provide a means to implement the theoretical frameworks and fill the gap between concepts and work in practice. Several authors highlight the importance of strong frameworks to guide indicator selection, rather than simply focusing the selection process around a set of characteristics that are purported to indicate the concept (cf. Freudenberg 2003, OECD 2008, Gall 2013, Ostadtaghizadeh et al. 2015).

Concluding the potentials and constraints of indicators for assessing community resilience, we can identify two principal research needs of researchers and policy makers: (1) the need to advance the conceptual understanding of community resilience and to enhance the operationalisation of the concept and (2) the requirement to provide concrete, easily understood indicators that can be applied in practice. Both are to some extent iteratively related, since a clear understanding and definition of the concept is the prerequisite for developing sound indicators. The emBRACE project covered these research needs through the development of an analytical framework of community resilience (Jűlich et al., 2014; emBRACE, 2015) and the elaboration of guidelines for resilience indicator development (Becker et al. 2015). We argue that indicators represent a valuable tool to consistently structure resilience assessments, by maintaining, at the same time, certain flexibility in terms of data acquisition, measurement methods and scales of application. This is of specific importance when assessing community resilience, since indicators can be applied not only to various perspectives of resilience, but also to different conceptualisations of communities.

2 Current indicator-based approaches for assessing community resilience

Existing indicator-based assessments of community resilience, as currently available in the literature, mainly follow two different approaches: (1) approaches that focus on identifying inherent characteristics of community resilience to allow for locally-specific- or self- assessments and (2) approaches based on composite indicators ('resilience indices'), which allow for comparing and mapping community resilience in space and time (cf. Becker et al. 2015).

(1) Locally-specific approaches (e.g. Twigg 2007, UNISDR 2014) generally provide indicators with flexibility in how to acquire the related data, since no fixed methods of data collection or data sources are given. Indicators should be applied to specific contexts and scales of application in order to support a concrete assessment. In this sense, most of these related studies apply qualitative indicators. They address specific target groups, propose their own frameworks and rely on specific perspectives of community resilience and sometimes case studies, which limits to some extent the possibilities in terms of comparability and generalisation (Gall 2013: 21). The identified indicators go beyond measuring basic resources, capacities or assets of a disaster resilient community by identifying important qualities and processes shaping community resilience, such as learning in response to feedbacks, acceptance of uncertainties and change, or of (potentially differing) social values. This helps in understanding the constituent factors of community resilience. Furthermore, this approach allows for setting priorities, targets and policy interventions.

(2) Composite indicator approaches (e.g. Cutter et al. 2010, Cutter et al. 2014, Burton 2015) aim to aggregate single (quantitative) indicators into a resilience index that allows for standardised comparisons

in space and time, while at the same time reducing complexity. This makes them an attractive tool for informing the decision making process. However, as Freudenberg states "the construction of composites suffers from many methodological difficulties, with the result that they can be misleading and easily manipulated" (Freudenberg 2003: 3). This applies particularly to complex phenomena such as resilience, since composite indicators have to combine different data, value ranges, scales, level of measurement, resolutions, thematic fields, etc. An inevitable characteristic of these approaches is the dependence on proxy indicators, since direct measurements are mostly not available due to missing or inconsistent data. Thus, proxies present often the only means to cover specific aspects of community resilience when applying composites. Proxy indicators can be useful for describing non-tangible factors but their validity, that is, their explanatory power in relation to the factor in question, must be verified and approved by the user (Fritzsche et al. 2014).

Both types of indicator-based approaches have their raisons d'être, advantages and disadvantages. These have to be understood individually. Thus, according to the type and objective of the resilience assessment, a particular approach may be favoured. Being explicit about the objectives and motivations of measuring resilience is of critical importance for choosing the right assessment approaches. In addition, it requires a clear design of the assessment study in terms of the research questions, scales of application, target groups, conceptualisations of resilience and policy realms. The strict limitation to only one of the approaches and indicator types is often not advisable since both have constraints and both offer benefits.

We believe that resilience assessments require innovative approaches that take into account current conceptualisations and operationalisations of (community) resilience. However, until now, many studies rely on similar methods and indicators as they have been used, for example, in vulnerability assessments, even though the differences between the concepts are clearly emphasised by all presented studies (Gall 2013: 21). Rather than relying on existing indicator systems, we should focus on trying to integrate the achievements developed in previous adjacent concepts (such as social vulnerability, social sustainability or adaptive management) into recent resilience conceptualisations and methodologies (cf. Kelman et al. 2015).

Given the complexity and difficulty of resilience assessments, it is clear that no reductionist, easy approaches exist. Gall for example argues for assessment approaches that use 'hybrid research methods' and combines quantitative and qualitative indicators in order to capture all relevant aspects of resilience (Gall 2013). Also Weichselgartner and Kelman recommend "to move beyond description through data (e.g. 'true or false'), to emphasize equally normative aspects of resilience (e.g. 'better or worse'), to include qualitative analyses alongside quantitative analyses, and to include values and preferred norms alongside facts and observations" (Weichselgartner and Kelman 2015: 257). Burton brings up alternate assessment standards "such as approaches that make use of resilience scorecards that are highly customisable and make use of primary source data" (Burton 2015: 18). One example and promising development is the self-assessment tool proposed by UNISDR that is applied in the Disaster Resilience Scorecard for Cities (UNISDR 2014). It incorporates different indicator types, mixed methods of data collection and is conducted through a multi-stakeholder process. However, until now few experiences, pilot cases or concrete applications exist that follow these approaches.

3 From concept to assessment: the emBRACE approach

3.1 The emBRACE definition of community resilience indicators

Within emBRACE, we approach indicators of community resilience as qualitative/subjective or quantitative/objective measures that have a clearly understood relevance (either by the practitioner or by the researcher or by both) for community resilience. The use of indicators of and for resilience aims at closing the gap between the theoretical framework and a description of resilience characteristics useful in

practice for decision-taking. We understand communities as a delimited part of one or several socio-ecological systems functioning at various spatial scales. They can (i.e. not necessarily must) have a spatial expression where a common identity coincides with shared use of space, e.g. groups of actors living in the same area or close to the same risks that share a common identity. Though the spatial aspect of communities might be of particular interest from a natural hazard perspective, socially-constructed types of communities, such as communities of interest, circumstance, identity or supporters are equally important when applying indicators of community resilience.

Recognising the emBRACE conceptual framework, we understand community resilience as a dynamic and steadily re-shaping process that can be neither assessed through a static snapshot in time nor by considering 'the resilient community' as an achievable end goal. Going beyond the assessment of only that which is simply measurable, we aim at capturing community resilience in its constituent facets including transformative aspects of resilience as well as different perspectives of communities. Community resilience indicators include both, aspects that are more readily measurable using numerical metrics (i.e. quantitative analysis) and aspects that require more subjective understanding (i.e. qualitative data). Therefore, we propose an integrative indicator-based approach that combines both quantitative and qualitative indicators, across multiple levels of measurement, scales of application and methods of data collection, in order to provide the most complete picture for a resilience assessment

3.2 The process of grounding our indicators

Within emBRACE, we have iteratively developed and refined a framework of community resilience (Jülich et al. 2014, emBRACE 2015), which provides a possible structure and route to relate our community resilience aspects to indicators. This conceptual framework is grounded on empirical research within the five case studies of emBRACE, thus is strongly supported by local research findings on community resilience. By generating our case-study-specific indicators within the framework provided by it, we have provided a route not only to select and conceptually locate our indicators but also to (re)locate our theoretical framework within the cases studies.

We derived the indicators from our assessment of the specific local-level systems that we explored within the case studies. This grounding of our indicators empirically and generation of indicators of community resilience 'from the bottom up' – but within the emBRACE framework – allows us to meaningfully understand the relation of our local-level indicators to community-level resilience. Due to this grounding, our actual indicators are not comprehensive (because our case studies cannot be comprehensive) and it has to be emphasised that we cannot provide a single, all-encompassing and all-applicable list of indicators at the community level. Because of our understanding that resilience is complex and cannot easily be measured by any simple list of indicators, we were also not looking for new indicators per se, but we did want to understand how better to use, integrate and apply the indicators that we did know and have.

Concretely, we have created an indicator spreadsheet template that was distributed to the case study researchers, in order to collect the indicators and the associated information related to the operationalisation of indicators. The template requested, in particular, information about the allocation of the indicator within the emBRACE framework, the means of parameterisation, the relationship of the indicator to resilience, the methods of data collection, the scale of application and the context- and hazard-specificity of the indicator. The following figure summarises the indicator development within emBRACE:
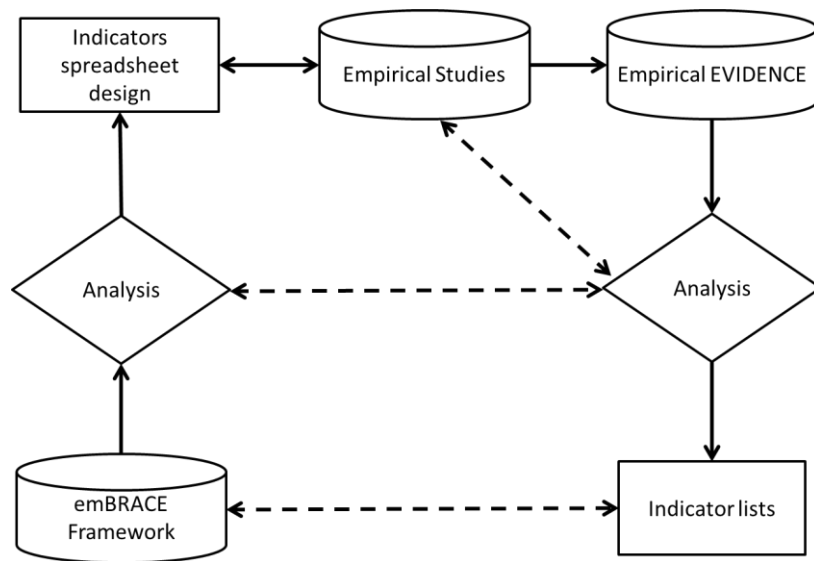
Figure 1 Diagram of the evidence-driven development of indicators within emBRACE. A solid lined, single pointed arrow represents a simple flow of data, information or thought; a double-ended arrow an iterative flow; and a dotted arrow a process of checking back against an earlier point in the process (after Lucas 2011: Fig.1 and Kemp-Benedict et al. 2010: Fig.1).

Starting bottom left of fig.1, the emBRACE framework fed into our analysis, and we derived the spreadsheet based on our analysis of it, and also our iterative testing of the spreadsheet with emBRACE case-study researchers. They then filled in the spreadsheet, which we used to create the indicator lists: but, importantly, at any stage in our final analysis we could and did test our ongoing analysis back against our original conceptions coming out of the framework and also with the case-study researchers. The indicator lists are then tested back conceptually at a high-level against the framework.

The question about how to combine and integrate quantitative and qualitative indicator is an important issue, especially when assessing and measuring complex systems such as community resilience. Rather than integrating in the sense of aggregating data into one index, we support the combination of indicators by two means:
- using different types of indicators according to different steps in the assessment. In the Alpine case study, for example (see chapter 13) the quantitative indicator "how often each organisation has been contacted in case of an event" allowed to identify through a questionnaire the frequency with which more than 900 persons contacted specific organisations. In a second step, qualitative indicators were then used to assess information through interviews with experts from the identified organisations.
- applying different types of indicators in parallel that give a contribution to better understand community resilience. The combination lies in assessing the different results that can add a piece to the bigger "resilience picture". In particular, we consider the need to integrate qualitative information into an indicator set to be a crucial element in designing any systemic depiction. We followed this way of combination through a systematization and classification of indicators that allowed us to derive emBRACE key-indicators of community resilience, which are – as a set of indicators – combinative and integrative.

4 Our way to systematise the indicators

Because our indicators and our framework are linked systemically and in a structured manner, we were able to cluster and systematise our indicators into what can meaningfully be described as emBRACE

indicators of community resilience. The aim of the systematisation is to derive a substantial and more manageable list of key-indicators out of all indicators applied within the emBRACE case studies, which can be applied across different scales and contexts and that have a clear relation to community resilience. The choices for clustering are based upon certain predefined criteria and remain to some degree subjective. However, they are based upon expert knowledge and justified across the whole consortium (cf. Becker et al. 2015).

We initially identified 177 case study indicators that were reduced to a number of 128 indicators through merging of indicators and removing repetition (several indicators were mentioned by more than one case study). The main challenge then was to synthesise the indicators since they differ to some extent and sometimes considerably in terms of the applied scales of application, methods of data collection, types of natural hazards, and level of measurements, which is due to the heterogeneity of the emBRACE case studies. However, exactly these aspects served us as filter criteria to create the list of key-indicators.

One main aspect of the systematisation was to locate the indicators within the emBRACE framework. The following table shows that the majority of indicators have been allocated by the case study researchers to the resources and capacities domain of the emBRACE framework, with fewer to the actions and learning domains (most indicators have been allocated to more than one domain):

emBRACE framework domains	Count of indicators
Resources and Capacities	110
Actions	63
Learning	51

Table 1 Allocation of indicators to the emBRACE framework domains

The focus on resources and capacities is congruent with the findings from literature, revealing that most existing indicator-based approaches assess community resilience through a set of capacities (e.g. Norris et al. 2008). It seems that resources and capacities are easier to grasp by means of indicators than aspects related to the actions and learning domains. Going one level further down in the emBRACE framework to the 'components', we can see the following classification scheme of indicators (Table 2):

emBRACE framework components		Count of indicators
Resources and Capacities		
Natural / Place-based		7
Socio-political		48
Financial		12
Physical		16
Human		39
Actions		
Civil protection	Preparedness	19
	Response	13
	Recovery	9
	Mitigation	28

Social Protection	Vulnerability Reduction	-
	Social Safety Nets	2
Learning		
Risk/Loss Perception		4
Problematizing Risk/Loss		19
Critical Reflection		6
Experimentation and Innovation		4
Dissemination		9
Monitoring and Review		6

Table 2 Allocation of indicators to the emBRACE framework components

Indicators have been allocated mostly to the socio-political and human components of the resources and capacities domain. Concerning the actions domain, most indicators cover the mitigation and (with minor importance) the preparedness components. The response and recovery components are less often addressed. This also confirms observations in literature that most approaches measuring resilience focus on preparedness and the pre-hazard event phase (Birkmann et al. 2012) and also "the fact that stakeholders perceive of vulnerability in more concrete manner than resilience" (Taylor et al. 2014: 256). Concerning the learning domain, the component problematizing risk/loss appears most prominent.

Regarding the other criteria of systematisation, most of the emBRACE indicators are designed for the individual scale, followed by the household and the community scale. The majority of indicators are not context- or hazard-specific, but universally applicable across various types of natural hazards, types of communities, cultural differences, institutional and governmental disparities, etc. In addition, most indicators have a clear relation to resilience, although this relation does seem to be difficult to define for certain indicators that do apply to specific scales and contexts. However, we can regard those indicators that do have a clear relation to resilience at all possible levels as particularly important for measuring community resilience.

Comparing the indicators of community resilience within emBRACE with indicators identified in literature, we can reveal and emphasise certain indicator (topics) that are neglected in current approaches. These include:
- trust (e.g. mutual (social) trust between community members, trust in authorities involved in disaster risk management);
- type of integration within social networks (e.g. type of persons people go for help and support to in case of an event, modularity of the response network, time needed to activate the local response network);
- community capacity to experiment and innovate;
- spaces within the organisational structure for critical reflection;
- past learning experience and implementation;
- calibration of risk to organisational mandate;
- community engagement in renewal and transformation processes;
- local governance aspects (e.g. presence of a formal process through which locally-affected communities can draw on government support, existence of a legal foundation and specific legislation for disaster risk management);

➢ individual/psychological aspects (e.g. belief in being prepared for hazards, satisfaction with external support received, adaptive coping strategies of the individual).

These somehow 'unique emBRACE indicators' contribute in particular to the learning domains of community resilience and stress the need to include transformative aspects, such as capacities to innovate and re-organise, as well as individual/psychological aspects, into assessments of community resilience. In particular, the specific research methods applied within emBRACE revealed certain indicators that may not be identified through other approaches. An example is the use of the social-network mapping methodology (cf. Matin et al. 2015) that identified concrete indicators related to the community member's role and integration within social networks. Through this, emBRACE clearly adds value to current research activities on community resilience indicators.

5 Deriving key-indicators of community resilience

The systematisation of indicators allowed us to apply a certain type of filtering in order to derive a list of key-indicators of community resilience within emBRACE. Specifically, we defined emBRACE key-indicators as indicators that were rated with a high importance by the case studies, are universally applicable, show a clear relation to resilience and that were mentioned by more than one case study.

Thus, these indicators are applicable across different contexts and types of natural hazards. Grounded within the conceptual framework as well as within the empirical fieldwork of emBRACE, we believe that these generic indicators can be regarded as a core set of indicators of community resilience being especially significant at a higher policy level while retaining their social acceptance at the community level. Of course, this set represents a suggestion of one possible route (e.g. in terms of applied scales, ways of parameterisation or used methods of data acquisition) whilst always acknowledging that other ways will exist. Nevertheless, we believe that these indicators should be considered when assessing community resilience by means of indicators and supplemented with other, more locally and context-specific indicators. Table 3 lists the emBRACE key-indicators:

Indicator title	Possible way of parameterisation	Scale of application	Level of measurement	Pre-/Post-hazard event phase
Presence of a active third sector emergency coordination body	Presence, yes/no	Community/ County	Quantitative/ Objective	Pre & Post
Social/Mutual trust	A scale measuring whether or not community members trust each other	Individual/ Community/ Ward	Qualitative/ Subjective	Pre & Post
Type of physical/infrastructural connection of community	Multiple access routes, ports, etc. Counting of primary-route access into area	Community/ Regional/ City	Qualitative/ Subjective	Pre
Sense of belonging in community	A scale measuring having a sense of community belonging	Individual/ Household/ Community/ Ward	Qualitative/ Subjective	Pre
Existence of local tested community emergency plan	Yes/no question	Community	Quantitative/ Objective	Pre

% of households in the community subscribed to an early-warning system	Yes/no question,%	Individual/ Household/ Ward	Quantitative/ Objective	Pre
Belief in being well prepared for hazards & able to control the impacts	A scale measuring level of preparedness of individuals/households/communities for relevant hazards	Individual/ Household/ Community	Qualitative/ Subjective	Pre
% of persons with mandatory hazard insurance	Yes/no question, %	Individual/ Household	Quantitative/ Objective	Pre
Collaboration and information exchange among involved actors in risk management	Frequency of coordination actions and information exchange among involved actors	National/ Community/ Institutional	Quantitative/ Objective	Pre & Post
Presence of cross-departmental municipality staff training programmes related to emergency management	Yes/no question, number per year	Community/ County	Quantitative/ Objective	Pre
Integration in social networks	-	Individual/ Community/ Ward	Qualitative/ Subjective	Pre & Post
Social support	Receive of psychological/ physical/ financial support from others during and after the hazard event	Individual/ Household	Qualitative/ Subjective	Post
Belief in effectiveness of self in coping with disaster-related adversities	A scale for belief in effectiveness of self in coping with disaster-related adversities	Individual/ Household	Qualitative/ Subjective	Pre
Satisfaction with external financial support received	A scale on how content the actors felt in regard to the amount of external financial support they received in the post-disaster phase	Individual/ Household/ Regional/ City	Qualitative/ Subjective	Post

Table3 Key-indicators of community resilience within the emBRACE project

This list of key-indicators supports our choice of an integrative approach within emBRACE, since both quantitative and qualitative indicators, as well as different scales of application resulted as being important. Thus, different types of indicators have to be included when assessing community resilience by means of indicators and in any aims to support monitoring and evaluation as well as decision making in practice. This blending of indicators does not allow for aggregation in quantitative terms (e.g. creating an interval scale resilience index), but enables further structuring in order to enhance the possibilities for concrete prioritisation and targeting. Through the provision of supplementary information related, for example, to the level of measurement, scale of application and possible ways of parameterisation, the list offers a valuable toolbox for applying community resilience indicators in local-specific contexts.

Of course, some important indicators might not be considered in this list due to the applied filtering criteria within the emBRACE research process, but this type of filtering allowed us to create an agreed list of indicators that is concise and substantive. It is important to consider the indicator set as a whole, since one single indicator is not able to explain a community's resilience. However, we have to acknowledge that we cannot and do not provide a fixed and comprehensive set of indicators. Rather, the indicators will almost inevitably differ across case studies and they still would need supplementary indicators referring to the specific study characteristics (Deeming et al. 2013: 9). We do not consider this as a problem, since we have provided a structure within which key-indicators can be extracted (Becker et al. 2015), whilst at the same time recognising (and emphasising) local and contextual circumstances of resilience assessments. In other words, the proposed structure allows key-indicators to be extracted, but does not necessitate that all key-indicators must be extracted in every circumstance; those decisions remain context dependent.

However, besides identifying and selecting suitable indicators, it is crucial to understand how to use, integrate and apply indicators (BAHADUR et al. 2010). Concrete instructions in this sense provide a useful source of information for proper indicator application in practice and we recommend using some form of guideline for community resilience indicator development (cf. for example Becker et al. 2015). In particular, the possible methods of data collection require attention, since they affect not only the methods adopted to parameterise the indicators, but also the scale of application. One single indicator can be measured with different methods and at different levels of quantification. Thus, the initial research questions should be always: What do I want to measure? And what do I want to use it for? Being explicit about the objectives of the resilience assessment is the prerequisite for sound and reliable indicator data.

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