emBRACE

24-06-2015

Report

Work Package 3

Guidelines for development of indicators, indicator systems and provider challenges

Deliverable 3.5

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Contract Number: 283201

Project Acronym: emBRACE

Title: Building Resilience Amongst Communities in Europe

Deliverable N°: 3.5

Due date: 31-05-2015

Delivery date: 24-06-2015

Short Description: This deliverable 3.5 discusses indicators and indicator systems of community resilience by taking into account current research activities and findings obtained from the emBRACE project. We propose to use an integrated approach for assessing community resilience by means of indicators, considering multiple level of measurements, scales and perspectives of community resilience. The emBRACE conceptual framework and the empirical grounded indicators of the emBRACE case studies allow us to derive key-indicators of community resilience that can be applied across different contexts and types of natural hazards.

Lead Beneficiary: EURAC

Partner/s contributed: SEI-York, UCL, UoN

Made available to: all partners

Version Control		
Version	**Date**	**Name, Affiliation**
0.1	**27-05-2015**	**Daniel Becker**
0.2	**22-06-2015**	**John Forrester, José M Rodríguez-Llanes**
0.3	**24-06-2015**	**Daniel Becker, Hugh Deeming**

Acknowledgements

Funding for this report was made available by the European Commission under the 7th Framework Programme – Grant Agreement No 283201. emBRACE

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About emBRACE

The primary aim of the emBRACE project is to build resilience to disasters amongst communities in Europe. To achieve this, it is vital to merge research knowledge, networking and practices as a prerequisite for more coherent scientific approaches. This we will do in the most collaborative way possible.

Specific Objectives

- ⇨ Identify the key dimensions of resilience across a range of disciplines and domains
- ⇨ Develop indicators and indicator systems to measure resilience concerning natural disaster events
- ⇨ Model societal resilience through simulation experiments
- ⇨ Provide a general conceptual framework of resilience, tested and grounded in cross-cultural contexts
- ⇨ Build networks and share knowledge across a range of stakeholders
- ⇨ Tailor communication products and project outputs and outcomes effectively to multiple collaborators, stakeholders and user groups

The emBRACE Methodology

The emBRACE project is methodologically rich and draws on partner expertise across the research methods spectrum. It will apply these methods across scales from the very local to the European.

emBRACE is structured around 9 Work Packages. WP1 will be a systematic evaluation of literature on resilience in the context of natural hazards and disasters. WP2 will develop a conceptual framework. WP3 comprises a disaster data review and needs assessment. WP4 will model societal resilience. WP5 will contextualise resilience using a series of Case studies (floods, heat waves, earthquakes and alpine hazards) across Europe (Czech Republic, Germany, Italy, Poland, Switzerland, Turkey and UK). WP6 will refine the framework: bridging theory, methods and practice. WP7 will exchange knowledge amongst a range of stakeholders. WP8 Policy and practice communication outputs to improve resilience-building in European societies.

Partners

- ⇨ Université catholique de Louvain (UCL) - **Belgium**
- ⇨ University of Northumbria at Newcastle (UoN) - **UK**
- ⇨ King's College London (KCL) - **UK**
- ⇨ United Nations University Institute for Environment and Human Security (UNU), **Bonn**
- ⇨ Accademia Europea per la Ricerca Applicata ed il Per-fezionamento Professionale Bolzano (EURAC) - **Italy**
- ⇨ Helmholtz-Zentrum Fuer Umweltforschung GMBH - UFZ (UFZ) - **Germany**
- ⇨ University of York (SEI-Y) - **UK**
- ⇨ Stockholm Environment Institute - Oxford Office Limited (SEI-O) - **UK**
- ⇨ Swiss Federal Institute for Forest, Snow and Landscape Research - WSL (WSL) - **Switzerland**
- ⇨ Middle East Technical University - Ankara (METU) – **Turkey**
- ⇨ University of Reading (UoR) – **UK**

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1. Introductory part

1.1 Aim, target group and structure of the deliverable

Indicators and indicator systems are perceived as important instruments to assess, measure and evaluate resilience. Current research activities focus on developing reliable indicators that apply at different scales and policy realms and address different types of shocks and perspectives of resilience. This deliverable 3.5[1] aims to contribute to the research activities by integrating results from latest literature on resilience indicators (state-of-the-art) and the findings obtained from the emBRACE project. We therefore focus on community resilience to natural hazards and rely to a great extent on the conceptual approach and the five case studies within emBRACE. We reveal the potentials and advantages of indicator-based approaches for assessing community resilience and present indicators that enable transferring theoretical and conceptual considerations into specific applications. At the same time, we underline the challenges and limitations of such approaches considering in particular the conceptual understanding of resilience and case study approaches within emBRACE (cf. emBRACE 'Description of Work' document (DoW): 13).

The deliverable is composed of one main report (this one) and one additional policy brief. The main report is intended for scientists, who work in applied research as well as practitioners with academic background and/or academic interest. It comprises three main parts. The first part deals with conceptual and theoretical aspects of resilience indicators and summarises current research activities in this field (chapter 2). The second part describes the procedure within emBRACE of developing the 'emBRACE indicators' and presents the selected 'key-indicators' of community resilience (chapter 3). The last part outlines major challenges of indicator use in practice by pointing out important steps of indicator development and application, as well as typical challenges and potential pitfalls (chapter 4). The shorter 'policy brief' is designed for policy makers and advisors and aims at supporting the decision-making process within communities for assessing resilience by means of indicators. The policy brief provides a quick overview of what the full report has to offer including

[1] Throughout this document reference will be made to the other emBRACE reports, whose delivery has underpinned the development of this Del 3.5 output. All these project deliverables are available for download from the project website (www.embrace-eu.org).

practical considerations on resilience indicators, a guideline summary and a collection of key-indicators.

Incorporating previous work in emBRACE, deliverable 3.5 draws upon several work packages and deliverables, especially WP1 (literature review; especially BIRKMANN et al. 2012b and ABELING et al. 2014), WP2 (conceptual framework), WP3 (disaster data review; especially RODRIGUEZ-LLANES et al. 2013 and RODRIGUEZ-LLANES et al. 2015), WP5 (case studies) and WP6 (refinement of the framework).

1.2 Research needs and user requirements

Most researchers in the field emphasise that research on measuring community resilience is still in the early stages of development. Current approaches mainly draw on indicators, however no single or widely accepted method exists so far (CUTTER et al. 2014: 66). 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. Whilst in the past few years a couple of articles have been published that present first attempts to consolidate research on community resilience indicators (e.g. TWIGG 2007; NORRIS et al. 2008; CUTTER et al. 2010), academic literature still struggles with developing concrete assessment approaches and reliable indicators (cf. ABELING et al. 2014; BIRKMANN et al. 2012b).

We identified two main research needs/user requirements: One stemming from academic research to advance the conceptual understanding of community resilience and one stemming from practitioners and policy makers/advisors to provide concrete indicators that are applicable 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 need to enhance the conceptual understanding of community resilience is accompanied by the intention (and interest) among different academic and related practitioner fields to define and operationalise resilience, as well as to create analytical frameworks encompassing all constituent components of community resilience. The frameworks allow for deriving conceptual grounded indicators that in turn provide a mean to implement the theoretical frameworks and fill the gap between concepts and work in practice. The requirements of practitioners draw mainly upon the development of indicators that are “easily understood and applicable to the

decision making process" (CUTTER et al. 2010: 17). This implies having concrete instructions of how to best develop and apply indicators of community resilience, including scaling and aggregating issues, methods of data collection as well as potential problems and pitfalls concerning data availability and updates (BAHADUR et al. 2010: 19; see also DoW: 13). This deliverable tackles these research needs and user requirements by consolidating research on existing indicator sets of community resilience and incorporating the conceptual and empirical findings of emBRACE, in order to provide concrete indicators that can be applied in practice.

2. Resilience indicators

2.1 Definitions and terms

The term ‘indicator’ is widely used in research, especially in the interface between science and policy. However, despite its popularity, the term remains often ambiguous, which is partially due to the different definitions and applications of the concept in many scientific fields (chemistry, medicine, economy, ecology, sociology, etc.). From a basic understanding, an indicator ‘indicates’ something from which conclusions on the phenomenon of interest (*indicandum*) can be inferred. This indicandum is often difficult to grasp, thus, in the common understanding, indicators communicate simplified information about specific circumstances that are not directly measurable, or can only be measured with great difficulty (MEYER in STOCKMANN 2011: 192). In this sense, we use the definition of FREUDENBERG in this deliverable and understand 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).

Indicators may be more or less direct in their relationship to the phenomenon they are intended to measure. An example of a direct indicator is the rainfall amount as an indicator for precipitation. Indirect indicators or so-called **proxy indicators** are used when direct measurements are unfeasible or inappropriate. Proxy indicators are also applied for highly complex parameters or when no data are available. A widely used example is the GDP (Gross Domestic Product), which has been used as a proxy for economic performance. 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 (FRITZSCHE et al. 2014: 77).

An increasingly popular role in informing policy making is played by so-called **composite indicators (or indices)**. They allow for measuring phenomena of interest that can hardly be captured by one indicator through combining several single indicators into one composed indicator. Composite indicators combine large amounts of information (and data), while reducing complexity in communicating scientific results for policy makers (OECD 2008: 13; ABELING et al. 2014: 17; FREUDENBERG 2003: 29). However, as the construction of composites is difficult and requires sound methodologies in terms of scaling, weighting or aggregating of indicator and data, researchers face considerable challenges in developing these indices (see also chapter 4.1).

Indicators are often distinguished according to different criteria. One method is to classify/systematise indicators according to their domains/perspectives. In terms of resilience, we could apply for example indicators referring to ecological and social-ecological resilience, psychological resilience, critical infrastructural resilience or organisational and institutional resilience (cf. BIRKMANN et al. 2012b). Another example is the classification according to the indicator content, i.e. in terms of resilience: risk information, hazard experience, risk assessment, disaster preparedness, recovery, etc. This type of classification is simple but as MEYER states "often the content of indicators is less interesting in classifying indicators than criteria related to the measurement of indicators" (MEYER in STOCKMANN 2004: 194). Therefore, a common practice to classify indicators is the distinction between **qualitative and quantitative indicators**. However, this distinction 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, quantitative and qualitative indicators are distinguished according to the so-called 'level of measurement' (see MEYER in STOCKMANN 2011: 201ff.):

- Nominal scales (also called categorical scales): every indicator value can be allocated to exactly one class. The categories differ according to their quality where no ordering or ranking between classes is possible. Nominal scales represent the lowest level of measurement and do not allow statements whether one indicator value is better than another. Examples include 'gender' or 'hazard type'.
- Ordinal scales: they indicate whether one given indicator value is larger or smaller (higher or lower, better or worse, etc.) in comparison with another. Ordinal scales allow a ranking of classes, but the interval between classes is undefined or unknown. Examples include 'education level' or the 'resistance of house types against earthquake events'.
- Interval scales: interval scales allow for creating equal, constant and quantifiable intervals between the classes. They represent the highest level of measurement. Examples include 'net income in €/year' or 'temperature in °C'[2].

[2] Some authors also distinguish a fourth level of measurement, the 'ratio scales'. These include the concept of absolute zero. An example would be the temperature measured in Kelvin. However, this category is not applied in this deliverable.

In the strict sense, one can argue whether it is useful to use indicators that apply at the nominal scale, since no interpretation or evaluation of values is possible. Taking the example of 'gender', we cannot state whether female or male is the 'better', 'higher', 'greater', etc., but, in combination with other indicators gender is definitely of interest. If you combine 'gender' for example with an indicator measuring the 'social support after a hazard event', you could draw important inferences about the different usage of social networks of male and female persons (which might be of interest when assessing community resilience). In this case, gender can be used as an additional 'quality' to help analysing and interpreting other measures.

One condition of quantitative indicators, in contrast to qualitative indicators, is that they have to be fully operationalised. For example, the indicator '% of citizens with access to WAP-enabled mobile phones' is a fully operationalised quantitative/objective indicator, whereas 'trust in authorities' is an example of a qualitative/subjective indicator covering individual judgements, perceptions and feelings that cannot so easily be represented by numerical constants. However, it is possible to make qualitative indicators 'quantifiable'. One way of doing so, is to derive proxies, another is the use of a rating scale (e.g. the commonly-used Likert scale), a 'structured subjective' method (e.g. see FORRESTER et al. 2015 after EDEN et al. 2005) or coding schemes (e.g. emergent coding through word clouds or content analysis). Each of these can be used to derive a numerical output from subjective, qualitative data. However, it has to be noted that despite transferring qualitative indicators into quantitative metrics, the underlying information remains still subjective. Also, the interpretation of Likert scales for example is always based on the subjective opinion of the person filling in the original questionnaire.

Another (and here last discussed) type of classification that is of interest for resilience indicators, is the distinction between **outcome and process indicators**. Per definition, outcome indicators measure a cumulative effect at a defined point in time, whilst a process indicator measures "an interrelated series of activities, actions, events, mechanisms, or steps that transform inputs into outputs for a particular beneficiary or customer" (O'LEARY 2004: 47). According to O'LEARY, "the best process indicators focus on processes that are closely linked to outcomes, meaning that a scientific basis exists for believing that the process, when performed well, will increase the probability of achieving a desired outcome. […] Process indicators may also be useful - or may be the only type of indicator whose use is feasible - when an outcome related to the process is difficult to measure for one or more reasons such

as its rarity or occurrence at some distant time. […] In such a case, measuring processes (linked to the outcome) with process indicators is more useful than measuring the outcome itself" (O'LEARY 2004: 48).

2.2 Potentials and challenges of resilience assessments by means of indicators

Indicators are used in particular for benchmarking, targeting, monitoring and evaluating performances and transformation. Also, for measuring resilience indicator-based approaches seem to be promising tools, as they allow – when evaluated at regular intervals – monitoring changes over time in both magnitude and direction, as well as space (CUTTER et al. 2010: 2). They allow for identifying major weaknesses or drawbacks of resilience and in terms of disaster resilience, indicators help setting policy priorities, allocating resources – financial, personal, technical, etc. – before and after a hazard event and evaluating the effectiveness of risk reduction efforts or emergency activities (OECD 2008: 13; GALL 2013: 15).

However, the purpose and intention of using indicator-based approaches differs. Most applications focus on prioritising and targeting of activities or performances, but with different emphasis on the need to compare and monitor indicator values. For example, the use of qualitative indicators for constant comparison and evaluation of changes in the spatial and temporal term is very much more difficult (albeit not impossible) than with quantitative indicators. That is – because the data is subjective – any change observed is less generalisable. Of course, the same caveat applies to some interval scale quantitative indicators, for example 'net income in €'. However, the critical difference is that with straight-quantitative interval scale indicators the figures can be adjusted to take externalities (i.e. the passage of time or national average incomes) into account, the same cannot be done so relatively simply with qualitative ordinal scales[3].

BIRKMANN et al. 2012b: state, that the "fundamental challenge of assessing resilience is to answer the question of why this is intended, in the first place" (BIRKMANN et al. 2012b: 14). Being explicit about the objectives and motivations of

[3] There are attempts to come up with scales for comparing very subjective phenomena (e.g. wellbeing). We do not discuss this in depth in this deliverable, but taking wellbeing as an example, a useful reference might be COULTHARD et al. 2011 and/or ARMITAGE et al. 2012.

measuring resilience is of critical importance for choosing the right assessment approaches (see chapter 4.1). Also, it requires a clear design of the assessment study (scale of application, target group, conceptualisation of resilience, policy realm, etc.), since in contrast to concepts and frameworks, studies are always case-specific.

As former emBRACE deliverables concluded, resilience is a multidimensional and transformative concept that seems to be difficult to measure (cf. BIRKMANN et al. 2012b: 13). ARMITAGE et al. noted that "resilience is complex, context-specific, and highly dynamic – all characteristics that make it hard to operationalize 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 dynamic, constantly re-shaping and context-dependent concept. However, taking into account these challenges, we believe that indicator-based approaches provide valuable tools for measuring resilience, since indicators offer means to evaluate transformation (and transformative capacity) and provide flexibility in terms of data collection, as well as levels of measurement and scales to be chosen. The key-challenge seems to be to select/develop the right indicator approach that integrates current conceptualisations and operationalisations of resilience. Within emBRACE the basic preconditions for deriving indicators are a conceptual framework and indicators that are empirically grounded within the case studies and local research.

2.3 Relationship between vulnerability indicators and resilience indicators

Resilience and vulnerability are related terms, even though the relationship between both concepts is not clearly defined (GALL 2013, CUTTER et al. 2014). Both are perceived as multi-faceted concepts which require trans-disciplinary research approaches (DEEMING et al. 2013: 4). They focus on adaptive capacities, which can be viewed as a set of socio-economic, natural, institutional, et al. resources and capacities that allow systems (e.g. communities) to be better prepared and capable of mitigating negative impacts. But, while vulnerability focuses more on static stressors such as the exposure and sensitivity (IPCC definition[4]), and, respectively,

[4] "Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a

the hazard, exposure and disaster risk (UNISDR definition[5]) of the system, resilience is a dynamic concept. Thus, resilience adds – somehow as a unique characteristic – transformative aspects such as learning, critical reflection or re-organisation.

In terms of the assessment methodologies, both concepts differ. Whereas research efforts on vulnerability indicators 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), indicators represent a rather new approach for assessing (community) resilience. This might be due to the challenges that occur when implementing operational frameworks of resilience or because of the transformative nature of resilience. GALL in this context notes that "given the novelty of resilience frameworks and the challenges associated with their implementation, researchers tend to rely on approaches and methodologies developed elsewhere – such as in the vulnerability community" (GALL 2013: 21). In fact, many approaches of measuring resilience rely on similar methods and indicators as they have been used, for example, in vulnerability assessments, even though the differences between both concepts are clearly emphasised by all presented studies. This suggests that, 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 assessment approaches and methodologies (see also KELMAN et al. 2015).

2.4 State-of-the-art: indicators for community resilience

In this chapter we summarise the latest research activities on indicators of community resilience. We considered in particular literature identified by WP1 and WP3 (especially BIRKMANN et al. 2012b; ABELING et al. 2014 and RODRIGUEZ-LLANES et al. 2013) and conducted our own non-systematic literature review (limited

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system is exposed, its sensitivity, and its adaptive capacity" (http://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-p-z.html)

[5] "The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (http://www.unisdr.org/we/inform/terminology#letter-v)

in extend) that included both, academic and non-academic literature[6]. The literature review revealed broadly two main techniques of resilience assessments by means of indicators that are further discussed in the following:

(1) Qualitative indicator-based approaches that focus on identifying important characteristics of community resilience and self-assessments, and
(2) Quantitative indicator-based approaches that focus on developing composite indicators ('resilience indices') and quantifying resilience.

2.4.1 Qualitative indicator-based approaches

One of the most cited papers addressing community resilience indicators is the guidance note of John TWIGG**, Characteristics of a Disaster Resilient Community' (TWIGG 2007)**, which summarises from his perspective the most important components that shape community resilience. TWIGG understands community resilience as a multi-faceted concept that goes beyond isolated capacities and views communities not only in spatial terms, but recognises also common interests, values, activities and social structures (TWIGG 2007: 6). The disaster resilient community in this sense is defined as an ideal state, which in reality is never achievable. TWIGG's guidance note includes a list of 'key indicators of community resilience', which has been assembled based on reports of three non-governmental organisations involved in DRR and international development cooperation:

[6] The non-academic literature comprises mainly reports from organisations involved in disaster risk reduction, international development cooperation and emergency management.

Table 1: collection of key-indicators of community resilience by TWIGG 2007 (TWIGG 2007: 12-13)

Key indicators of community resilience

Some organisations and researchers are beginning to think about the most important indicators of resilience with a view to setting priorities for DRR interventions. No consensus has been reached on this but recent suggestions include the following:

ADPC: Indicators of a 'minimum level of resiliency'	***Plan International: indicators of community resilience***	***Practical Action: key characteristics of a resilient community***
• A community organisation • A DRR and disaster preparedness plan • A community early warning system • Trained manpower: risk assessment, search and rescue, medical first aid, relief distribution, masons for safer house construction, fire fighting • Physical connectivity: roads, electricity, telephone, clinics • Relational connectivity with local authorities NGOs, etc. • Knowledge of risks and risk reduction actions • A community disaster reduction fund to implement risk reduction activities • Safer houses to withstand local hazards • Safer sources of livelihoods	1. Governance: • Extent and nature of access/ presence/influence of children and other vulnerable groups (or groups that represent their interests) – to/in/over functions of governance at local, sub-national, national levels: ○ Policy ○ Legislative ○ Planning ○ Budgeting ○ Monitoring • Awareness of community members of their rights • Access of community members to legal and other avenues to enforce rights/provide redress (e.g. through linkages to legal rights NGOs, pro-bono lawyers) 2. Risk assessment: • Existence and quality of community risk assessments and maps that are 'owned' by both community and government • Extent and quality of participation of vulnerable groups in development of community risk assessments and maps • Extent to which vulnerability and risk analysis is incorporated in development planning 3. Knowledge and education: • Awareness levels in the community, particularly children and vulnerable groups, of EWS • Awareness levels in the community, particularly of children and vulnerable groups, of risks and risk reduction strategies 4. Risk management and vulnerability reduction:	• A community organisation such as a development/disaster management group, representing majority of people. Existing groups can be groomed for this role. • A DRR and Disaster Preparedness plan (supported by local/central government) • Early warning systems • Trained persons – risk assessment, search and rescue, first aid, relief distribution, safer house construction, fire fighting; effective delivery system. • Physical infrastructure – access to roads, electricity, phones, clinics, etc. • Linkages with local authorities, NGOs, humanitarian agencies, etc. • Knowledge and awareness of risks and risk reduction strategies • Safer housing to withstand local

	• Extent and nature of social capital • Health status • Sustainable livelihoods/natural resource management • Extent of climate change adaptation • Food security • Extent of diversity of livelihood options • Extent to which DRR has been • integrated into development planning • Access to social protection mechanisms e.g. social insurance 5. Disaster preparedness and response: • Existence and quality of early warning systems • Existence, practice and revision of preparedness and contingency plans • Extent and nature of participation of vulnerable groups in development, practice and revision of preparedness and contingency plans • Extent and quality of linkages with local authorities, NGOs, etc. • Extent of diversity of physical and communications infrastructure and assets, e.g. roads, boats, mobile phones, etc. • Access to resources for mitigation, response and recovery activities	hazards • Safer/appropriate/more diverse sources of livelihoods including protection of assets most at risk. • Access to resources for mitigation, response and recovery activities
Source: ADPC 2006, Critical Guidelines: Community-based Disaster Risk Management (Bangkok: Asian Disaster Preparedness Center; www.adpc.net) p.25	*Source: Plan International*	*Source: Practical Action*

The indicators include both outcome and process indicators and cover a broad range of topics ranging from risk assessments, risk knowledge and information, disaster preparedness, participation, social and economic capital, physical infrastructure, insurance, funding, etc. TWIGG stresses the need to adapt the indicators to the specific local context of the resilience assessment, the applied methods and involved stakeholders.

An interesting approach of assessing community resilience is provided by UNISDR and their **'Making Cities Resilient' initiative (UNISDR 2012)**. They have developed their 'local government self-assessment tool' to enable urban communities to set baseline scenarios for measuring disaster resilience, to measure advancements over time and to argue for priority settings and budget allocation within city councils and national governments (UNISDR 2012: 78). Their assessment should be undertaken in a multi-stakeholder process comprising local government authorities, civil society organisations, local academia, business community and community-based organisations. As part of the Making Cities Resilient initiative, UNISDR developed the 'Ten Essentials for Making Cities Resilient' that are aligned to the Hyogo Framework's priorities for Action and core indicators (see UNISDR 2012: 25). It includes also a so-called **'Disaster Resilience Scorecard for Cities'** that identifies eighty-five 'disaster resilience evaluation criteria' which are divided again in several 'local-context indicators' (UNISDR 2014). The following table shows the ten essentials and the associated key questions underpinning the UNISDR approach (the entire list of indicators is too large for this report, but can be accessed through the Disaster Resilience Scorecard for Cities[7]):

[7] See: http://www.unisdr.org/2014/campaign-cities/Resilience%20Scorecard%20V1.5.pdf

Table 2: key questions for self-assessment based on the "Ten Essentials for Making Cities Resilient" (UNISDR 2012: 80-82)

Ten Essentials for Making Cities Resilient	Key Questions per Essential
ESSENTIAL 1: Put in place organization and coordination to clarify everyone's roles and responsibilities	1. How well are local organizations (including local government) equipped with capacities (knowledge, experience, official mandate) for disaster risk reduction and climate change adaptation? 2. To what extent do partnerships exist between communities, private sector and local authorities to reduce risk? 3. How much does the local government support vulnerable local communities (particularly women, elderly, infirmed, children) to actively participate in risk reduction decision making, policy making, planning and implementation processes? 4. To what extent does the local government participate in national DRR planning?
ESSENTIAL 2: Assign a budget and provide incentives for homeowners, low-income families and the private sector to invest in risk reduction	5. To what extent does the local government have access to adequate financial resources to carry out risk reduction activities? 6. To what degree does the local government allocate sufficient financial resources to carry out DRR activities, including effective disaster response and recovery? 7. What is the scope of financial services (e.g. saving and credit schemes, macro and micro-insurance) available to vulnerable and marginalised households for pre-disaster times? 8. To what extent are microfinancing, cash aid, soft loans, loan guarantees, etc. available to affected households after disasters to restart livelihoods? 9. How well established are economic incentives for investing in disaster risk reduction for households and businesses (e.g. reduced insurance premiums for households, tax holidays for businesses)? 10. To what extent do local business associations, such as chambers of commerce and similar, support efforts of small enterprises for business continuity during and after disasters?
ESSENTIAL 3: Update data on hazards and vulnerabilities, prepare and share risk assessments	11. To what degree does the local government conduct thorough disaster risk assessments for key vulnerable development sectors in your local authority? 12. To what extent are these risk assessments regularly updated, e.g. annually or on a bi-annual basis? 13. How regularly does the local government communicate to the community information on local hazard trends and risk reduction measures (e.g. using a Risk Communications Plan), including early warnings of likely hazard impact?

	14. How well are local government risk assessments linked to, and supportive of, risk assessments from neighbouring local authorities and state or provincial government risk management plans? 15. How well are disaster risk assessments incorporated into all relevant local development planning on a consistent basis?
ESSENTIAL 4: Invest in and maintain risk reducing infrastructure, such as storm drainage	16. How far do land use policies and planning regulations for housing and development infrastructure take current and projected disaster risk (including climate related risks) into account? • housing • communication • transportation • energy 17. How adequately are critical public facilities and infrastructure located in high-risk areas assessed for all hazard risks and safety? 18. How adequate are the measures being taken to protect critical public facilities and infrastructure from damage during disasters?
ESSENTIAL 5: Assess the safety of all schools and health facilities and upgrade these as necessary	19. To what extent have local schools, hospitals and health facilities received special attention for “all hazard” risk assessments in your local authority? 20. How safe are all main schools, hospitals and health facilities from disasters so that they have the ability to remain operational during emergencies 21. To what degree do local government or other levels of government have special programs in place to regularly assess schools, hospitals and health facilities for maintenance, compliance with building codes, general safety, weatherrelated risks etc.? 22. How far are regular disaster preparedness drills undertaken in schools, hospitals and health facilities?
ESSENTIAL 6: Enforce risk compliant building regulations and land use planning, identify safe land for low-income	23. How well enforced are risk-sensitive land use regulations, building codes, and health and safety codes across all development zones and building types? 24. How strong are existing regulations (e.g. land use plans, building codes, etc.) to support disaster risk reduction in your local authority?

citizens	
ESSENTIAL 7: Ensure education programmes and training on disaster risk reduction are in place in schools and communities	25. How regularly does the local government conduct awareness-building or education programs on DRR and disaster preparedness for local communities? 26. To what extent does the local government provide training in risk reduction for local officials and community leaders? 27. To what degree do local schools and colleges include courses, education or training in disaster risk reduction (including climate-related risks) as part of the educational curriculum? 28. How aware are citizens of evacuation plans or drills for evacuations when necessary?
ESSENTIAL 8: Protect ecosystems and natural buffers to mitigate hazards, adapt to climate change	29. How well integrated are the DRR policies, strategies and implementation plans of local government into existing environmental development and natural resource management plans? 30. To what degree does the local government support the restoration, protection and sustainable management of ecosystems services? 31. To what degree do civil society organizations and citizens participate in the restoration, protection and sustainable management of ecosystems services? 32. To what degree does the private sector participate in the implementation of environmental and ecosystems management plans in your local authority?
ESSENTIAL 9: Install early warning systems and emergency management capacities	33. To what degree do local institutions have access to financial reserves to support effective disaster response and early recovery? 34. To what extent are early warning centres established, adequately staffed (or on-call personnel) and well resourced (power back ups, equipment redundancy etc.) at all times? 35. How much do warning systems allow for adequate community participation? 36. To what extent does the local government have an emergency operations centre (EOC) and/or an emergency communication system? 37. How regularly are training drills and rehearsals carried out with the participation of relevant government, non-governmental, local leaders and volunteers? 38. How available are key resources for effective response, such as emergency supplies, emergency shelters, identified

	evacuation routes and contingency plans at all times?
ESSENTIAL 10: Ensure that the needs and participation of the affected population are at the centre of reconstruction	39. How much access does the local government have to resources and expertise to assist victims of psycho-social (psychological, emotional) impacts of disasters? 40. How well are disaster risk reduction measures integrated into post-disaster recovery and rehabilitation activities (i.e. build back better, livelihoods rehabilitation)? 41. To what degree does the Contingency Plan (or similar plan) include an outline strategy for post-disaster recovery and reconstruction, including needs assessments and livelihoods rehabilitation?

The UNISDR approach represents a very comprehensive collection of 'key-questions' and indicators related to disaster resilience. Since the focus is set on urban communities, many indicators of the Scorecard address critical infrastructures that gain importance in the case of a disaster event, such as the healthcare system, electricity, transportation, sanitation, water and gas networks or the supply networks of food, shelter, staple goods and fuel. However, the indicators cover also governmental aspects such as the coordination of local government institutions involved in disaster related activities or the participation and engagement of local citizens, vulnerable groups and grass-root organisations. Other essential indicators encompass disaster risk assessment (awareness, knowledge of hazard risks, exposure and vulnerability, etc.), early warning systems, building codes, land use planning, financial planning (contingency, insurance, etc.), as well as training drills and education. Through further guidance on how to best measure the identified indicators, the Scorecard becomes a valuable source of information.

The **'City Resilience Framework'** developed by Arup International Development and the Rockefeller Foundation should support municipal governments in making their cities resilient (**ARUP & ROCKEFELLER FOUNDATION 2014**). The intention is to create a 'City Resilience Index' based on different single indicators allowing to measure resilience at the city scale. The report provides 12 'key indicators' that should in future be further divided into 48-54 'sub-indicators' and 130-150 'variables'. However, until now, the report provides merely these 12 key-indicators that reveal important components of a resilient urban community. The sub-indicators and variables are not yet provided. The 12 key-indicators of the City Resilience Framework are:

Table 3: the 12 key-indicators of the City Resilience Framework (ARUP & ROCKEFELLER FOUNDATION 2014: 7)

1. Minimal human vulnerability
2. Diverse livelihoods and employment
3. Adequate safeguards to human life and health
4. Collective identity and mutual support
5. Social stability and security
6. Availability of financial resources and contingency funds
7. Reduced physical exposure and vulnerability
8. Continuity of critical services
9. Reliable communications and mobility
10. Effective leadership and management
11. Empowered stakeholders
12. Integrated development planning

According to the ARUP & ROCKEFELLER FOUNDATION, the intention of the initiative is to help cities allocating their investment decisions and to engage in urban planning practices that ensure a resilient city (independently to the shock they encounter). The objective of the city resilience index is not to rank or compare cities, but rather to "better understand what it is that makes a city resilient" (ARUP & ROCKEFELLER FOUNDATION 2014: 21). Hence, this approach can be regarded as conceptual, that requires support for operational application.

Another noteworthy paper is the report of the International Federation of Red Cross and Red Crescent Societies in 2012 about **'Characteristics of a Safe and Resilient Community'** (**IFRC 2012**), which has been developed in order to mainstream community resilience in all 'community-based disaster risk reduction programs' of the Red Cross. Without identifying its own indicators of community resilience, the report includes a valuable and very comprehensive collection of characteristics of a safe and resilient community. The characteristics are justified by important literature on community resilience indicators:

Table 4: characteristics of a safe and resilient community (IFRC 2012: 14-16)

External Resources

A safe and resilient community has access to:

1. connections & information
   - Transportation and infrastructure (Cutter, 2010; IOTWS, 2007).
   - Communication and information (Twigg, 2009; Cutter, 2010).
   - Technical advice (IOTWS, 2007; Twigg, 2009).
2. services (at a scale larger than a community)
   - Municipal services (Cutter, 2010).
   - Medical care (Cutter, 2010; Twigg, 2009).
   - Government (and other) funding sources (Twigg, 2009; IOTWS, 2007).
3. natural resources (at a scale larger than a community)
   - Land (Mayunga, 2007).
   - Water (Mayunga, 2007).
   - Ecosystem (Mayunga, 2007).

Assets

A safe and resilient community has:

4. physical assets
   - Public facilities (Mayunga, 2007; Twigg, 2009).
   - Housing (Cutter, 2010; Mayunga, 2007).
   - Transportation infrastructure e.g. roads, rail, boat etc (Cutter, 2010).
   - Stockpiles for emergencies (ADPC, 2006; UNISDR, 2008; IOTWS, 2007; Mayunga, 2007).
5. economic assets
   - Livelihood assets (Pasteur, 2011; Twigg, 2009).
   - Employment & income (Cutter, 2010; Mayunga, 2007; Twigg, 2009).

- Savings and contingency fund (Mayunga, 2007, UNISDR, 2008; Twigg, 2009).
- Investment (Mayunga, 2007).
- Insurance (Twigg, 2009).
- Business/industry (CRPT, 2000; Mayunga, 2007).

6. environmental assets
   - Ownership of natural resources (Bahadur, 2010; Twigg, 2009).
7. human assets
   - Local and traditional knowledge (Bahadur, 2010; Mayunga, 2007; IFRC, 2008; ADPC, 2006; Twigg, 2009).
   - Skills (Pasteur, 2011; Mayunga, 2007; Twigg, 2009).
   - Language competency (Cutter, 2010).
   - Health (Cutter, 2010; Mayunga, 2007; Twigg, 2009).
   - Education (CRPT, 2000; Mayunga, 2007; Twigg, 2009; IOTWS, 2007).
8. social assets
   - Community cohesion and cooperation (Bahadur, 2010; Mayunga, 2007; Twigg, 2009).
   - Religion (Cutter, 2010).
   - Community organisations with collaborative/partnership relationships eg. Economic development organisations (Bahadur, 2010; CRPT, 2000; Mayunga, 2007).
9. political assets
   - Effective and flexible governance and institutional structures (Bahadur, 2010, Cutter, 2010, Twigg, 2009).
   - Representative governance and institutional structures (Twigg, 2009; Bahadur, 2010; Pasteur, 2011; Cutter, 2010).

Capacities

A safe and resilient community has the capacity to:

10. be resourceful
    - Mobilise resources and services when needed (O'Rouke, 2008; Arup, 2010; Pasteur, 2010; CDRT, 2000).
    - Visualise and act (Arup, 2010).
    - Identify problems and establish priorities (Arup, 2010).
    - Innovate (Cutter, 2010).
    - Coordinate and provide emergency relief (Twigg, 2009).
11. be adaptive/flexible
    - Adapt to long term trends (organise and re-organise) (Pasteur, 2011; Arup, 2010).
    - Convert assets (Arup, 2010).
    - Accept uncertainty and proactively respond to change (Bahadur, 2010; Pasteur, 2011).
12. learn
    - Build on past experiences and integrate it with current knowledge (Arup, 2010; IFRC, 2008; ADPC, 2006; Bahadur, 2010; Twigg, 2009).
    - Assess, manage and monitor risks (IFRC, 2008; Pasteur, 2011; Bahadur, 2010).
    - Build back after a disaster in such a way that reduces vulnerability (IFRC, 2008; Pasteur, 2011).

Qualities

A safe and resilient community has assets /resources that are:

13. strong/robust
    - Robust to withstand external pressure /demands without loss of
    - Function (O'Rouke, 2008).
    - Strong (UNISDR, 2008; Twigg, 2009; IOTWS, 2007).
    - Increased size e.g. community contingency fund (Twigg, 2009); local employers (CRPT, 2000).
14. well located

- Geographically distributed so that they are not all affected by a single event (Arup, 2010) e.g. decentralised government (Bahadur, 2010).
- Located outside of high risk areas (Twigg, 2009; IOTWS, 2007).

15. diverse
    - Able to meet its needs in a variety of ways e.g. social (variety of internal organisations), economic (multiple employers and employment opportunities), environmental (different groups in an ecosystem) (Arup, 2010; Bahadur, 2010; Cutter, 2010; Pasteur, 2011; CRPT, 2000; Twigg, 2009; IOTWS, 2007).
16. redundant
    - Able to offer spare capacity to accommodate extreme pressure so that alternate options and substitutions are available under stress (O'Rouke, 2008; Arup, 2010; Bahadur, 2010; Twigg, 2009).
17. equitable
    - Equal and allow inclusive access and ownership (Cutter, 2010; CRPT, 2000; Twigg, 2009; Bahadur, 2010).

There were also a number of qualities that were associated with human behavior and attitude that emerged:

18. Commitment to reducing risk in the long-term (IFRC, 2008; Twigg, 2009; CRPT, 2000).
19. Self-sufficiency (IFRC, 2008; CRPT, 2000; ADPC, 2006).

The list incorporates many other important papers dealing with community resilience indicators (the specific indicators cannot be shown in this report, but can accessed via the reports). Examples are the first discussion paper of the **'Strengthening Climate Resilience'** initiative by DFID (**BAHADUR et al. 2010**)[8] that assembled ten main characteristics and many other potential indicators of a resilient system (mostly related to disasters and climate change in the developing world), the **'critical guidelines of community-based disaster risk management'** by the Asian Disaster Preparedness Center (**ADPC 2006**)[9] that describes the main characteristics of a resilient community, divided into characteristics before, during and after a disaster event or the '**Framework for Analysis and Action to Build Community Resilience'** (**PASTEUR 2011**)[10] that sets out key-factors contributing to individual, household and community resilience.

At this point, we want to highlight also psychological research activities on resilience indicators – without naming specific studies – although they can hardly be allocated to either quantitative or qualitative indicator-based assessment approaches. Psychological perspectives of community resilience are well addressed in current

[8] See: http://opendocs.ids.ac.uk/opendocs/handle/123456789/2368#.VWVxH2M-d0Z

[9] See: http://www.preventionweb.net/files/9440_ADPCCriticalGuidelines.pdf

[10] See: https://practicalaction.org/media/download/9654

literature and seem to be very advanced in identifying indicators. **Deliverable 3.3** (RODRIGUEZ-LLANES et al. 2013) identified in its literature review on indicators of psychological resilience for example fifty-eight resilience indicators. These were then evaluated by pointing out those indicators that were mentioned by a majority of studies and that show the same effect on resilience. According to this evaluation, the most consistent and robust indicators of psychological perspectives of community resilience are gender (female gender was found as a higher risk group of suffering after a disaster) and social support (high levels of social support from relatives and friends increase resilience). Probable indicators are disaster exposure level, previous traumatic experiences, resource loss, human loss and the physical and mental health status of individuals. Potential indicators include substance abuse, being insured, event-related worry, education, income, marital status, age, being religious and ethnicity.

Further, **Deliverable 4.1** (KARANCI et al. 2015), focussing on "archetypes of personal attributes and cognition for psycho-social resilience", uses narratives from emBRACE case studies (mainly German flooding and Turkish earthquakes) to derive and assess indicators to capture individual experience of risk and vulnerability. It relates this to indicators of household resilience (KARANCI et al. 2015: 16-17) based on the same associated case study data that was fed into the process to produce this report. It concludes that: "mitigation actions seems to be not that sufficient in general to build at least the psychological and physical resilience of households that suffered from repetitive flooding. The usual socio-economic indicators like age, gender, employment and also income do not play that expected important role to build resilience. Existing vulnerability and resilience assessment indicators in flood risk management should be therefore critically scrutinized" (KARANCI et al. 2015: 19).

Thus, Del.4.1 "aimed to discover if there were additional indicators of [individual psychological] resilience not covered in existing models and theories" (KARANCI et al. 2015: 26); a process which this deliverable broadens out. However, Del.4.1 produced a list of 12 indicators of psychological resilience which include: individual socio-demography, religiousness, disaster exposure, personality, optimism, social capital (including social support), life satisfaction, domain-specific self-efficacy, damage attributions, coping, posttraumatic stress symptoms, stress-coping ability and suggest assessment tools to measure these. The conclude that "from the qualitative analysis human, social and financial capital and disaster impact appeared as the most pronounced indicators of resilience" (KARANCI et al. 2015: 24) but add

the rider that “regarding individual psychological resilience, belief in God and religion, financial resources, social networks, health, and personality characteristics were the most pronounced indicators of psychological resilience. Moreover, coping also included diverse strategies, social networks and religion appearing prominent among them” (KARANCI et al. 2015: 24-25). Of course all this data has also fed into this deliverable in a systematic manner through the process described in chapter 3.

A valuable source of information is also the systematic literature review of OSTADTAGHIZADEH et al. concerning assessment models and tools for measuring community disaster resilience with focus on public health (**OSTADTAGHIZADEH et al. 2015**). According to their literature review (17 papers), major elements of community disaster resilience include: religious affiliation, place of residence (place attachment), spirituality, ethnicity, culture, social trust, community education, community empowerment, practice, social networks, familiarity with local services, physical and economic security, economic development, social capital, information and communication, and community competence (OSTADTAGHIZADEH et al. 2015: 2).

Their study confirmed also the difficulties and limitations of current approaches of measuring community resilience that were identified also in this report, i.e. complexity of operationalisation and the development of measurable frameworks of the concept, lack of accepted definitions of community resilience (and community resilience indicators), lack of concrete assessment tools, etc. They revealed a considerable disparity between papers referring to community resilience and those actually attempting to measure the concept. “This disparity provides a tangible indication of the proliferation in the use of the concept of community resilience, the limited attention paid to its definition and systematic study, and the consequent need to identify a set of predictors that can inform the systematic assessment process” (OSTADTAGHIZADEH et al. 2015: 4). One suggestion of the authors is to use similar terms when addressing community resilience indicators (e.g. domain instead of component or dimension; indicator instead of factor, variable or criteria; index instead of composite indicator), which is an interesting point and is worthy of further consideration in order to harmonise and advance research on community resilience indicators.

2.4.2 Quantitative indicator-based approaches

The approach pursued by Susan CUTTER and her colleagues from the Hazard & Vulnerability Research Institute of the University of South Carolina is one of the most cited quantitative indicator-based approaches in current literature. They have published several papers dealing with disaster resilience indicators for communities, as for example the 'Disaster Resilience of Place (DROP) model in 2008 (CUTTER et al. 2008) that served as the framework for developing 'Baseline Resilience Indicators for Communities' and the 'Disaster Resilience Index' in 2010 (CUTTER et al. 2010), which was further refined in a paper about **'Geographies of Community Disaster Resilience'** in 2014 **(CUTTER et al. 2014)**.

CUTTER et al. use empirically-based indicators to measure the disaster resilience of communities in the United States. The paper published in 2014 proposes forty-nine indicators (called 'variables'), which are aligned to six different domains of community resilience: social resilience, economic resilience, community capital, institutional resilience, housing/infrastructural resilience and environmental resilience[11]:

Table 5: baseline resilience indicators for communities (after CUTTER et al. 2014: 69-70)

Resilience concept		Variable description
Social resilience	Educational attainment equality	Negative absolute difference between % population with college education and % population with less than high school education
	Pre-retirement age	% Population below 65 years of age
	Transportation	% Households with at least one vehicle
	Communication capacity	% Households with telephone service available
	English language competency	% Population proficient English Speakers
	Non-special needs	% Population without sensory, physical, or mental disability
	Health insurance	% Population under age 65 with health insurance
	Mental health support	Psychosocial support facilities per 10,000 persons
	Food provisioning capacity	Food security rate
	Physician access	Physicians per 10,000 persons
Economic resilience	Homeownership	% Owner-occupied housing units
	Employment rate	% Labor force employed
	Race/ethnicity income equality	Negative Gini coefficient
	Non-dependence on primary/tourism sectors	% Employees not in farming, fishing, forestry, extractive industry, or tourism

[11] The original table consists also information about the related dataset and the justifications (references) for each indicator (see CUTTER et al. 2014: 69-70).

	Gender income equality	Negative absolute difference between male and female median income
	Business size	Ratio of large to small businesses
	Large retail-regional/national geographic distribution	Large retail stores per 10,000 persons
	Federal employment	% Labor force employed by federal government
Community capital	Place attachment-not recent immigrants	% Population not foreign-born persons who came to US within previous five years
	Place attachment-native born residents	% Population born in state of current residence
	Political engagement	% Voting age population participating in presidential election
	Social capital-religious organizations	Persons affiliated with a religious organization per 10,000 persons
	Social capital-civic organizations	Civic organizations per 10,000 persons
	Social capital-disaster volunteerism	Red cross volunteers per 10,000 persons
	Citizen disaster preparedness and response skills	Red cross training workshop participants per 10,000 persons
Institutional resilience	Mitigation spending	Ten year average per capita spending for mitigation projects
	Flood insurance coverage	% Housing units covered by National Flood Insurance Program
	Jurisdictional coordination	Governments and special districts per 10,000 persons
	Disaster aid experience	Presidential disaster declarations divided by number of loss-causing hazard events from 2000 to 2009
	Local disaster training	% Population in communities with Citizen Corps program
	Performance regimes-state capital	Proximity of county seat to state capital
	Performance regimes-nearest metro area	Proximity of county seat to nearest county seat within a Metropolitan Statistical Area
	Population stability	Population change over previous five year period
	Nuclear plant accident planning	% Population within 10 miles of nuclear power plant
	Crop insurance coverage	Crop insurance policies per square mile
Housing/infrastructural resilience	Sturdier housing types	% Housing units not manufactured homes
	Temporary housing availability	% Vacant units that are for rent
	Medical care capacity	Hospital beds per 10,000 persons
	Evacuation routes	Major road egress points per 10,000 persons
	Housing stock construction quality	% Housing units built prior to 1970 or after 2000
	Temporary shelter availability	Hotels/motels per 10,000 persons
	School restoration potential	Public schools per 10,000 persons
	Industrial re-supply potential	Rail miles per square mile
	High speed internet infrastructure	% Population with access to broadband internet service
t a l	Local food suppliers	Farms marketing products through Community

		Supported Agriculture per 10,000 persons
	Natural flood buffers	% Land in wetlands
	Efficient energy use	Megawatt hours per energy consumer
	Pervious surfaces	Average percent perviousness
	Efficient Water Use	Inverted water supply stress index

The indicators identified by CUTTER et al. cover a broad range of resources and capacities that shape the disaster resilience of communities. These range from social capital (e.g. income and educational equality, presence of civic organisations, disaster volunteering) and community capital (e.g. place attachment, political engagement) to institutional (e.g. insurance coverage, disaster aid experiences, local disaster trainings) and infrastructural capacities (e.g. housing types, healthcare facilities, communication and transportation networks). The required data are derived from national census or statistical surveys at the administrative level (national to county level).

These baseline indicators are used to calculate a disaster resilience index including several steps of composite indicator development such as normalisation and aggregation (see also chapter 4.1): As a first step, CUTTER et al. used the 'min-max' normalisation technique to convert all indicator values into the same reference scale. Then, they calculated sub-indices for the six above mentioned domains of resilience (with equal weights for each domain) and in a final step aggregated them to the final disaster resilience index. The index allows mapping of results and comparing community resilience not only between different US counties, but also between different domains of resilience (sub-indices). Furthermore, the single indicators serve as a reference unit (baseline) for constant measurements of community resilience in the future.

A very similar approach to the one by CUTTER et al. is followed by BURTON in his study on **metrics for community resilience to natural hazards**, which takes Hurricane Katrina as a case study (**BURTON 2015**). The aim of his approach is to "advance the understanding of the multidimensional nature of disaster resilience and to provide an externally validated set of metrics for measuring resilience at sub-county levels of geography" (BURTON 2015: 1). BURTON identified in total sixty-four potential indicators (called 'variables') for resilience assessment that were grouped in the six components of community resilience: social resilience, economic resilience,

institutional resilience, infrastructure resilience, community capital and environmental systems[12]:

Table 6: potential indicators for resilience assessment (after BURTON 2015: 6-7)

Type		Variable
Social resilience	Social capacity	% population that is not elderly
		% population with vehicle access
		% population with telephone access
		% population that doesn't speak English as a second language
		% population without a disability
		% population that is not institutionalized or infirmed
		% population that is not a minority
		% population with at least a high school diploma
		% population living in high-intensity urban areas
	Community health/ well-being	Social assistance programs per 1,000 population
		Adult education and training programs per 1,000 population
		Child care programs per 1,000 population
		Community services (recreational facilities, parks, historic sites, libraries, museums) per 1,000 population
		Internet, television, radio, and telecommunications broadcasters per 1,000 population
		Psychosocial support facilities per 1,000 population
		Health services per 1,000 population
	Equity	Ratio % college degree to % no high school diploma
		Ratio % minority to % nonminority population
Economic resilience	Economic/livelihood stability	% homeownership
		% working age population that is employed
		% female labor force participation
		Per capita household income
		Mean sales volume of businesses
	Economic diversity	% population not employed in primary industries
		Ratio of large to small businesses
		Retail centers per 1,000 population
		Commercial establishments per 1,000 population
	Resource equity	Lending institutions per 1,000 population
		Doctors and medical professionals per 1,000 population
		Ratio % white to % nonwhite homeowners
	Economic infrastructure exposure	% commercial establishments outside of high hazard zones (flood, surge)
		Density of commercial infrastructure
Institutional resilience	Hazard mitigation/ planning	% population covered by a recent hazard mitigation plan
		% population participating in Community Rating System (CRS) for flood
		% households covered by National Flood Insurance Program policies
	Preparedness	% population with Citizen Corps program participation
		% workforce employed in emergency services (firefighting,

[12] The original table of BURTON consists also one column with justifications for each indicator (see BURTON 2015: 6-7).

		law enforcement, protection)
		Number of paid disaster declarations
	Development	% land cover change to urban areas from 1990 to 2000
Infrastructure resilience	Housing type	% housing that is not a mobile home
		% housing not built before 1970; after 1994
	Response and recovery	% housing that is vacant rental units
		Hotels and motels per square mile
		Fire, police, emergency relief services, and temporary shelters per 1,000 population
		% fire, police, emergency relief services, and temporary shelters outside of hazard zones
		Schools (primary and secondary education) per square mile
	Access and evacuation	Principal arterial miles
		Number of rail miles
	Infrastructure exposure	Density of single-family detached homes
		% building infrastructure not in flood and storm surge inundation zones
		% building infrastructure not in high hazard erosion zones
Community capital	Social capital	Religious organizations per 1,000 population
		Social advocacy organizations per 1,000 population
		Arts, entertainment, and recreation centers per 1,000 population
		Civic organizations per 1,000 population
	Creative class	% workforce employed in professional occupations
		Professional, scientific, and technical services per 1,000 population
		Research and development firms per 1,000 population
		Business and professional organizations per 1,000 population
	Cultural resources	National Historic Registry sites per square mile
	Sense of place	% population born in a state and still residing in that state
		% population that is not an international migrant
Environmental systems resilience	Risk and exposure	% land area that does not contain erodible soils
		% land area not in an inundation zone (100/500-year flood and storm surge combined)
		% land area not in high landslide incidence zones
		Number of river miles
	Sustainability	% land area that is nondeveloped forest
		% land area with no wetland decline
		% land area with no land-cover/land-use change, 1992–2001
		% land area under protected status
		% land area that is arable cultivated land
	Protective resources	% land area that consists of windbreaks and environmental plantings
		% land area that is a wetland, swamp, marsh, mangrove, sand dune, or natural barrier
		% land area that is developed open space
	Hazard event frequency	Frequency of loss-causing weather events (hail, wind, tornado, hurricane)

These indicators specifically cover social capacities, community health, well-being and equity (social resilience), community's economic and livelihood stabilities, resource diversity and equity, the exposure of a community's economic assets

(economic resilience), hazard mitigation and planning, disaster preparedness, urban development (institutional resilience), community response and recovery capacities (infrastructural resilience), relationships between individuals and the larger neighbourhood and community (community capital) and measures of risk and exposure, the presence of protective resources and dimensions of sustainability (environmental systems) (BURTON 2015: 5).

BURTON applied also a step-by-step approach to create the composite indicator of community resilience that includes (1) identification of relevant indicators, (2) normalisation, (3) multivariate analyses, (4) aggregation and (5) validation of indicators by means of external metrics. This twofold validation process (multivariate analysis & validation metrics) revealed that forty-one out of the original sixty-four indicators are analytically sound and achieve statistical significance in measuring disaster resilience of communities (see BURTON 2015: 8). The final disaster resilience index was then calculated by aggregating these forty-one indicators into sub-components indices and subsequently into the resilience index.

The approach of NORRIS et al. seeks for measuring community resilience as a **'set of networked adaptive capacities' (NORRIS et al. 2008)**. They have developed a 'community resilience model' that serves as a framework for operationalising community resilience. It comprises four components: economic development (resource volume and diversity, resource equity and social vulnerability), social capital (network structures and linkages, social support, community bonds, roots, and commitments), community competence (collective action and decision-making, collective efficacy and empowerment) and information and communication (systems and infrastructure for informing the public, communication and narrative) (NORRIS et al. 2008: 136).

Based on this operational framework, SHERRIEB et al. identified in their study on post-trauma mental health issues indicators for two of the four components of the 'community resilience model', that is economic development and social capital **(SHERRIEB et al. 2010)**. The other components of the framework were not covered due to data limitations. In order to identify suitable indicators, they first created a 'wish list' of relevant indicators based on a literature review and in a second step identified data sources that can be applied to the chosen indicators. After a correlation analysis of the indicators, they calculated composite indicators for the two components, which were validated against external metrics (e.g. the social

vulnerability index of CUTTER et al. 2003). Table 7 shows the underlying indicators of the two components economic development and social capital.

Table 7: indicators of economic development and social capital for the community resilience model (SHERRIEB et al. 2010: 240)

Economic Development:

- Employment/population ratio
- Median household income
- Number of medical doctors per 10,000
- Corporate tax revenues per 1,000
- Percent creative class occupations
- Income equity
- Percent population with less than a high school education
- Net business gain/loss rate
- Occupational diversity
- Urban influence

Social capital:

- Percent of two parent families
- Number of arts/sports organisations
- Number of civic organisations per 10,000
- Percent voter participation in 2004 presidential election
- Number of religious adherents per 1000 population
- Net migration per 1000 population
- Property crime rate

The indicators identified by SHERRIEB et al. focus on resource level, equity and diversity (economic development), as well as social support, social participation and community bonds (social capital) and allow for community resilience index development.

2.5 Summary findings on indicators of community resilience

Summarising the findings on current research on resilience indicators, we see that qualitative indicator-based approaches, as currently available in the literature, provide valuable collections of important characteristics of community resilience/of a 'resilient community'. The presented indicators are provided with flexibility in how to acquire the related data, since no fixed methods of data collection or data sources are given. They thus would need specification, before any values could be collected. This is also due to the fact, that – according to the authors – the indicators generally should be applied to specific contexts and scale of applications in order to support a

concrete assessment (e.g. see TWIGG 2007). In this sense, most qualitative indicator-based approaches address specific target groups, propose their own frameworks and rely on specific perspectives of resilience and sometimes case studies, which limits to some extent the possibilities in terms of comparability and generalisation (GALL 2013: 21).

The presented studies of qualitative indicator-based approaches explicitly recognise that resilience is a dynamic and multi-faceted concept that relates to multiple levels. Also, most approaches define communities not only in spatial terms, but equally consider social and societal factors such as common interests and values of communities. 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 understanding the constituent factors of community resilience, which facilitates operationalising the concept and developing analytical frameworks. Furthermore it allows for setting priorities, targets and policy interventions.

Concerning the quantitative indicator-based approaches, we can summarise that most of the presented studies approach community resilience as a set of capacities/capitals covering different perspectives of resilience (social, economic, community, institutional, environmental, etc.). They provide concrete metrics that are provided with data sources, justifications and sometimes the relationship to resilience (e.g. see CUTTER et al. 2010). Aspects such as equity, diversity, efficacy, participation, coordination and communication are central pillars of such approaches indicators. Transformative aspects of community resilience, such as learning, re-organisation and critical reflection, as well as the awareness of risk or willingness, openness to changes and innovation capacities are less often addressed.

The presented quantitative approaches focus on the inherent resilience of communities as it represents pre-existing and quantifiable characteristics within communities that can serve as baselines (BURTON 2015: 3). While CUTTER et al. and BURTON for example, explicitly recognise the multi-faceted and dynamic character of resilience as it is understood in current resilience research, for the purpose of quantification, nevertheless, they confine themselves to a ‘static snapshot of resilience’ (CUTTER et al. 2014: 66), and ‘disaster recovery outcomes’ (BURTON 2015: 3). However here, it raises question whether resilience can be assessed at a

certain point in time, recognising that it is such a dynamic and transformative concept (cf. BIRKMANN et al. 2012b: 14). In this sense, the transition of resilience from a rather outcome-driven to a more dynamic concept, as it took place in theoretical conceptualisations, is not reflected in quantitative indicator-based approaches.

Often the quantitative approaches, as currently available in the literature, aim to aggregate single indicators into a composite indicator. Composite indicators allow for standardised comparisons in space and time while 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 measurements, resolutions, thematic fields, etc. The challenges of creating composite indicators should not be underestimated. Furthermore, it has to be noted, that the reduction of complexity through the use of composite indicators goes hand in hand with the loss of information. The generation of composite indicators requires always simplification as well as normative decisions concerning the ways to aggregate, weight and scale the individual components.

Most of the presented quantitative approaches rely to a great extent on proxy indicators. Using proxy indicators is often an inevitable characteristic of these approaches since direct measurements are mostly not available due to missing or inconsistent data. Thus, proxy indicators present often the only means to cover specific aspects of community resilience when applying composites. However, there are two main disadvantages when using proxy indicators: first, you are losing information when deriving proxy indicators out of direct indicators and secondly there is a risk of you not measuring what you actually intend to measure. Taking the example 'Integration of community representatives in emergency management planning groups' (one of the emBRACE indicators), one could identify the proxy '% of community representatives per emergency management planning group', which represents an indicator that is operationalised to a 'quantifiable' level. However, it raises the question of whether this really captures the entire picture of the original indicator, since 'integration' can be understood not only in terms of the amount of present persons, but also in terms of active participation and engagement. Replacing qualitative indicators by proxies has to be decided carefully and case-dependent

(often it is a balance between data acquisition/availability and meaningfulness of the indicator), in order to avoid jeopardising the objectives of the assessment.

WEICHSELGARTNER & KELMAN conclude in this context: “while the political-administrative request to quantify resilience is comprehensible, i.e. to target resources, to measure impact and to judge cost benefits, along with the quantification of resilience comes its decontextualization, making it more difficult to recognize relevant contributing factors and to gain a full picture of how hazards shape a community’s or country’s response to them. That is especially the case with efforts to collapse all resilience indicators into a single index, because subtleties and contexts can be lost” (WEICHSELGARTNER & KELMAN 2014: 9). They continue “[…a] contemporary quantitative production mode of streamlining resilience into one community signature or country index hides far more than it discloses. In particular, geographical differentiation, cultural heterogeneity and social plurality may be named with regard to local practices and knowledge-making traditions” (WEICHSELGARTNER & KELMAN 2014: 15).

Concluding, we can state that both types of indicator-based assessment approaches have their raison d’être, advantages and disadvantages. It has to be decided individually and according to the type and objective of the resilience assessment, which one to favour (see chapter 4.1). When aiming at comparing resilience between space and time, composite indicators might be preferable. If the focus is rather on identifying the important constituent characteristics that shape community resilience, qualitative approaches seem to be preferable. It should not be the objective to contrast both approaches and compare them in terms of their performance (also it became clear that the distinction is not always so straightforward). Rather, given the complexity and difficulty of resilience assessments, it is clear that no reductionist, easy approaches exist for measuring community resilience. GALL for example argues for innovative assessment approaches that use ‘hybrid research methods’ and combines quantitative and qualitative indicators in order to capture all relevant aspects of resilience (GALL 2013: 21). Also BURTON brings up alternate assessment standards “such as approaches that make use of resilience scorecards that are highly customizable and make use of primary source data” (BURTON 2015: 18). Although, these approaches seem to be promising tools for measuring community resilience, few experiences and concrete assessment approaches exist so far.

3. Community resilience indicators within emBRACE

3.1 From concept to assessment: emBRACE framework & indicators

3.1.1 The emBRACE definition of community resilience indicators

Within the emBRACE project, we approach indicators of community resilience as qualitative or quantitative measures that allow drawing inferences about community resilience. They have a clearly understood relevance (either by the practitioner or by the researcher or by both) for community resilience. Communities in this sense are approached as a group of actors that share a common identity. 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 people living in the same area or close to the same risks. 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, circumstances, identity or supporters (cf. BIRKMANN et al. 2012a) are equally important when applying indicators of community resilience.

Several authors highlight the importance of strong conceptual 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: 7; OECD 2008: 22; GALL 2013: 21; DEEMING et al. 2013: 8). Within emBRACE, we have iteratively developed and refined a framework of community resilience (see JÜLICH et al. 2014) that provides the route to select and conceptually locate our indicators of community resilience. This conceptual framework is grounded on empirical research within the five case studies of emBRACE, thus strongly supported by local research findings on community resilience. The framework comprises three ‘domains’ (or ‘loops’) and several contributing ‘components’ of community resilience (Figure 1):

Figure 1: the emBRACE conceptual framework of community resilience: the framework depicts the dynamic interactions of **community resilience** across three component domains: **resources and capacities**, **actions** and **learning**. Further, community resilience is influenced by outside forces, comprising **context**, **disturbance** and **change** over time. With its **disaster risk governance** focus such external context is also acknowledged to encompass **laws, policies** and **responsibilities**, which enable and support **civil protection** practices. These influence community capacities and actions through all phases of the disaster risk management cycle of **preparedness, response, recovery, mitigation**. It contributes to **vulnerability reduction** alongside wider **social protection** mechanisms and services such as healthcare, housing, education and welfare provision. The framework represents a heuristic tool that policy and decision makers may wish to use when considering the components of resilience-related programmes and initiatives.

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, alternatively, 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. Considering the multitude of research questions, methodologies, scales of application and study objectives applied within the emBRACE case studies, aggregating these emergent indicators into any sort of single index was revealed through our analysis, to represent an unprofitable endeavour. WEICHSELGARTNER and KELMAN come to a similar conclusion by questioning approaches "being heavy on quantitative data while not acknowledging wide swathes of qualitative research" and thus 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 2014: 9).

Taking into account these conclusions, we propose an integrated approach within emBRACE that combines both quantitative and qualitative as well as outcome and process indicators and which captures all parts of the emBRACE framework. This approach enables us to reveal the most important 'key-indicators' of community resilience within emBRACE.

3.1.2 Do we need new set of indicators?

The delivery of a set of indicators is now seen as a fundamental output from projects such as emBRACE. Because emBRACE is not alone in suggesting indicators, we need to recognise that there's a complex interrelationship between some recognised emerging metrics of resilience, ongoing practice, and our own work. The published literature contains long lists of indicators of community resilience. Nevertheless, at the community level, resilience is complex and cannot easily be measured by any simple list of indicators: further, we should not attempt to define a single, all-encompassing, all-applicable list of indicators but rather provide a framework within which the indicators generated by the emBRACE case studies, although empirically-based and contextualised, can be applied to the higher societal level of resilience.

Thus, we maybe do not need new indicators per se, but we do need to understand better how to use, integrate and apply indicators.

There are some other important aspects of community resilience, which we need to ensure are reflected in any list of indicators (and at all levels of governance). One of these is reflected in the oft-asked question “resilience of whom?” Another is “resilience of what?” (BIRKMANN et al. 2012b: 13). In some cases of community adaptation to disaster risk, resilience is seen solely in terms of stability of social systems, but in other cases it is those very social systems which are imposing vulnerability on certain sections of communities. Therefore, a meaningful list of indicators in such communities would need to include some means of measuring social transformation – and thus transformative capacity – in order to make the community, as a whole, more resilient (cf. PEARSON & PELLING 2012).

Whatever the complexities at the local level, it is certainly the case that we want our emBRACE indicators of community resilience to be linked specifically to the constituent components of community resilience. Thus our ‘Indicators within the Framework’ approach in emBRACE.

Although we want to relate our indicators to our framework, it is important to note that our community-level indicators are equally grounded in our cases studies. They are derived from our assessment of the specific local-level systems that we explored, rather than from an a priori understanding of our framework. This grounding of our indicators empirically and this generation of indicators of community resilience ‘from the bottom up’ allow us to meaningfully understand the relation of our local-level indicators to community-level resilience. The process of analysis thus becomes one of relating those separate and diverse – but locally meaningful – indicators to our single framework. While this grounding of indicators in our empirical work might be thought by some to suggest a lack of transferability and a concomitant lack of policy relevance, we are convinced that by linking these highly grounded indicators to community resilience components in this way will ensure usability of our approach. It is important to offer the caveat that – in part due to this grounding – our actual indicators are not comprehensive (because our case studies cannot be comprehensive). However, it can be said that our overall approach is comprehensive and can lead to meaningful local-level, locally-subjective, qualitative and quantitative indicators being quickly generated in new application areas.

Finally, the emBRACE approach should not be seen as replacing other more 'top-down' approaches, but rather as providing a framework – and a Framework – within which community resilience aspects can be related to locally-specific indicators and indicator sets. Because our indicators and our framework are linked systemically and in a structured manner, this should be taken to reinforce the message in the minds of readers that although we might like the generation of indicators and the relating of those indicators to higher level processes to be a linear process, it is not. The framework is a 'knot', with no beginning and no end. The same thought should be assumed right the way down to local-level indicators. But a structured understanding is still possible.

3.1.3 The process of grounding our indicator set

Producing the structured understanding as outlined above is undoubtedly a non-trivial matter. However, it is necessary as maybe the only vehicle through which we can explain how the rather generalised rhetoric of 'community resilience' can be more effectively measured at higher levels, while remaining meaningful at local level. The process needs to be capable of allowing the case study practitioners to generate indicators which meet their needs: for example to reflect local-level processes which help to create resilience – or those which increase vulnerability. At the local level, structures, institutions and practices, which contribute to increased vulnerability are often more apparent than those contributing to the more conceptual idea of community resilience. Thus, we allow for 'negative' indicators which we want to reduce as well as positive ones we want to increase. This does not increase complexity.

The theoretical basis for such grounding resides in the theory of change held by case study practitioners: in other words we have asked the case studies not just to send us a list of indicators but to tell us why they think measuring these indicators – or even meeting the targets set therein – will bring about community resilience.

In order to collect these indicators and the associated information related to the operationalisation of indicators, we created an indicator spreadsheet template that was distributed to the case study responsible. The template requested, in particular, information about the allocation of the indicator within the emBRACE framework, the indicator title, the type of measurement used, the relationship of the indicator to resilience, the methods of data collection, the scale of application, the context- and

hazard-specificity, the effort of indicator development and an evaluation of the overall importance of the indicator for determining resilience:

Table 8: indicator spreadsheet template (including one example indicator to provide further guidance how to fill out the excel sheet)

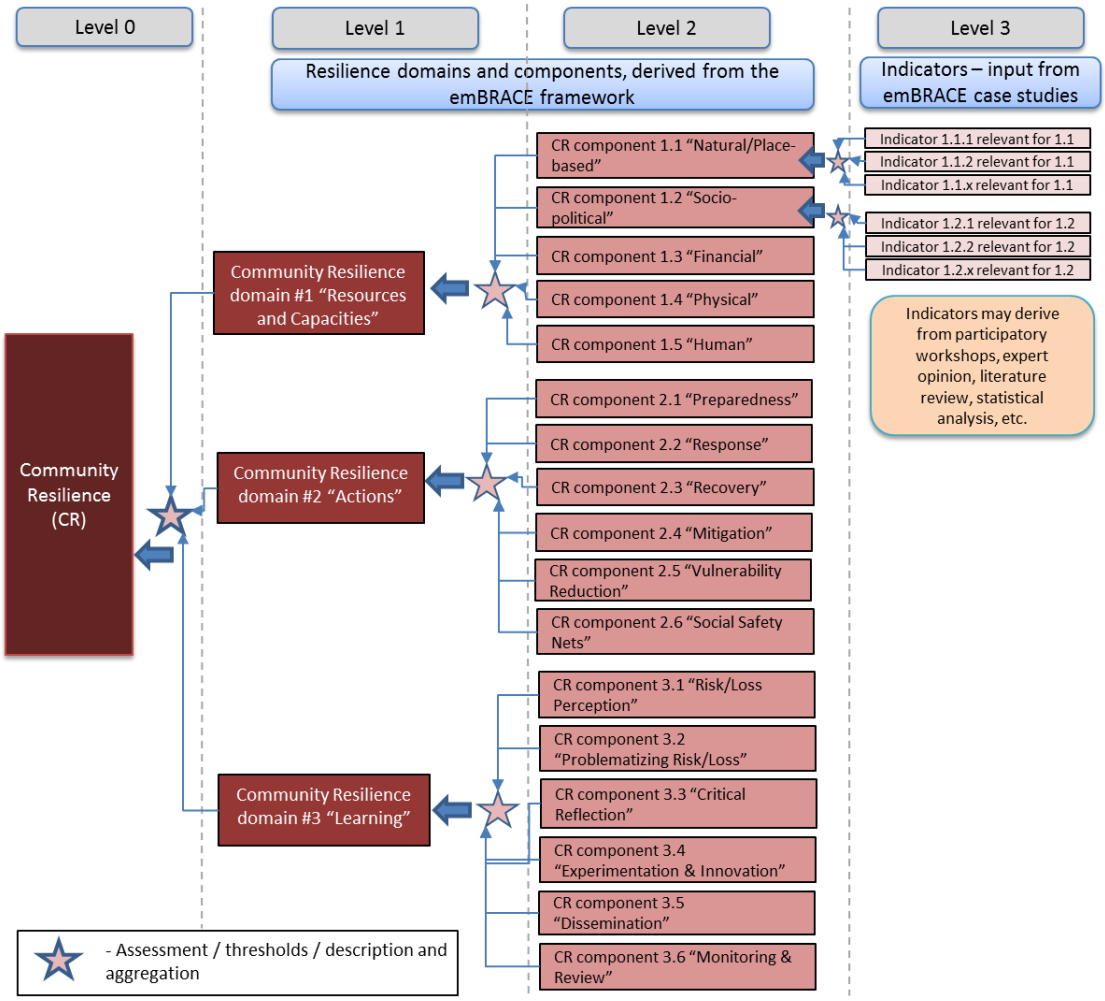
Level 0	***Level 1***	***Level 2***	***Level 3***			
emBRACE framework ***community resilience***	***emBRACE framework*** ***resources and capacities, actions, learning***	***emBRACE framework*** ***if resources and capacities then: physical, natural, human, financial, socio-political*** ***if actions then: preparedness, mitigation, response, recovery, reconstruction*** ***if learning then: experimentation and innovation, critical reflection, dissemination, risk/loss perception, problematization risk/loss***	***Indicator***		***Metric A - how will the indictor be quantified / parameterized?***	***Metric B - what is the value range of this indicator, what is the scale of measurement?***
This is fixed	*Select one of the three Level 1 aspects*	*Select one of the Level 2 aspect considering the selection you have made under Level 1*	*General topic (if applicable)*	*short description*	*Describe as detailed as possible, indicate if not defined yet or not possible*	*Give a description to allow for reproducibility. This will provide the info if nominal, ordinal or metric*
Community Resilience	Actions	Response	evacuation measures	provision of shelters for evacuated population	5 classes from 1 (no shelter) to 5 (sufficient shelter for all)	No. of places provided for evacuated population
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						
Community Resilience						

		Feedback information on indicators				…. Other ways of categorising indicators		General notes
Metric C - description of evaluation - how will the available data/information be interpreted (operationalization/indicator formula), what is the correlation relation with resilience	***Method - based on what approach has the indicator been selected***	***Positive or negative experience related to this indicator***				***IPCC / DFID Category of indicator (Adaptive Capacity, Exposure, Sensitivity)*** ***here: link to docs***	***Scale of application - the indicator might be feasible for certain scales but not for others (individual, household; organisation; community of circumstance, administrative unit…)***	***Any other comments on the indicator?***
Define the possible range of values and resulting resilience	*Specify if selection was based on literature research, expert/stakeholder opinion, participatory methods etc.*	*Effort for applying the indicator - for data/inforamtion acquisistion, processing etc. [low, medium, high + explanation]*	*Importance for determining / explaining resilience [low, medium, high + explanation (based on what opinion / experience?)]*	*Generalisation possible? (is this indicator hazard / context specific or broadly / universally applicable? - please explain*	*any other comment*	*please insert if possible*	*please insert if applicable*	
0 - very low resilience up to 5 very high resilience	inductive, based on expert interviews	medium (depending on data available, low if statistics available, high if experts need to be interviewed	high - as proxy for prevention measures - opinion of local civil protection	independent of context but only applicable for resilience to sudden hazards	difficulties may occur by specifiying the area, in that evacuation places are considered	Adaptive Capacity		

By requesting input from the case studies, we overcome the challenge that our theoretical framework is weak and, or, untestable. Further, by iteratively developing and refining our framework and generating our case-study-specific indicators within the framework provided by it, we have provided a route not only to develop and select indicators but also to (re)locate our strong theoretical framework within the cases studies.

The iterative process also allows us to move towards generating agreed sets of indicators for measuring resilience at different levels (cf. DEEMING et al. 2013: 39). The indicators are based upon multiple case studies at higher levels; but move towards utilising appropriate qualitative and/or quantitative (Q^2) methods at lower levels. Thus, while the individual indicators are scale-dependant, the whole understanding possible within the 'Indicator Set + Framework' approach transcends scale. The spreadsheet structure makes this evident. The local level indicators (indicators of community resilience) are grounded within the case studies; the higher level indicators (indicators of societal resilience) are grounded more within the emBRACE framework; and the spreadsheet provides the framework to unite the two:

Figure 2: our process of linking the case study indicators and the emBRACE framework

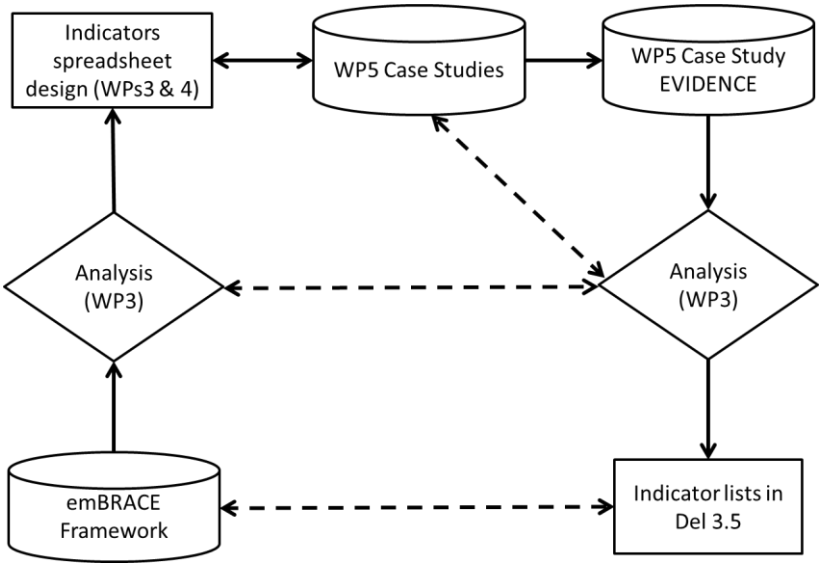


Furthermore, by linking across the scales, we can move away from simple indicators of community action (and/or measures of vulnerability) to actually understand how these elements of increasing social action and reducing citizen vulnerability can and do contribute to community resilience at a societal level. Relatively sophisticated justification can be made about causes, effects and outcomes on the ground: these are contextualised within local-level perceptions and beliefs about the structure and the behaviour of the system and thus that legitimacy can be transferred 'up' the system along the lines of linkage within the emBRACE spreadsheet. The fact that some of the local level indicators are reflecting actions and some are reflecting states [of being] or physical structures is not problematic. The framework allows for this multiplicity of understandings. Finally, it subsumes both a technical understanding

and an anthropological understanding and thus is amenable to use with both qualitative and quantitative indicators.

The process of generation of indicators can be reverse-engineered to test indicators. Any indicators at any level within the system can – and should – be tested against the evidence for plausibility but within our system, because of the clear and visual 'paper trail' provided by the spreadsheet, they can be tested back against the social phenomena (i.e. the people/community) which informed our evidence in the first place:

Figure 3: diagram of our evidence-driven development of indicators within emBRACE (after LUCAS 2011: Fig.1 and KEMP-BENEDICT et al. 2010: Fig.1)



In Figure 3, 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.

Thus, starting bottom left, 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 (i.e. coming down the right-hand-side of Fig. 3) we could and did test our ongoing analysis back against our original conceptions coming out of the Framework and also with the WP5/case study researchers. The indicator lists (in

this deliverable report) are then tested back conceptually at a high-level against the Framework.

However, one arrow missing in the above diagram would be to test the indicators back against the Case Study Evidence (i.e. with the constituencies that informed what the WP5 researchers told us). We have not had the resources to do this globally across the project: yet, because of the checks and balances within our system above we believe that this would be easily possible and would point to a general acceptance of the lists. Further, as indicated above, the same process could be used to test any given set of indicators against both our Framework and any particular empirical case.

The actual indicator – at any level within the overall structure – will always only be partial, but indicator sets, taken together, may be useful. Further, the overall and overarching structure of Indicator Set + Framework starts to give a clearer reflection of the fact that things are much more complicated (and also complex) than over simplified or over abstracted lists of indicators might lead a reader to believe (cf. WEICHELGARTNER & KELMAN 2014).

The practicalities of our emBRACE approach have meant that we may not be able to produce a simplified list of indicators, but we can produce a framework within which higher level indicators can be understood in local contexts and vice versa. Because each case study is clear – at their own level – about their theory of change and how their indicator sets relate to community resilience on the ground, and because they are also feeding their own indicators into the process of description for this deliverable, we also have the knock-on benefit of weeding out those indicators which only measure some other form of resilience other than community resilience, or at the very least we can provide and document an understanding of how such indicators of technical resilience relate to and contribute to community resilience. Thus we can also provide for both generic indicators (at higher levels) and also hazard-specific indicators (at more local levels).

In order to address the 'social' within community resilience, ADGER et al. note that "… the selection of robust indicators […] should be based on understanding of the multiple processes that shape vulnerability" [/resilience] (ADGER et al. 2004: 17). We believe that a multi-level framework such as we suggest is one way to address this.

Our practical approach has allowed our case studies to generate indicators for every component on the emBRACE framework. Of course there are clusters of indicators

which overlap, but there are also clear areas where one or other case study is manifestly better at measuring one element: here there is much knowledge and learning we can transfer one-from-another in order to generate more balanced lists of indicators, which will be more useful at higher-levels of abstraction but still meaningful at local community level. The highly visual and structured paper trail of emBRACE allows this.

We have not tried to impose a top-down 'relevance' measure but we have asked the case study responsible to frame their responses (through several iterations of their filled-in spreadsheets) within the overarching structure of the emBRACE project framework. This provides sufficient structure to compare across case studies but also leaves deliverable 3.5 researchers free enough not to be constrained in their choices for clustering. The initial choices for clustering are to a large degree subjective – but clearly based upon expert knowledge. Further, it is justified across the whole consortium so that expertise is distributed. The output is the process of clustering single and sets of case study indicators into what can meaningfully be described as indicators of community resilience.

Finally, a spinoff of the whole process is the identification of indicator overlap, which can suggest where fewer indicators are possible with a knock on reduction in data collection and of data management. However, by allowing for a more complex representation and framing of locally-generated indicators or resilience within the higher level conceptual emBRACE framework, we can start to understand how communities that aspire to be more resilient can mobilise the resources available to it in the most effective way possible. This needs to be in terms of resources and capacities, actions or learning as determined by the framework domains/loops, and in terms of local needs as determined by the empirical data and experience from the community itself.

3.2 Indicators identified by the emBRACE case studies

This chapter aims at analysing the indicators identified by the emBRACE case studies and assembled in the distributed spreadsheet. We propose a route that enables classifying/systematising the indicators and provides a structure for creating a condensed list of emBRACE indicators, as well as deriving emBRACE key-indicators of community resilience.

One of the main challenges of the indicator analysis was to synthesize the indicators identified by the different case studies, 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 perspectives of community resilience. Some of the indicators for example relate to the individual scale and were measured through interviews or questionnaires (e.g. 'Belief in…'), whilst others apply at the community scale and have to be measured with quantitative survey or existing statistics (e.g. '% of…'). Therefore, in the first step, it is useful to distinguish the indicators according to some criteria in order to separate indicators that can be measured with the help of qualitative research methods from indicators that can be better measured with quantitative methods; and also separating out indicators that can be applied across contexts from indicators that have to be used with local-context or hazard specificity.

This classification of indicators serves in a second step to create a more manageable (condensed) list of indicators. In a last step, we derived key-indicators by applying certain criteria to the condensed list indicators. This list of 'emBRACE key-indicators' adds value to current research activities on community resilience indicators and may serve as a hands-on toolbox for researchers and policy advisors to select the most suitable indicators for their resilience assessment. More precisely, the analysis of the indicators identified by the case studies includes:

- locating indicators within the emBRACE conceptual framework;
- distinguishing indicators according to the scale of application;
- highlighting indicators that are generally applicable, i.e. neither context- nor hazard-specific;
- presenting indicators that have a clear relation to community resilience;
- emphasising indicators that were evaluated as very important by the case studies for assessing community resilience.

3.2.1 Classification of indicators

In total, we received **177 proposed indicators** of the five emBRACE case studies:

Table 9: collection of indicators by the emBRACE case studies

emBRACE case study	Count of indicators
Central European Floods (UFZ)	45
Earthquakes in Turkey (METU)	47
Alpine Hazards in South Tyrol (EURAC) and Grison (WSL)	25 (EURAC: 21, WSL: 4)
Heat Waves in London (KCL & University of Reading)	14 (KCL: 13, University of Reading: 1)
Floods in Northern England (UoN)	46
Total	**177**

Several indicators were mentioned by more than one case study. Thus, after merging all indicator spreadsheets and removing repetition, **we reduced the number to 128 indicators,** which formed our 'indicator database' for analysing the emBRACE indicators (see table 15 in the annex for the entire list of 128 indicators).

One of the main objectives of the indicator request was to determine the **indicators' location within the conceptual framework of emBRACE** in order to position the indicator within the concept of community resilience and to draw inferences about the usability, operationality – and operationalisability – of the framework itself. The indicators were allocated by the case studies through a (subjective) evaluation and interpretation of the framework, based on expert knowledge and according to the specific contexts of the case study[13]. However, the allocation of indicators is not so straightforward. Most case studies allocated their indicators to more than one category of the framework, thus the total number exceeds the actual amount of 128 indicators. Concerning the 'domains/loops' of the framework (cf. figure 1), the indicators were located in the following way:

Table 10: allocation of indicators to the emBRACE framework domains

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

[13] In this context, it has to be noted again, that the emBRACE framework has gone through several iterations since the case study work served as a validation of the theoretical framework and led to constant refinements.

The majority of indicators have been allocated to the resources and capacities domain of the framework, with fewer to the actions and learning domains. The focus on resources and capacities is congruent with the findings from the literature review, revealing that most existing indicator-based approaches assess community resilience through a set of capacities (cf. chapter 2.5). Thus, it seems that resources and capacities are easier to grasp by means of indicators than aspects related to the actions and learning loops. Going one level further down in the framework to the 'components' (cf. figure 1), we can see the following classification scheme of indicators (also here, most indicators have been allocated to more than one component):

Table 11: allocation of indicators to the emBRACE framework components

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

Indicators have been allocated mostly to the socio-political and human components of the resources and capacities domain. This focus is certainly to some extent due to the context of the emBRACE case studies, which examined mainly civil society and risk governance issues of community resilience (Floods in Northern England, Central European Floods, Heat waves in London), psychological perspectives of individual resilience (Earthquakes in Turkey) or perceptions and social networks in risk governance (Alpine hazards in South Tyrol). Concerning the actions domain, most indicators cover the mitigation and (with minor importance) the preparedness component. The response and recovery components are less often addressed. This would confirm observations made by BIRKMANN et al. 2012b: that most approaches measuring resilience focus on preparedness and the pre-hazard event phase (BIRKMANN et al. 2012b: 53)[14]. Concerning the learning loop, the component problematizing risk/loss appears most prominent.

Another important classifier of the emBRACE indicators is the **scale of application,** since it reveals not only the appropriate scale of the resilience assessment, but affects also the methods of data collection used: while for assessment at larger scales (in this sense: spatial scales), e.g. the individual or household scale, qualitative methods of indicator data collection play an important role, assessments at smaller scales, e.g. the regional scale, often make use of quantitative methods in order to allow for spatial differentiation and representation. The following figure shows the scale of application of the identified emBRACE indicators (also here, most indicators were associated to more than one scale):

[14] The vulnerability reduction and social safety nets components were mostly neglected by the case studies, which is probably due to the fact that these components appeared in the framework (with the last refinement of the framework) after the main work on the spreadsheets was already completed.

Figure 4: classification of indicators according to the scale of application

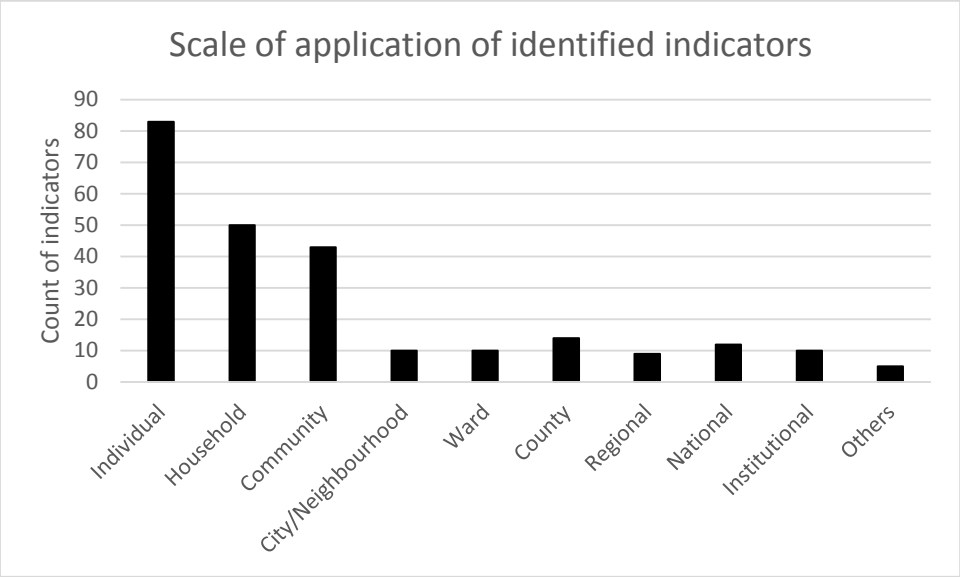


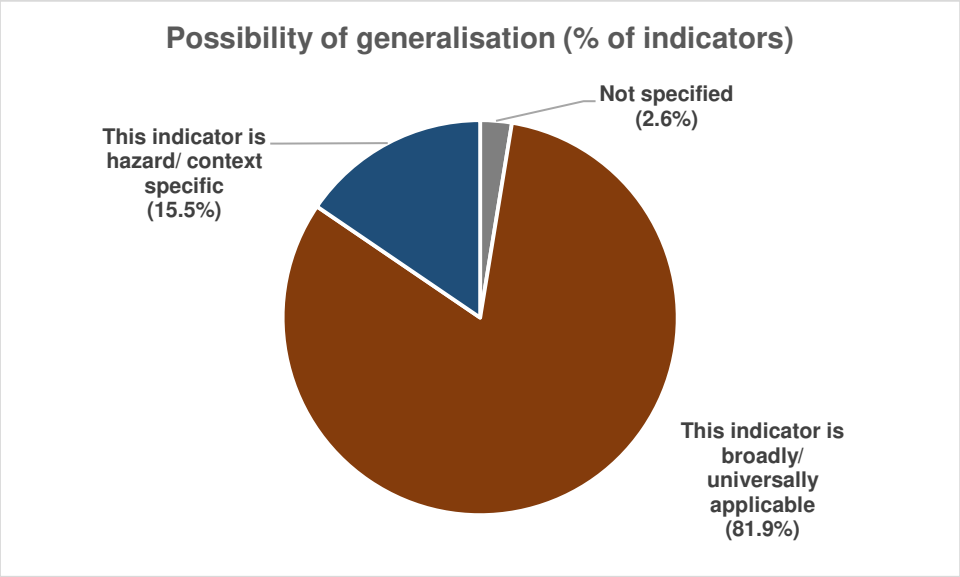
Figure 4 reveals that most indicators are designed for the individual scale, followed by the household scale and the community scale. The term 'scale' was mainly interpreted in the spatial term, having just few examples of other types of scales such as the institutional scale or the scales 'community of circumstances' and 'community of interest' (both arbitrarily categorised under the category 'Others').

The indicator spreadsheet revealed that indicators applied at the individual scale (and less the household scale) generally assess personal traits, experiences and knowledge; whereas indicators applied at the community level address mainly governmental and institutional aspects of community resilience. Most of the indicators are scale-dependent and can hardly be transferred to other scales. However, the transferability of scales is an important issue, since many processes that shape resilience vary between scales (WEICHSELGARTNER & KELMAN 2014: 10). A means to transcend scales are survey-related research methods such as questionnaires and associated sampling methodologies that enable measuring for example individual characteristics also at the community level (up-scaling). This stresses the importance of indicators, which are initially designed at the individual scale, for assessing community resilience (cf. KARANCI et al. 2015). In contrast, down-scaling (e.g. from the regional scale to the community scale) is generally not feasible without resulting in an incorrect picture. In this sense, the use of specific scales for resilience assessments is very much dependent on the methods of data collection used.

Within emBRACE, most case-study teams applied subjective qualitative research methods such as interviews (METU, UoN, EURAC, KCL, UFZ, WSL); focus group discussions (METU, UoN); methods such as questionnaires (METU, UFZ, EURAC) or social network mapping (EURAC, UoN) or some combination of the above (EURAC, UoN both with SEI). Two case studies focused on objective approaches such as modelling (University of Reading) and statistical correlation analysis (WSL) (for a detailed description of applied methods of data collection within emBRACE see table 14 in the annex). This selection of research methods explains to some degree the prominence of the individual scale within emBRACE. The case study about earthquakes in Turkey for example focused on psychological perspectives of community resilience, hence referring mostly to the individual scale when developing indicators (see KARANCI et al. 2015 for further details) while some case studies – such as the alpine hazards in South Tyrol – however, collected data mainly at the individual scale without referring to individual resilience. In contrast, none of the case studies attempted to assess resilience by means of aggregating single indicators or applying composite indicators to regional scales.

In order to derive important emBRACE indicators, we analysed another indicator characteristic that relates to the **possibility of generalisation**, that is, whether the indicator can be considered as universally applicable or as context- or hazard-specific. The distinction in generic and context-/hazard-specific indicators is important, since approaches aiming to compare resilience require indicators that can be applied across contexts, while measuring resilience to hazards that will express themselves locally needs adjustment of indicators to the specific local context (DEEMING et al. 2013: 9). Thus, the objective of this classification is to distinguish the generic indicators that can be applied across various types of natural hazards, types of communities, cultural differences, institutional and governmental disparities, etc. from local-specific indicators:

Figure 5: classification of indicators according to the possibility of generalisation



The figure shows that – according to the evaluation of the case studies – the majority of identified indicators (81.9%, n=105) are broadly or universally applicable. Only 15.5% (n=20) of the indicators are context- or hazard-specific, which is a good result in terms of the transferability of indicators to other assessments of community resilience. However, it has to be noted that for the purpose of simple analysis, we transferred the case study evaluations into a fixed pattern (universally applicable vs. context/hazard-specific), that in reality is often more complex. Some case studies emphasised the complexity of such a classification (e.g. UFZ). This is also reflected by the fact, that case studies evaluated one similar indicator differently in terms of its possibility of generalisation (e.g. indicator no. 13 'previous hazard experience' in table 15 in the annex).

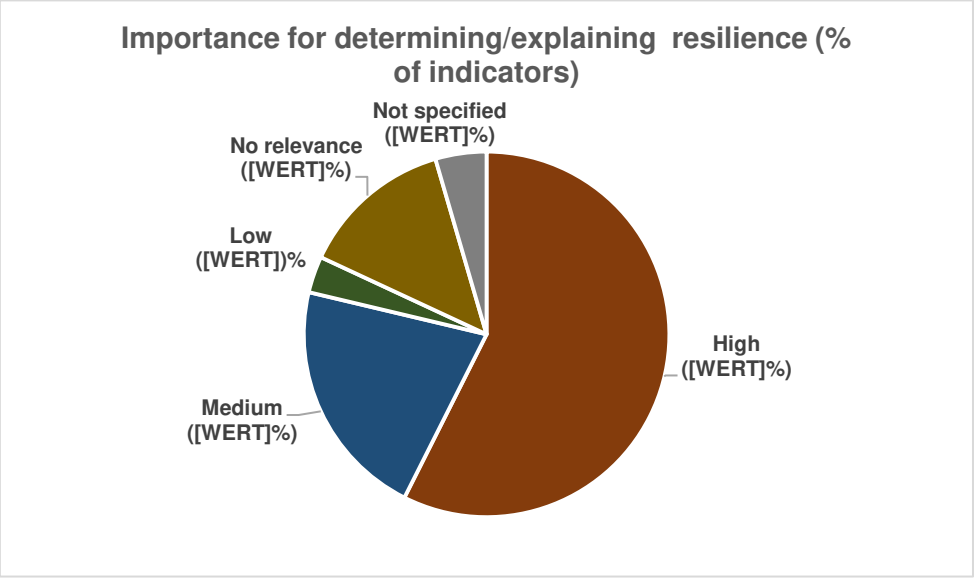
The classification of indicators according to their **relation to resilience** is a particularly interesting criterion, since the relation is a prerequisite for measuring resilience in quantitative terms. In fact, having indicators with no relation to resilience, that is, whether one indicator value indicates higher or lower resilience in comparison to another one, makes them useless for creating resilience indices. However, since we are not focusing on aggregating single indicators to indices within emBRACE, indicators without a clear relation are not excluded per se from our assessment. Also, for certain indicators a general relation seems difficult to define, since they apply on specific scales. The evaluation is especially difficult, when indicators are not validated against external metrics (e.g. through correlation analysis), as it was the

case in most of the emBRACE case studies (except of UFZ and WSL). Thus, the classification of indicators in terms of their relation (and direction) to resilience, remains to a great extent subjective.

According to the case studies' evaluation, 83% of the indicators have a clear relation to resilience, whereas 17% do not. However, here we also have to note that for the purpose of analysis, we applied this rigid classification scheme (nevertheless most of the case studies were very sure about their evaluation). Only few indicators were evaluated ambiguously by the case studies. One example is indicator no. 83 'Number of buildings with protection measures as % of all hazard exposed buildings' (see table 15 in the annex): Whereas UoN came to the conclusion that a higher number of buildings with protection measures indicates higher resilience, UFZ argued that those who implement protection measures have a lower resilience, since they usually suffer from more severe and repeated consequences with higher damages. This example reveals that the relation of the indicator to resilience is highly context specific and therefore difficult to define at a higher level. It has to be evaluated according to the specific context and scale of the resilience assessment. In contrast, we can consider indicators with a clear relation to resilience at all possible levels as particularly important for measuring community resilience (cf. RODRIGUEZ-LLANES et al. 2015).

The last classifier that was applied to the emBRACE indicators is an evaluation of the indicator's general importance for assessing community resilience. This classification is not based on empirical results, but on a subjective evaluation of the case study researchers taking into account also the above mentioned characteristics of indicators:

Figure 6: classification of indicators according to the importance for determining resilience



The request revealed that most of the identified indicators (57.4%, n=73) were evaluated with high importance and only 21.3% (n=27) and 16.7% (n=21) with medium, respectively low importance/no relevance. This classification is especially important for the next step of our indicators analysis within emBRACE.

3.2.2 Condensed list of indicators

Based on the systematisation of indicators, we created a condensed list of emBRACE's indicators in order to provide a more manageable list and to highlight the most important indicators. We reduced the list of 128 indicators (cf. table 15 in the annex) by

- further clustering similar indicators and
- excluding indicators rated with 'medium importance', 'low importance' and 'no relevance' by the case studies.

Thus, this condensed list of indicators includes only those indicators rated with 'high importance' for determining/explaining resilience (=68 indicators). The following table shows the selected indicators classified according to above mentioned criteria of systematisation (allocation to the emBRACE framework, scale of application, possibility of generalisation, relation to resilience). As an additional characteristic (not requested from the case studies), we distinguished the indicators

according to the level of measurement indicating whether the indicator is rather qualitative/subjective or quantitative/objective (important for this classification is not the indicator itself, but the way of parameterisation, see the third column of table 12). Furthermore, it has to be noted that the allocation of indicators according to the emBRACE framework categories is based on our subjective evaluation. We did not use the classification provided by the case studies in the spreadsheets, since multiple entries did not allow a coherent classification. Also, we agreed to use one single type of interpretation of the emBRACE framework for classifying the indicators, since, indeed, most indicators could be allocated to more than one category:

Table 12: condensed list of emBRACE indicators (=68 indicators)

emBRACE framework level (own evaluation)		Indicator title	How will the indicator be parameterised? (according to case studies)	Scale of application (according to case studies)	Generalisation possible? (according to case studies)	Relation to resilience (according to case studies)	Level of measurement (own evaluation)	Mentioned by case study
Resources and Capacities	Natural/Place-based	Storage heat flux	Surface Urban Energy and Water Balance Scheme	Neighbourhood/ City	No	Yes	Quantitative/ Objective	University of Reading
	Socio-political	Existence of a committee-led hazard action group	Existence, yes/no	Community	Yes	Yes, increases resilience	Quantitative/ Objective	UoN
		Presence of a (active) third sector emergency coordination body	Presence, yes/no	Community/ County	Yes	Yes, increases resilience	Quantitative/ Objective	METU, UoN
		Existence of a legal foundation and specific legislation for disaster risk management	A scale for whether or not there is legal foundation and specific legislation	National/ Institutional	Yes	Yes, increases resilience	Qualitative/ Subjective	METU
		Existence of state policy for disaster risk management	Yes/no question	National	Yes	Yes, increases resilience	Quantitative/ Objective	METU
		Community cohesion	-	Community/ Ward	Yes	Yes, higher values indicate higher resilience	Qualitative/ Subjective	UoN
		Social/Mutual trust	A scale measuring whether or not community members trust each other	Individual/ Community/ Ward	Yes	Yes, higher level of trust indicates higher resilience	Qualitative/ Subjective	UoN, METU
		Peace and equality in the country/region	A scale for whether or not there is peace and equality in the country/region	Regional/ National	Yes	Yes, increases resilience	Qualitative/ Subjective	METU
	Financial	Presence of a formal process through which	Yes/no question	County	Yes	Yes, increases	Quantitative/ Objective	UoN

		locally-affected communities can draw on government support				resilience		
		Availability of adequate economic resources for disaster-related activities	A scale for whether or not the community has adequate economic resources for preparedness, mitigation, training, etc.	All scales	No	Yes, increases resilience	Qualitative/ Subjective	METU
	Physical	Type of physical/infrastructural connection of community	Multiple access routes, ports, etc. Counting of primary-route access into area	Community/ Regional/ City	Yes	Yes, multiple access routes increase resilience	Qualitative/ Subjective	UoN, METU
		Number of buildings with protection measures as % of all hazard exposed buildings	Yes/no question, open question	Community/ Household/ Individual	No	No, different findings between case studies	Quantitative/ Objective	UFZ, UoN
		Property of house	Multiple choice question: privately-own house/ house from family member/ rental property/ other, etc.	Individual/ Household	Yes	Yes, property owner have lower resilience	Qualitative/ Subjective	UFZ
		Dwelling type	Bed room ventilation, orientation, floor number - nominal	Individual and by aggregation community of interest/network	Yes	Yes, access to and ability to modify dwelling form increases resilience	Qualitative/ Subjective	KCL
		Bedroom Layout	Ability to control temperature in dwelling by opening windows, thermostat control, positioning bed, blinds, trees	Individual and by aggregation community of interest/network	Yes	Yes, increases resilience	Qualitative/ Subjective	KCL
	Human	Trust in authorities	-	Community/ Ward	Yes	No, different findings between case studies	Qualitative/ Subjective	EURAC, UoN
		Sense of belonging in	A scale measuring having a	Individual/	Yes	Yes, higher	Qualitative/	UoN, METU

			community	sense of community belonging	Household/ Community/ Ward		level of belonging indicate higher resilience	Subjective	
			Physical and psychological health situation of individual	A scale for whether or not an individual is physically and psychologically healthy	Individual	Yes	Yes, healthy situation indicates higher resilience	Qualitative/ Subjective	METU
			Gender	Female/ Male	Individual	Yes	No, different findings between case studies	Qualitative/ Subjective	METU, KCL, UFZ
			Age	Birth year	Individual	Yes	No, different findings between case studies	Quantitative/ Objective	KCL, UFZ
			Level of education	Level of school education	Individual/ Household	Yes	No, different findings between case studies	Qualitative/ Subjective	METU, UFZ
			Income	Monthly or annual household income	Individual/ Household	Yes	No, different findings between case studies	Quantitative/ Objective	METU, UFZ
Actions	Civil Protection	Preparedness	Existence of local tested community emergency plan	Yes/no question	Community	Yes	Yes, increases resilience	Quantitative/ Objective	UoN, EURAC
			Existence of integrated and validated emergency business continuity management plans by sector in hazard zone	Yes/no question	County	Yes	Yes, increases resilience	Quantitative/ Objective	UoN
			Access to information and ability to synthesise and prioritise	-	Individual/ Ward	Not easy	Yes, access to appropriate information and the	Qualitative/ Subjective	KCL

							capacity to learn from this increases resilience		
			Knowledge about hazard risk communication	Yes/no question	Individual/ Household	Yes	Yes, increases resilience	Quantitative/ Objective	UFZ
			Awareness about hazard risks and vulnerabilities in the area	A scale for whether or not an individual knows about hazard risks and their vulnerabilities	All scales	No	Yes, increases resilience	Qualitative/ Subjective	METU
			Existence of a community early-warning system	-	Community/ Individual	Yes	No, different findings between case studies	Quantitative/ Objective	UoN, KCL
			% of households in the community subscribed to an early-warning system	Yes/no question,%	Individual/ Household/ Ward	Yes	Yes, higher values indicate higher resilience	Quantitative/ Objective	UoN, WSL
			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	No	Yes, high level of preparedness indicates higher resilience	Qualitative/ Subjective	UFZ, METU
		Response	Time needed to activate the local response network	-	Community of circumstances	Yes	Yes, the lower the value the higher the resilience	Quantitative/ Objective	EURAC
			Provision of temporary and/or permanent housing after a hazard event	A scale for whether or not permanent housing is provided in a timely and adequate manner	Institutional	No	Yes, increases resilience	Qualitative/ Subjective	METU
			Having an effective system for the provision of post-disaster aid and services	A scale assessing adequacy and timing of aid and services	Institutional	Yes	Yes, increases resilience	Qualitative/ Subjective	METU

			Efficiency of disaster management system	A scale for whether or not there is good planning and organization of disaster management	Institutional/ Regional/ National	Yes	Yes, high efficiency indicates higher resilience	Qualitative/ Subjective	METU
			% of buildings inspected and built according to the recent earthquake code	Proportion of buildings inspected and built according to the recent earthquake code	Neighbourhood/ City	No	Yes, higher values indicate higher resilience	Quantitative/ Objective	METU
			Modularity of the community response network	Number of nodes representing organisations in a social network map. Balance between centrality and dispersiveness	Community	No	No	Quantitative/ Objective	EURAC
		Recovery	Presence of a 3rd sector community disaster-loss compensating funding mechanism	Yes/no question	County	Yes	Yes, increases resilience	Quantitative/ Objective	UoN
			% of persons with mandatory hazard insurance	Yes/no question, %	Individual/ Household	No	Yes, higher values indicate higher resilience	Quantitative/ Objective	UFZ, METU
			% of hazard-exposed properties that are insurable at 'affordable' cost	Yes/no question, %	Household	Yes	Yes, higher values indicate higher resilience	Quantitative/ Objective	UoN
		Mitigation	Risk assessment developed in a participatory process	Yes/no question	County	Yes	Yes, increases resilience	Quantitative/ Objective	UoN
			Integration of community representatives in Integrated Emergency Management (IEM) planning groups	-	County	Yes	Yes, increases resilience	Qualitative/ Subjective	UoN
			Existence of a community-developed risk register	Yes/no question	County	Yes	Yes, increases	Quantitative/ Objective	UoN

							resilience		
			Legislations/Regulations for risk management are implemented properly	A scale for whether or not the legislations/regulations for disaster risk mitigation are implemented properly	National/ Institutional	Yes	Yes, increases resilience	Qualitative/ Subjective	METU
			Presence of cross-sector Flood Risk Management planning process/forum at catchment scale	Yes/no question	River catchment	No	Yes, increases resilience	Quantitative/ Objective	UoN
			Community engages in renewal and transformation processes	A scale measuring level of urban renewal and transformation activities that the government engages in	National/ Institutional	Yes	Yes, increases resilience	Qualitative/ Subjective	METU
			Collaboration and information exchange among involved actors in risk management	Frequency of coordination actions and information exchange among involved actors	National/ Community/ Institutional	Yes	Yes, increases resilience	Quantitative/ Objective	EURAC, METU
			Knowledge of institutions and organisations people should go to in case of an event	Coherence between emergency plan and community risk behaviour	Community	Yes	Yes, increases resilience	Qualitative/ Subjective	EURAC
			Presence of cross-departmental municipality staff training programmes related to emergency management	Yes/no question, number per year	Community/ County	Yes	Yes, increases resilience	Quantitative/ Objective	EURAC, UoN
	Social Protection	Vulnerability Reduction	-	-	-	-	-	-	-
		Social safety nets	Integration in social networks	-	Individual/ Community/ Ward	Yes	Yes, increases resilience	Qualitative/ Subjective	UoN, METU, EURAC
			Access to carer	A range of issues including the legal responsibility of the carer, degree of oversight and formality, knowledge of the carer, freedom to act of the carer,	Individual and by aggregation community of interest/network	No	Not easy	Qualitative/ Subjective	KCL

				power of the vulnerable subject or others to influence and monitor carer actions					
			Social support	Receive of psychological/ physical/ financial support from others during and after the hazard event	Individual/ Household	Yes	Yes, higher support indicates higher resilience	Qualitative/ Subjective	UFZ, METU, KCL
Learning	Risk/Loss perception		Risk/loss perception	Statement correlated against vulnerability based on age and health conditions etc.	Individual and by aggregation community of interest/network	Not easy	Yes, high perception increases resilience	Qualitative/ Subjective	KCL
			Previous hazard experience	Knowledge about hazard events in the past	All scales	Yes	No, different findings between case studies	Qualitative/ Subjective	EURAC, UFZ, METU, UoN
			Severity of impact experienced in the past	A scale for how severe the individuals were affected by the disaster	Individual/ Household	No	Yes, high severity indicates higher resilience	Qualitative/ Subjective	METU
	Problematizing risk/loss		Calibration of risk to organisational mandate	-	Individual	Not easy	Yes, increases resilience when risk managers fulfil their mandates	Qualitative/ Subjective	KCL
			Financial damage from previous hazards	Yes/no question, amount in €	Individual/ Household	Yes	Yes, higher values indicate higher resilience	Quantitative/ Objective	UFZ
			% of total damage covered by external financial support for previous hazards	-	Individual/ Household	Yes	No	Quantitative/ Objective	UFZ
			Satisfaction with life	A scale for measuring life	Individual	Yes	Yes, higher	Qualitative/	METU

			satisfaction			satisfaction indicates higher resilience	Subjective	
		Adaptive coping strategies	A scale assessing adaptive coping strategies (e.g. high level of problem-focused coping & low level of helplessness coping)	Individual	Yes	Yes, high level of adaptive coping indicates higher resilience	Qualitative/ Subjective	METU
		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	Yes	Yes, high level of self-efficacy indicates higher resilience	Qualitative/ Subjective	METU, UFZ
		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	Yes	Yes, high level of satisfaction increases resilience	Qualitative/ Subjective	UFZ, METU
	Critical reflection	Individuals have considered resettling as a result of previous hazards	Yes/no question	Individual/ Household	Yes	No	Quantitative/ Objective	UFZ
		Spaces within the organisational structure for critical reflection - formal and informal	Opportunities within community organisations for critical reflection of their work	Individual	Not easy	No	Qualitative/ Subjective	KCL
		Gaps and missing links in the risk management network	Number of identified missing links (social network maps)	Community	Yes	Yes, the lower the value the higher the resilience	Quantitative/ Objective	EURAC
	Experimentation & Innovation	Community has made organisational reform to increase effectiveness of disaster management	Yes/no question	National/ Regional/ City	Yes	Yes, increases resilience	Quantitative/ Objective	METU
		Organisational capacity to	-	Individual	Not easy	Yes, ability to	Qualitative/	KCL

		experiment and innovate				challenge existing practices and processes and to suggest alternatives increases resilience	Subjective	
	Dissemination	Information is disseminated effectively across all stakeholders	A scale for whether or not information is disseminated effectively across all stakeholders	Institutional/Community	Yes	Yes, increases resilience	Qualitative/ Subjective	METU
	Monitoring & Review	Past learning experience and implementation	-	Individual and by aggregation community of interest/network	Not easy	Yes, ability to access and process information increases resilience	Qualitative/ Subjective	KCL

The condensed list of emBRACE indicators provides a reference against which indicators identified in literature (cf. chapter 2.4) can be matched. Comparing both, we can conclude that the majority of indicators cover broadly the same content-related aspects (in this sense not indicators) of community resilience such as:

- hazard exposure (e.g. exposed infrastructure and populations, previous hazard experience);
- risk information and communication (e.g. access to information, knowledge and perceptions of risks);
- risk assessment (e.g. disaster preparedness plans, disaster research);
- risk management, pre-disaster phase (e.g. training programmes, early warning systems, community member participation)
- risk management, post-disaster phase (e.g. social support, provision of housing, coordination of emergency activities);
- governance/institutional aspects (e.g. collaboration between actors involved disaster management, presence of civil society organisations in disaster management);
- funding/insurance (e.g. receive of financial support after hazard event, people having hazard insurance, disaster reduction funds);
- infrastructural (e.g. physical/infrastructural connectivity of community, structural protection measures);
- social capital (e.g. community cohesion, place attachment, local knowledge, mutual support).

However, we can distinguish also certain aspects that are mentioned in current literature on community resilience indicators, but which are not covered (or only to a limited extend) by our emBRACE indicators. These include for example:

- economic diversity;
- employment, income or educational equity;
- provision of basic community needs, such as food supply, health care, education, transportation networks;
- environmental assets of communities and land use planning.

In contrast, the condensed list reveals certain unique indicators of community resilience within emBRACE that are not found in current literature so far. 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 with the usually applied methods. An example is the use of the social network mapping methodology (see 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 on community resilience indicators.

The emBRACE indicators combine not only different perspectives of community resilience (or: communities and resilience), but also qualitative and quantitative indicator approaches. Through the provision of supplementary information related to the level of measurement, scale of application and possibilities of generalisation, the list offers a valuable toolbox for applying community resilience indicators at different

scales and contexts. Further, it allows us (in the next chapter) to derive our emBRACE key-indicators.

However, it has to be clarified again that we are not attempting to provide a comprehensive and agreed set of indicators. Rather, we have to acknowledge that indicators will almost inevitably differ across case studies (DEEMING et al. 2013: 9). This is not regarded as a problem, since we can provide a structure within which key-indicators can be extracted, 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.

3.2.3 List of emBRACE key-indicators

In order to derive the key-indicators of community resilience, we used the above-mentioned criteria to select suitable indicators. In detail, we defined the 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;
- were mentioned by more than one case study.

Grounded within the conceptual framework of emBRACE and the empirical research of the case studies, we consider these key-indicators to be especially significant at a higher policy level while retaining their social acceptance at the community level. We call them 'higher-level indicators of societal resilience', since they represent generic indicators that can be applied independently of specific contexts and types of hazards. While being measured at different scales, they all relate to community resilience through the linkages within the emBRACE framework:

Table 13: key-indicators of community resilience within the emBRACE project (=14 indicators)

Indicator title (according to case studies)	How will the indicator be parameterised? (according to case studies)	Scale of application (according to case studies)	Level of measurement (own evaluation)	Pre-/Post-hazard event phase (own evaluation)
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

We identified fourteen emBRACE key-indicators through applying the above mentioned selection criteria. This selection process is one way of deriving key-indicators and remains subjective. The list may be altered by using different criteria or filter methods. Some important indicators might not be considered in this list due to the applied criteria (especially the criteria 'mentioned by more than one case study' reduces the list significantly), but this way of filtering allows us to create a list of indicators that is concise and substantive. Also, we believe that the most significant indicators for measuring community resilience within emBRACE are included in the list.

Besides the already discussed indicator criteria 'scale of application' and 'level of measurement', we applied another criterion, that is the distinction of indicators measurable before (ex-ante) or after (ex-post) a hazard event. This aspect emerged as an important topic that deserves attention when developing indicators, since it provides a useful source of information for proper selection and application of resilience indicators (cf. RODRIGUEZ-LLANES et al. 2013: 23; WEICHSELGARTNER & KELMAN 2014: 6). While indicators related to the ex-ante phase mainly address the reduction of risks and vulnerabilities of communities, indicators related to the ex-post phase mainly address capacities to cope after a hazard event. Thus, they may be used separately to monitor the progress of resilience within communities before and after a hazard event, which might be of specific importance for work in practice.

The selected key-indicators refer – according to our own evaluation in table 11 – to all of the three domains of the emBRACE framework, focusing mainly on the actions domain (eight indicators). The resources and capacities domain (four indicators) and the learning domain (two indicators) are less often addressed. The parameterisation of each indicator refers to the emBRACE case study evaluation and when transferring the indicators to other resilience assessments can/should be specified and modified. In terms of the scale application, most indicators (nine) refer to the individual scale, however these can be applied also to other scales (mostly the household or community scale). Five indicators apply explicitly to broader scales than the individual or household scale. Concerning the type of measurement, the selected indicators are equally distributed, with a slight majority of eight qualitative/subjective indicators, compared to six quantitative/objective indicators. Considering finally the ex-ante/ex-post classification of indicators, we see that eight indicators apply explicitly to the pre-hazard event phase, while only two indicators apply to the post-hazard event phase (four indicators apply to both).

In our understanding, this list of key-indicators represents the basis for assessing community resilience by means of indicators. We propose to include these indicators into assessments of community resilience that pursue the emBRACE approach. However, this collection of key-indicators does not present a fixed or comprehensive set of indicators that can be used exclusively, nor are the indicators capable of measuring community resilience in all its contributing aspects. Rather, they have to be understood as solid core-indicators that form the heart of an indicator-based community resilience assessment. They still would need supplementary indicators referring to the specific study characteristics.

This list of key-indicators supports our choice of an integrative approach within emBRACE, since different scales of application, as well as level of measurements of indicators are considered to be important. Thus, different types of indicators have to be included when assessing community resilience by means of indicators. This blending of indicators does not allow for aggregation in quantitative terms (creating an interval scale resilience index), but nevertheless enables further structuring in order to enhance the possibilities for concrete prioritisation and targeting. One promising approach to do so is the self-assessment tool by UNISDR applied in the Disaster Resilience Scorecard of Cities (see chapter 2.4.1), that makes use of mixed methods of data collection (expert interviews, surveys, GIS analysis, models, etc.) and is undertaken in a multi-stakeholder process. It could be also helpful to apply rating scales or structured subjective methods as presented in chapter 2.1 to support the indicator approach. However, as stated earlier in the deliverable, the chosen approach must be adapted according to the concrete objectives, research questions and adopted methodologies of the resilience assessment. The potentials and limitations of each approach have to be balanced, in order to allow for reliable and sound assessment results.

4. Challenges of indicator use in practice

These guidelines are addressed to practitioners/users who need to carry out an indicator-based resilience assessment with the concrete purpose to support decision making. Its objective is to provide the readers with a series of proposed activities to be considered when developing, selecting and/or applying indicators. This chapter is on one hand based on the outcomes of the emBRACE project, namely the literature review and the case study work and hence strongly linked to the first chapters of this report. On the other hand it is also informed by previous work carried out by the authors within the context of indicator-based approaches to assess vulnerabilities, risks and resilience (see for example: FRITZSCHE et al. 2014, SCHNEIDERBAUER et al. 2014, ZEBISCH et al. 2014, SCHNEIDERBAUER et al. 2011).

There are a couple of underlying basic principles and assumptions that back this chapter, namely:

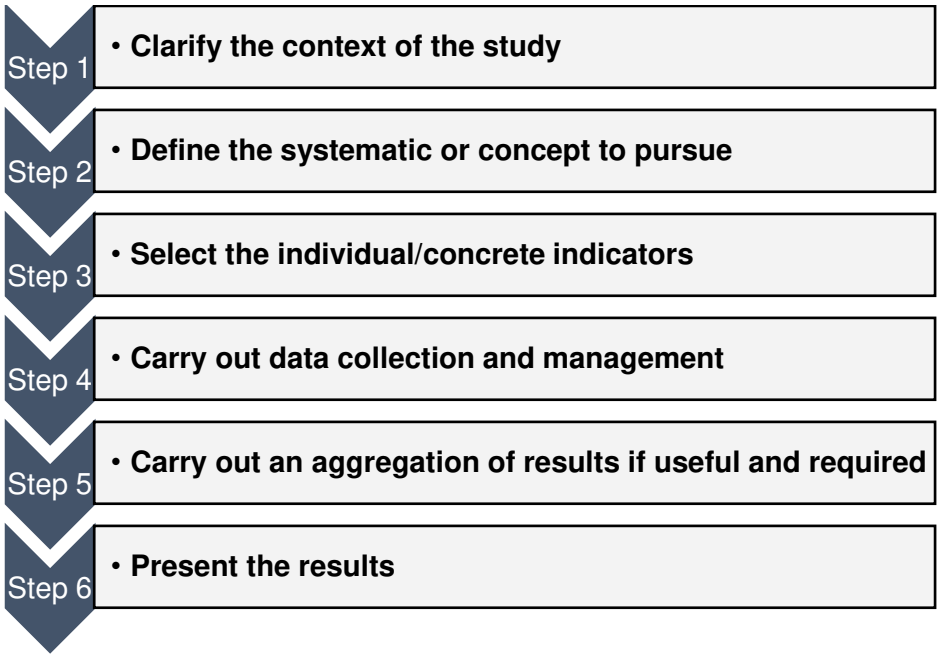
- We cannot and do not want to provide a fixed set of indicators to be used in a generic manner. For each assessment one needs to identify its own best-suited set of indicators depending on the purpose and the context of the study.
- There are a number of issues that need to be considered when going through the process of indicator selection and certain pitfalls/typical challenges that one should be aware of. These rather methodological aspects are of general type and can be useful for all type of indicator-based assessments.

4.1 Indicator development and application

Chapter 1-3 of this report clearly demonstrates that the selection of best suited indicators is far from being a trivial task. At the same time, this working step is crucial within the process of a resilience assessment: and it also needs to be decided whether the anticipated results can be achieved with the available resources and whether the outcomes are likely to meet the desired quality necessary.

Experience has shown that a well-structured procedure is helpful to select the best-suited indicators out of the vast pool of available and potentially useful ones. We therefore propose the following six-step approach:

Figure 7: six steps for selecting indicators for resilience assessments



Each of these steps is further divided into a number of activities that are described more in detail:

- **Step 1: Clarify the context of the study**

This is an important first preparatory step for the indicator selection procedure. Its aim is to specify in detail the purpose and the essential underlying conditions of the study. Especially the important questions ‘resilience of whom?’, ‘resilience of what?’ and ‘resilience to what?’ should be answered in this step. Another important ambition of this step is to agree on realistic outcome of the study and avoid expectations which cannot be fulfilled with the financial and time resources available.

The results of this step should be a precisely formulated set of objectives as well as a clearly defined spatial and thematic scope. In addition, and given that we consider resilience assessment as a process with crucial participatory elements, relevant stakeholders and institutions to be involved in the work should be identified. At the end of this task an implementation plan can be generated that defines tasks, responsibilities and a timetable of the work. The following questions may be used to guide through all relevant considerations:

- *What is the main purpose of the assessment, and who would like to learn what?*
- *Who is the target group of the assessment, and into what decision making process is the assessment feeding?*
- *Are there already assessments with a similar objective that have been carried out previously within the region?*
- *Which stakeholder and institutions can and should be involved? How should they be addressed and by whom? What will their role be in the assessment?*
- *What is the scope of the study, and what is the envisaged outcome?*
    - *What is geographical extension (if possible to define) and what is the spatial scale? Is the outcome meant to be spatially explicit?*
    - *What type of community is considered?*
    - *Which timescale is targeted (i.e. only the present or also future conditions)?*
    - *Is there a specific hazard or stress the assessment is focusing upon?*
    - *With which resources in terms of budget, time, as well as knowledge and experience is the study equipped?*
    - *What is the desired output of the study (maps, reports, statistics, numbers, figures, text?)?*

➢ ***Step 2: Define the systematic or concept to pursue***

This is the important second preparatory step for the indicator selection procedure. The academic world has generated several approaches that conceptualise resilience such as developed by emBRACE (see chapter 3.1). From these available theoretical constructions, the most appropriate concept for the study under consideration should be selected according to a number of relevant key characteristics. Therefore it is recommended not only to consider the description of the available concepts as such, but to verify any previous application of those concepts which might serve as a basis for further and deeper understanding. Having in mind the context, objectives and scope of the study, the following questions can support the selection of an adequate and suitable concept:

- *Is the study hazard dependent or not?*
- *Is the study focusing at local, national or international scale?*
- *Is the study following a holistic / systemic approach or is the intention to focus on particular aspects of resilience such as social, cultural, physical or environmental resilience?*

Ideally, any given application will develop its own theoretical framework according to the objectives and scope of the assessment (as it was the case within emBRACE), however this requires not only sufficient resources, but also expert knowledge and a comprehensive and conceptually strong understanding of resilience. In any case, experience has shown that besides the selection of the concept, a decisive factor for the success of assessment studies is to stick consistently to one chosen concept and avoid to try and combine different approaches.

The selected concept should also consistently provide means for definitions of key terms such as 'resilience' but also,'susceptibility', 'recovery', 'resistance' etc. Naturally, these terms may be modified according to the concrete conditions of the study. However, as it is important to stick to the selected concept, it is useful to select definitions with care since later adjustments during the process of the assessment may trigger confusion and misunderstandings.

- ***Step 3: Select the individual/concrete indicators***

This working step is the conceptual core component of any indicator-based assessment. It closes the gap between the underlying theoretical framework and the concrete step of evaluation based on data and information. The indicator selection is usually coined by the two conflicting poles of desired explanatory power and available datasets (or data acquirable with reasonable effort) and their technical or content related constraints (for example actuality, spatial resolution, accuracy, preciseness of data acquisition etc.). Consequently, the indicator selection is usually an iterative process with alternating check of data supply and verification of their usefulness within the conceptual design. The result of this step is a provisional 'ideal list of indicators' representing all aspects of relevance for the particular assessment study at stake. The following activities are recommended in order to efficiently go through the selection process and to prepare the subsequent tasks:

I. *Based on your selected theoretical concept (step 2), and in cooperation with stakeholders/experts, select aspects of relevance and concern for your study by taking into account the specificities of the particular study (step 1). In other words, the theoretical framework provided by the concept – and usually comprising of widely formulated thematic fields – is broken down into concrete facets of relevance for the concrete purpose and context of the particular study.*

II. *For each of these identified facets the most appropriate indicator is to be selected taking in consideration existing datasets or information sources as well as time and financial resources required for an optional data collection.*

The following list provides a number of characteristics for 'good' indicators:

- *It is **valid and relevant**, i.e., it represents well the factor to be addressed.*
- *It is **reliable and credible** and also allows for data acquisition in the future.*
- *It has a **precise meaning**, i.e. stakeholders agree on what the indicator is describing in relation to resilience.*
- *It is **clear in its direction**, i.e. an increase in value is unambiguously positive or negative with relation to resilience and taking into account the specific context of the study.*
- *It is **practical and affordable**, i.e., it comes from an accessible data source or its acquisition is in line with the available budget and time.*
- *It is **appropriate**, i.e., the temporal and spatial resolution fits the purpose.*

III. *For each indicator it is required to define with which methodology and within which time frame the relevant data will be collected or acquired (see also step 4).*

IV. *Finally, for each indicator an 'assessment scheme' needs to be specified. This scheme unambiguously links certain numbers, values or information content of each indicator to a meaning related to resilience. For example, for an indicator '% of households in the community subscribed to an early-warning system (emBRACE indicator no. 32 in*

table 15 in the annex), it is required to specify which percentage of households are seen as an indication for low, medium and high resilience. Classes and related thresholds (e.g. critical, neutral, good) for such an assessment scheme needs to be defined with care. They are highly context specific and it is recommended to get local expert and stakeholders involved for this task.

- ***Step 4: Carry out data collection and management***

This task is the technical core working step of the resilient assessment. The here described activities translate the conceptual framework and the identified indicators into operational mode.

Data availability and data acquisition is a big issue in all assessment works. The effort required to carry out this step is in the majority of studies underestimated. Related methods vary from downloading statistic via GIS analysis to questionnaires and interviews. To describe all possible methods would go beyond the scope of this report. However, in most assessments, the data is a result of the application of one or a combination of methodologies:

- *Measurements.*
- *Censuses and surveys.*
- *Modelling.*
- *Expert judgement.*

These methods vary significantly in time and effort needed for the implementation. Therefore, the data acquisition methodology is not only dependent on the indicator, but to a large extent on the resources with which the study is equipped.

Independent of the data acquisition methodology, two points are worth considering for data management to ensure a smooth generation of assessment results and in order to strengthen their acceptance:

- ***Meta-data:*** *it is crucial to describe in detail the data on that the assessment is based. This description must include the data acquisition method, any used underlying data that have further been processed, temporal and spatial specifications of the datasets and information about*

its quality and/or accuracy.

- ***Data management:*** *it is equally important to use an appropriate tool for data management. This tool has to be chosen according to the type of data and is possibly related to the type of analysis carried out (for spatially explicit assessments it will probably be a GIS although a GIS can be used as a repository for a wide range of non-spatial data as well). Well-performing data management eases further analyses, related corrections and improvements as well as an update of the assessment at a later stage.*

  Typical challenges of data management work include (see FRITZSCHE et al. 2014):

  - *Dealing with different data formats.*
  - *Dealing with different temporal and spatial coverage of incoming datasets.*
  - *Dealing with missing values and outliers.*
  - *Dealing with datasets of different or inappropriate geographical projection (for spatial data) or date of different types/scales/indices (e.g. inches or centimetres).*

Concerning the **data provider challenges** previous deliverables (VOS et al. 2012; RODRIGUEZ-LLANES et al. 2015) within emBRACE have looked more in detail at data bases that collect data about the magnitude, impacts and damages of hazardous events. These disaster impact databases are important sources for evidence base within resilience assessments. That is, at least theoretically and in any case limited to individual and spatially confined cases, it should be possible to underpin and in ideal cases test empirically the results of such an assessment with data about damages and/or losses (human, social or economic) as the realisation of not being resilient – or vice versa. However in contrast, these databases have limited importance for deriving indicators of community resilience. According to the analysis of RODRIGUEZ-LLANES et al. 2015, approximately 5% of all indicators will require data from such databases.

The most important data sources for resilient-relevant disaster data bases are governmental agencies. As such, especially in Europe, the challenge for years to come is to create adequate policies, standards and technical systems able to

compile, validate, aggregate and share data that is regularly compiled by the local governments. This is an important finding from the emBRACE project.

In recent years, a great effort was made in order to integrate geospatial data of fine resolution into disaster databases, for example the georeferencing of human impacts in EMDAT. Also across Europe, numerous national databases exist that compile hazard specific magnitude and human impact data, sometimes even reporting displaced or relocated people, and so on (see VOS et al. 2012). A possible option would be to propose EUROSTAT to take the lead on the task to provide data on indicators selected by this project (emBRACE) and further projects that generate indicators on resilience and other cross-cutting policy issues. One of the major challenges would be to provide data at spatial resolution of relevance for sub-national assessments. The well-known databases of international organisations such as the OECD, the World Bank, UN agencies or EUROSTAT all provide most data at national scale, which is clearly insufficient for assessing sub-national systems or communities. Other important data-related issues when thinking about standardised data collection are the transparency about data acquisition and analysis methods, the comparability between datasets of different sources (leading to required standard procedures) and the free access to relevant datasets.

- ***Step 5: Carry out an aggregation of results if useful and required***

The emBRACE project strives for results that are useful in practice. Policymakers and the general public often find it easier to comprehend a composite indicator than numerous discrete indicators (OECD 2008). Therefore, in most cases decision makers request aggregated results. This working step tackles the question of aggregating the results of individual indicators or sub-indices in order to receive a higher aggregated outcome (although the step of aggregation is not followed by this deliverable, see chapter 3.1.1).

The aggregation of indicators can support the illustration of a complex and multi-dimensional problem. In addition, the aggregation step is combined with a weighting process. That is, a certain importance is allocated to each individual component and hence may be able to influence the aggregation results to a smaller or larger extent. However, aggregation always goes hand in hand with a loss of underlying information. Moreover, when dealing with complex phenomena a combination of individual components means often to compare datasets that have been generated

from data sources of various statistical scale levels. Therefore, the decision whether to aggregate should be carefully considered. The main criteria to be taken into account is the purpose of the study. An aggregation may be useful if the outcome is intended to identify hotspots or to support the allocation of resources based on the comparison of different regions or communities. However, when the study's main objective is to identify those aspects that lead to low resilience or has the main aim to develop strategies or select future activities to increase resilience, the step of aggregation may, and possibly should, be disregarded in favour of a more holistic view of how the disaggregated indicators fit into the bigger picture (in emBRACE's case using 'the Framework'): this is not aggregating, but it can be considered analogous to looking at different scales at the same time.

In any case, when and however aggregation is carried out, it is absolutely necessary to make transparent exactly which methodology has been applied and with which weight each individual indicator or each individual sub-indices has contributed to the overall results. It is also highly recommended to keep hold of the information of the underlying individual components in order to be able to explain the reasons behind aggregating results.

A detailed description of the various existing aggregation methods would go beyond this report. A number of most common methods with their advantages and constraints is provided by the OECD handbook for composite indicators (OECD 2008). As a rule of thumb it can be said that the simpler methods may have conceptual constraints but are easier to comprehend. To the contrary, the more complex and scientifically sound methods yield in results that are more difficult to trace back.

Before the aggregation of assessment components can be carried out, the data needs to be normalised and a decision about the allocation of weights is required:

- *Normalisation: This tasks transforms indicator values measured at different scales and in different units into unit-less values possessing a common scale. Existing normalisation methods are numerous. The most adequate method for normalisation is strongly dependent on the statistical scale of your datasets (see FRITSCHE et al. 2014 for a more detailed guidance).*
- *Weighting: Weights should be allocated to the various assessment components if they are considered to have different importance in*

relation to the resilience. More important indicators or components should have a greater influence on the aggregated results than less important ones. It is vital to mention that not (explicitly) allocating weights means in practice that you apply equal weights to all components. In either case, the decision – and the weightings – may be determined by subjective procedures even if the indicators themselves are objectively determined.

- ***Step 6: Present the results***

There are numerous ways to present the results of a resilience assessment. Any report generated about the carried out assessment should provide a clear description of the objectives, the methods applied as well as the key findings. The attractiveness of the results' presentation is increasing when the report is complemented by illustrations that summarise certain outcomes in an attractive and comprehensive way. Maps, diagrams and graphs represent high-level views of data and are valuable tools to visualise the results. However, as it is the case with the aggregation of indicators, these high-level views go hand in hand with a loss of information and they cannot tell the complete story. Therefore we strongly recommend to always communicate the narrative behind numbers and figures since they often contain crucial information necessary to fully understand the situation with regards to resilience. Summarising, the following three main points should be fulfilled when presenting the results of a resilience assessment:

- *Consideration of the target audience.*
- *Transparency of the process and communicating of accuracy / uncertainty.*
- *Findings presented with the support of illustrations and narrative (background) information.*

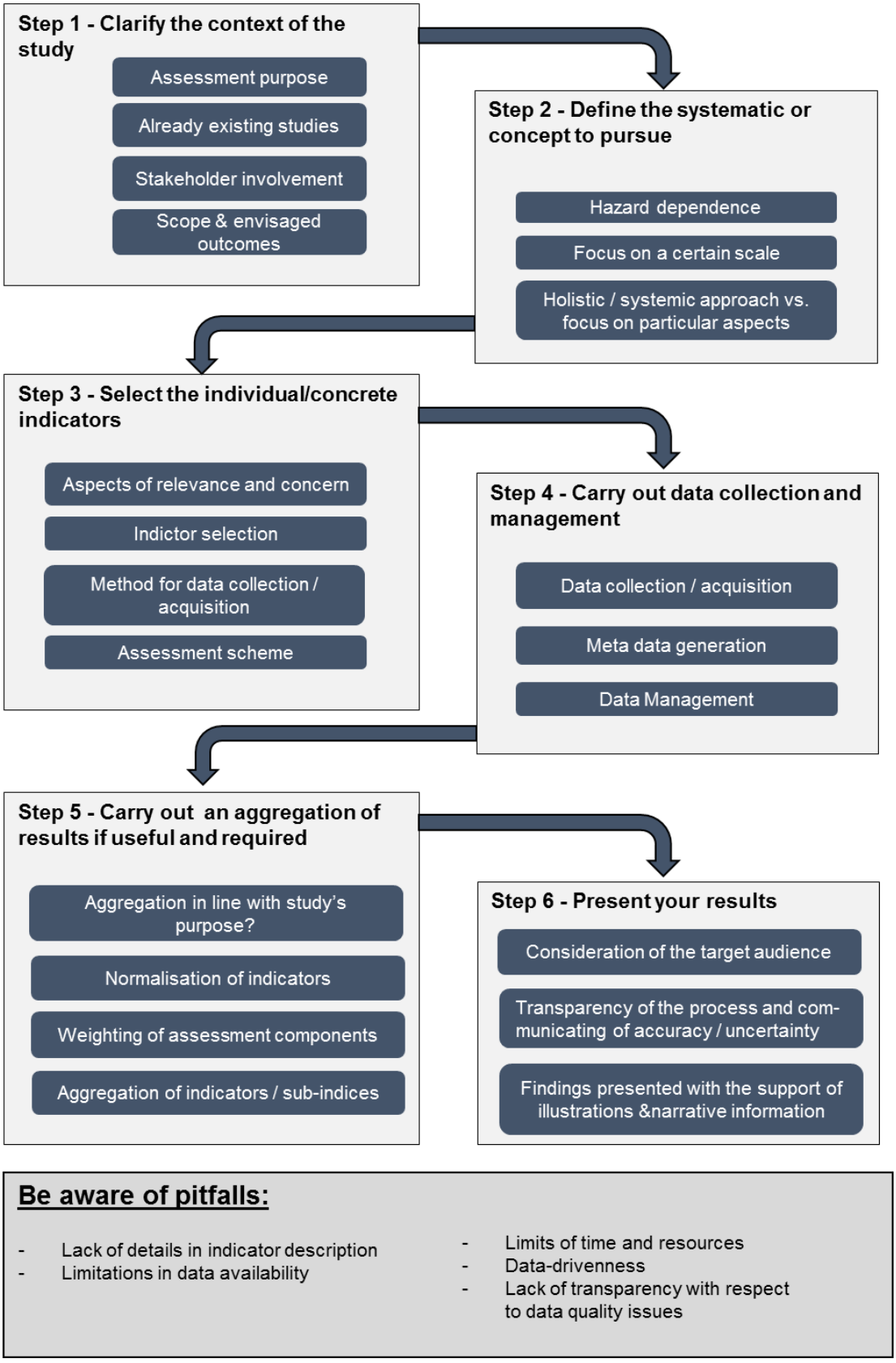
4.2 Typical challenges and pitfalls

There are a number of typical challenges and pitfalls when assessing resilience or other similar complex phenomena by means of indicators. According to our experience the most relevant ones are:

- **Limits of time and resources:** The overestimation of the resources and time available, or – in reverse expression – the underestimation of effort and time that a particular resilience assessment require.
- **Data-drivenness:** Under the pressure to produce outcomes of certain types (for example spatially-explicit outputs) and with an underestimation of the effort to collect the required data (see above) the choice of indicators is often influenced by data availability. This goes hand in hand with the risk to neglect those aspects that are significant for resilience but which may be perceived as – or actually – more difficult to measure (see chapter 2.5). One possible way to avoid data-drivenness is to identify the aspects of relevance for the assessment before the concrete indicators are selected by taking data availability into consideration (in this context see also the generation of impact chains for vulnerability assessments, described in SCHNEIDERBAUER et al. 2014 and FRITZSCHE et al. 2014.
- **Lack of transparency with respect to data quality issues**: Resilience assessments often deal with data of rather poor quality and face limited access to data sources. A detailed description of data (meta-data) and transparency about data accuracy issues is of particular importance as it will greatly influence the impact of the assessment. The lack of communicated details about the data used in the assessment threatens the credibility of the whole study.
- **Lack of details in indicator description:** Indicators are often formulated without fully elaborating on relevant details, such as spatial and temporal coverage. Experience shows that a lack of meticulous care when describing indicators for the selection process can lead to a later rejection of indicators and cause a severe loss of time and effort.
- **Limitations in data availability**: Another frequent pitfall in indicator selection is underestimating the question of data availability or effort to access and acquire it. The best indicator is inoperable if there is no feasible way to obtain the required data.

The flowing figure summarises our six-step approach for an indicator-based assessment of (community) resilience and the related challenges and pitfalls:

Figure 8: our six-step approach for an indicator-based resilience assessment



5. Conclusions

Concluding the findings of this deliverable, we can state that indicator-based approaches provide useful means for assessing community resilience. Resilience assessments face challenges and limitations related in particular to the dynamic conceptualisation and in the approaches of operationalisation. Perhaps particularly because of these fuzzy framework conditions, 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 might be 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.

The potentials and challenges of indicators for assessing community resilience must be evaluated according to the specific approach applied. We can differentiate between 'qualitative' and 'quantitative' indicator approaches, both having their raison d'être and both bringing great advantages and disadvantages in terms of subjectivity and objectivity. For selecting the right indicator-based approach, it is crucial, to be explicit about the motivations, objectives, research questions and target groups of the assessment in the first place. For example, a composite indicator might be the right choice when the objective is to compare resilience between communities in space and time. However, qualitative indicator approaches might be more appropriate when the focus is set on identifying inherent characteristics that shape community resilience. Nonetheless, in most cases the strict limitation to only one of these approaches is not advisable since both have significant constraints. Often a mixed indicator-based approach will yield the best results and provide the most complete picture for a resilience assessment. Further, a clear distinction in quantitative and qualitative approaches is often ambiguous, or just impossible.

Within emBRACE, we suggest to use an integrative indicator-based approach incorporating multiple levels of measurement, scales and methods of data collection. Recognising the emBRACE conceptual framework and the methodologies applied within the emBRACE case studies, it is clear that no reductionist, easy approach can be applied. However using such an integrative and to some extent innovative approach provides challenges, since few experiences, pilot cases or concrete applications exist so far. 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.

The indicators identified by the emBRACE case studies allowed us to derive key-indicators of community resilience that are applicable on a higher level of societal resilience, across different contexts and hazard types. Grounded within the conceptual framework as well as within the empirical field work of emBRACE, we believe that these generic indicators add value to current research activities on community resilience indicators by transferring theoretical considerations of our project into specific applications. The emBRACE key-indicators can be seen as a core set of indicators for measuring community resilience. 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) always acknowledging that other ways will exist. It has to be emphasised that we cannot and do not want to provide a fixed and comprehensive set of indicators. Rather 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.

Besides identifying and selecting suitable indicators, it is crucial to understand how to use, integrate and apply indicators. Concrete indicator guidelines in this sense provide a useful source of information for proper application in practice. 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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7. Annex

Table 14: Applied methods of data collection in the case studies (after KUHLICKE 2015: 2-3)

emBRACE case study	Methods/empirical basis of the case studies
Resilience and River Floods in Central Europe	- 26 semi-structured interviews with representatives of municipalities, local disaster agency, regional governments and planning agencies; - A survey with 990 questionnaires received back from flood affected households in Saxony (Germany); - An additional survey with 390 questionnaires received back from flood affected households in Bavaria (Germany);
Earthquakes in Turkey	- 90 in-depth interviews with disaster survivors and members from relevant organisations; - 8 focus group interviews with staff of local public organisations and NGOs; - Survey with 360 questionnaires received back from disaster survivors;
Alpine Hazards in South Tyrol (Italy) and Grison (Switzerland)	- A survey with 1096 questionnaires received back the community of Badia (South Tyrol) - Additional semi-structured interviews with representatives of relevant organisations in the case study region
Heat-waves biophysical and social aspects	- 49 semi-structured expert interviews with risk planning officials from local authorities and NHS organisations in London; - 33 semi-structured interviews and 43 structured interviews conducted with independent elderly people, community center managers, carers and local government officer;
Floods in Northern England	- 65 interviews with affected individuals, representatives of government organisations as well as service-delivery organisations; Participant observation at 7 Community-Resilience focused events;

Table 15: entire list of indicators identified by the emBRACE case studies (=128 indicators)

No.	Indicator title	Mentioned by case study	emBRACE Framework domain	emBRACE Framework component	How will the indicator be quantified / parameterized?	Scale of application	Generalisation possible (neither hazard- nor context-specific)?	Relation to resilience (Yes/no, direction)	Importance for determining/explaining resilience	Methods of data collection	Effort for applying the indicator	Based on what approach has the indicator been selected?
1	**Occurrence of natural disasters in the past**	WSL	Actions	Preparedness, Prevention, Response	Factor Time = max.{1-(Years/10);0} Factor Casualties = min.{Deaths/10;1} Factor Distance = max.{1-(km/50);0}	Pixel on a GIS map	- not specified -	Yes, higher values indicate higher resilience	- not specified -	No data were collected	- not specified -	1. Expert interviews 2. Thinking
2	**% of hazard-exposed residential buildings/commercial buildings/critical infrastructure as % of all**	UoN	Resources and Capacities, Actions, Learning	Place-based, Mitigation, Problematizing risk/loss	Hazard-exposed buildings as % of all buildings 0-1 (100% = 0, 0% = 1)	Community	Flood specific in this case, but principle relates to all hazards (e.g. seismic maps would provide similar mapping potential for earthquake exposure)	Yes, 100% = lowest resilience	High	GIS-derived	Medium	Literature research
3	**Exposition to rock fall**	WSL	- not specified -	- not specified -	Annual km driven	Individual/ Household	- not specified -	Yes, higher distance indicates higher resilience	- not specified -	No data were collected	- not specified -	1. Expert interviews 2. Analysis of death by rock fall 3. Thinking

4	**Degree of being directly or indirectly affected from last hazard events**	EURAC	Resources and Capacities, Learning	Human	Yes/No question, if yes what kind of impact	Individual	Yes, if there is a reference event	No	Very Low	Questionn aire	High	- not specified -
5	**% of households with access to >2MB Broadband connectivity**	UoN	Resources and Capacities, Actions, Learning	Place-based, Mitigation, Disseminat ion	Overlay comparison between hazard zones and broadband maps	Ward	Flood specific in this case, but principle relates to all hazards (e.g. seismic maps would provide similar mapping potential for earthquake exposure)	Yes, 100% = maximum resilience	Medium	GIS-derived	Medium	Literature research
6	**Access to information and ability to synthesise and prioritise**	KCL	Learning	Risk/Loss perception	Assessment from individual officials or organisational overview	Shapes scope for individual adaptation and risk within the networked community of the vulnerable elderly	Not easy	Yes, access to appropriate information and the capacity to learn from this increases resilience	High	Interview data and secondary literature	High	A review of the literature - deductive process

7	**Trust in information sources**	UFZ	Actions	Mitigation	Score of 1 = not trustworthy, then positive score of 2, 3, 4 and 5 depending on how trustworthy the individual believes each information source to be.	Individual/ Household	Generally yes, requires further research	No	No relevance	Questionnaire	High	Based on previous research and own interests
8	**Active commitment of persons to inform themselves about risks**	UFZ	Actions	Mitigation	Yes/no question	Individual/ Household	Generally yes, requires further research	No	No relevance	Questionnaire	High	Based on previous research and own interests
9	**Knowledge about hazard risk communication (e.g. flood risk maps)**	UFZ	Actions	Mitigation	Yes/no question	Individual/ Household	Generally yes, requires further research	Yes, robust relation, high indicator value indicates high resilience	High	Questionnaire	If access to maps via internet can be spatially explicit traced, than low, if not: high	Based on own research interest - to what extent are such maps known to the general public?
10	**Knowledge of the Federal Water Law**	UFZ	Learning	Critical Reflection	Yes/no question	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	High	Previous research
11	**Belief that Federal Water Law is reasonable**	UFZ	Learning	Critical Reflection	Yes/no question	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	High	Previous research

12	**Information is disseminated effectively across all stakeholders**	METU	Resources and Capacities, Learning	Socio-political, Dissemination	A scale for whether or not information is disseminated effectively across all stakeholders	Institutional/Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
13	**Previous hazard experience**	EURAC	Resources and Capacities, Learning	Human, Socio-political	Number of experienced events	Community	This indicator is broadly/universally applicable	No	Medium	Questionnaire	High	Literature
		UFZ	Learning	Problematizing risk/loss	Year and water source	Individual/ Household	Generally yes, requires further research	Yes, the more often flood experience, the lower the resilience	- not specified -	Questionnaire	Low	Based on literature
		UoN	Resources and Capacities, Actions, Learning	Place-based, Preparedness, Risk/loss perception	Community of place affected by previous hazard events Yes / No?	Community	Hazard mapping is specific to hazard (risk mapping may be more generalizable), so if no policy on mapping exists then data availability will be dependent upon a locality's engagement	Yes, recent experience is increasing resilience	Medium	Key-informant interview-derived and/or literature-derived	Medium	Expert/ Stakeholder opinion

							with those hazards					
		METU	Resources and Capacities	Human, Socio-political	Simple yes/no (whether the individual has previously experienced a disaster)	All possible scales	This indicator is hazard / context specific	Yes, more experience indicates higher resilience	Medium	Interviews, focus groups	Medium	Interviews, focus groups, literature
14	**Past learning experience and implementation**	KCL	Learning	Experimentation and innovation	Statement and description of past learning and implementation	Individual and by aggregation community of interest/network	Not easy	Yes, ability to access and process information increases resilience	High	Text data based on diary and interviews	High	A review of the literature - deductive process
15	**Risk/loss perception**	KCL	Learning	Risk/Loss perception	Statement correlated against vulnerability based on age and health conditions etc.	Individual and by aggregation community of interest/network	Not easy	Yes, high perception increases resilience	High	Interview data	High	A review of the literature - deductive process
16	**Knowledge about hazard events in the past**	EURAC	Resources and Capacities, Learning	Human, Socio-political	Yes/No, if yes what kind of information source (local knowledge, from media, etc.)	Community	This indicator is broadly/universally applicable	Yes, high number of ticks=high resilience	Medium	Questionnaire	High	Literature

17	**Area perceived as prone at high risk for hazards**	EURAC	Resources and Capacities, Learning	Human	Yes/no	Individual	This indicator is broadly/universally applicable	No	Medium	Questionnaire	High	- not specified -
18	**Awareness about hazard risks and vulnerabilities**	METU	Resources and Capacities, Learning	Human, Socio-political, Risk/loss perception	A scale for whether or not an individual knows about hazard risks and their vulnerabilities	All possible scales	This indicator is hazard / context specific	Yes, high level of awareness indicates higher resilience	High	Interviews, focus groups	High	Literature, interviews, focus groups
19	**Belief in being negatively affected by previous hazards**	UFZ	Learning	Problematizing risk/loss	Score of 1 = not affected, then positive score of 2, 3, 4 and 5 depending on how badly affected the individual felt after each flood event.	Individual/ Household	Generally yes, requires further research	Is part of the depend variable (e.g. core of resilience)	High	Questionnaire	- not specified -	Based on literature and previous research
20	**Financial damage from previous hazards**	UFZ	Learning	Problematizing risk/loss	Yes/no question, amount in €	Individual/ Household	Generally yes, requires further research	Is part of the depend variable (e.g. core of resilience)	High	Questionnaire	Medium	Based on literature and previous research
21	**Severity of impacts of disaster**	METU	Resources and Capacities	Human	A scale for how severe the individuals were affected by the disaster	Individual/ Household	This indicator is hazard / context specific	Yes, high severity indicates higher resilience	High	Interviews, focus groups, questionnaire	Medium	Literature, interviews, focus groups, quantitative survey

22	**Religious faith/Fatalism**	METU	Resources and Capacities	Human	A scale for whether or not an individual believes in power of fate and/or has religious faith	Individual/ Household/ Community	This indicator may be culturally specific and thus may not be broadly/universally applicable	Yes, high level of belief indicates higher resilience	Medium	Interviews, focus groups, questionnaire	Medium	Literature, interviews, focus groups, quantitative survey
23	**Physical and psychological health situation of individual**	METU	Resources and Capacities	Human	A scale for whether or not an individual is physically and psychologically healthy	Individual	This indicator is broadly/universally applicable	Yes, better health situation indicates higher resilience	High	Interviews, focus groups, questionnaire	Medium	Literature, interviews, focus groups, quantitative survey
24	**Existence of a community-developed risk register**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Monitoring and review	Existence of CRR - Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key-stakeholder interview	High	Expert/ Stakeholder opinion
25	**Risk assessment developed in a participatory process (involving local residents/community members)**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Monitoring and review	Presence of participatory risk-assessment/planning process in location: Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key-stakeholder interview	- not specified -	Participatory methods

26	**Presence of cross-sector Flood Risk Management planning process/forum at catchment scale**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Problematizing risk/loss	Presence of constituted FRM planning process or forum with reporting to local level - Yes = 1, No = 0	River catchment	Flood specific, but principle applies to all hazards that hold potential to impact different communities located within any relevant planning boundary (e.g. administrative zones)	Yes, increases resilience	High	Key-stakeholder interview	Medium	Expert/Stakeholder opinion
27	**Belief in being well prepared for hazards & being able to control the impacts**	METU	Resources and Capacities, Actions	Human, Socio-political, Preparedness	A scale measuring level of preparedness of individuals/households/communities for relevant hazards	Individual/ Household/ Community	This indicator is hazard / context specific	Yes, high level of preparedness indicates higher resilience	High	Questionnaire, Interviews, focus groups	High	Quantitative survey, literature, interviews, focus groups
		UFZ	Learning	Problematizing risk/loss	Score of 1 = not prepared, then positive score of 2, 3, 4 and 5 depending on how prepared the8individual felt after each flood event.	Individual/ Household	Generally yes, requires further research	Yes, the more often flood experience, the higher the preparedness, and the higher the resilience	High	Questionnaire	High	Based on literature and previous research

28	**Knowledge of institutions and organisations people should go to in case of an event**	EURAC	Actions	Preparedness, Response	Coherence between emergency plan and community risk behaviour	Community	Universally applicable. Questions, data collection and validation might need to be adapted to the context	Yes, increases resilience	High	Interpretation and validation with stakeholders	High	Case study design and field work
29	**Existence of disaster research in the community**	METU	Learning	Critical Reflection	A scale for evaluating presence of research on disasters	National/ Institutional	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Interviews, focus groups	High	Interviews, focus groups
30	**Existence of an early-warning system**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Preparedness, Dissemination	Scaled response per number of elements in place 0=0, 1 = 1, 3 = 3	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Expert interview	Low	Participatory methods
31	**Heat wave warning**	KCL	Actions	Preparedness	A qualitative description including (1) access to weather forecasts from a range of media (newspaper, radio, TV, internet) or organisations (council, informal networks, community groups) and 92) quality and timeliness of warning	Individual and by aggregation community of interest/network	Yes	No	High	Qualitative statements	Very high	A review of the literature - deductive process

		UoN	Resources and Capacities, Actions, Learning	Socio-political, Preparedness, Dissemination	No. of properties as % of all exposed properties - 100% = 1, 0% = 0	Ward	This indicator is broadly/universally applicable	Yes, 100% = maximum resilience	High	GIS or Key-stakeholder derived	Medium	Expert/Stakeholder opinion
32	**% of households in the community subscribed to an early-warning system**	WSL	- not specified -	- not specified -	Resilience = 0 if not subscribed to warning service(s) Resilience = 1 if subscribed to at least one natural hazard warning service (e.g. MetoSwiss, KGV, …)	Individual/ Household	- not specified -	Yes, higher values indicate higher resilience	- not specified -	No data were collected	- not specified -	1. Expert interviews 2. Thinking
33	**Existence of location-based or (cell-) broadcasting of warning messages or risk information (e.g. via SMS, social media)**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Preparedness, Dissemination	Assessment of operating protocols held by local or regional emergency responder agencies, e.g. Police operations-room/control-room standard operating procedures (SoPs)	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Key-stakeholder interview or local plan review	Medium	Expert/Stakeholder opinion
34	**Existence of hazard-warden based warning and information system (e.g. door-knocking)**	UoN	Resources and Capacities, Actions, Learning	Physical, Mitigation, Monitoring and review	Existence of accredited Warden scheme - Yes = 1, No = 0	County	Flood specific, but could be applied universally	Yes, increases resilience	Medium	Key-stakeholder interview	Medium	Participatory methods

35	**Existence of legal foundation and specific legislation for disaster risk management**	METU	Resources and Capacities	Socio-political	A scale for whether or not there is legal foundation and specific legislation	National/ Institutional	This indicator is broadly/universally applicable	Yes, high level of foundation indicates higher resilience	High	Interviews, focus groups	Low	Interviews, focus groups
36	**Existence of state policy for disaster risk management**	METU	Resources and Capacities	Socio-political	Simple yes/no (whether there is a state policy for disaster risk management)	National	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	Low	Interviews, focus groups
37	**Community has adequate economic resources for emergency activities**	METU	Resources and Capacities	Financial	A scale for whether or not the city has adequate economic resources for preparedness and mitigation	National/ Regional/ City	This indicator is hazard / context specific	Yes, high level of resources indicates higher resilience	High	Interviews, focus groups	Medium	Interviews, focus groups
38	**Community has adequate economic resources for training programs**	METU	Resources and Capacities	Financial	A scale for whether or not there are adequate economic resources for trainings	National/ Regional/ City	This indicator is hazard / context specific	Yes, high level of resources indicates higher resilience	High	Focus groups	Medium	Focus groups
39	**Community has financial resources and/or investments in the post-disaster phase**	METU	Resources and Capacities	Financial	A scale for whether or not there are financial resources and/or investments in the city in the post-disaster phase	National/ Regional/ City	This indicator is broadly/universally applicable	Yes, high level of resources indicates higher resilience	High	Interviews, focus groups	Medium	Interviews, focus groups
40	**Individuals/Households have adequate economic resource**	METU	Resources and Capacities	Financial	A scale for whether or not individuals and/or families have financial resources	Individual/ Household	This indicator is broadly/universally applicable	Yes, high level of resources indicates higher resilience	High	Interviews, focus groups	Medium	Interviews, focus groups

41	**Efficiency of disaster management system**	METU	Resources and Capacities, Actions	Socio-political, Response	A scale for whether or not there is good planning and organization of disaster management	Institutional/ Regional/ National	This indicator is broadly/universally applicable	Yes, high efficiency indicates higher resilience	High	Interviews, focus groups	High	Interviews, focus groups
42	**Presence of a (active) third sector emergency coordination body**	METU	Resources and Capacities	Socio-political	Presence of active NGOs in the community	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
		UoN	Resources and Capacities, Actions	Socio-political, Mitigation	Presence: Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	Confirmed through interviews with 3rd sector stakeholders	Medium	Participatory methods
43	**Existence of a committee-led hazard action group**	UoN	Resources and Capacities, Actions	Socio-political, Mitigation	Presence of HAG - Yes = 1, No = 0	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key-stakeholder interview	Medium	Participatory methods
44	**Composition of hazard action group (hazard-exposed, hazard-unexposed members)**	UoN	Resources and Capacities, Actions	Socio-political, Mitigation	Membership is split Yes = 1, No = 0	Community	This indicator is broadly/universally applicable	Yes, membership split between hazard exposed and unexposed will increase resilience	- not specified -	Key-stakeholder derived	- not specified -	Participatory methods

45	**Strategy in place for recovery management group**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Recovery, Monitoring and review	Activation strategy for recovery group in place: Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Key-stakeholder interview	Medium	Expert/Stakeholder opinion
46	**Integration of community representatives on the strategic Integrated Emergency Management (IEM) planning group**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Dissemination	Is there a community representative on the strategic Integrated Emergency Management (IEM) planning group? Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key-stakeholder interview	Medium	Expert/Stakeholder opinion
47	**Legislations/Regulations for risk management are implemented properly**	METU	Resources and Capacities	Socio-political	A scale for whether or not the legislations/regulations for disaster risk mitigation are implemented properly	National/ Institutional	This indicator is broadly/universally applicable	Yes, high level of proper implementation indicates higher resilience	High	Interviews, focus groups	High	Interviews, focus groups
48	**Presence of trained/employed staff to engage communities in hazard-related planning**	UoN	Resources and Capacities, Actions, Learning	Human, Mitigation, Dissemination	Staff employed - Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Key-stakeholder interview	High	Expert/Stakeholder opinion

49	**Emergency-role duties are included in role profiles of social/civil protection departments**	UoN	Resources and Capacities, Actions, Learning	Human, Mitigation, Dissemination	Emergency-role duties are included in role profiles - Yes =1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Key-stakeholder interview or local-plan review	Medium	Expert/Stakeholder opinion
50	**Collaboration and information exchange among involved actors in risk management**	METU	Resources and Capacities	Socio-political	A scale for whether or not there is good planning and organization of disaster management	National/ Institutional	This indicator is broadly/universally applicable	Yes, high level of collaboration indicates higher resilience	High	Interviews, focus groups	High	Interviews, focus groups
		EURAC	Actions	Preparedness, Response, Recovery	Frequency of coordination actions and information exchange among involved actors	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Expert interview	Medium	Field work
51	**Gaps and missing links in the risk management network**	EURAC	Learning	Critical Reflection	Number of identified missing links	Community	This indicator is broadly/universally applicable	Yes, the lower the value the higher the resilience	High	Expert interview	Medium	Own evaluation
52	**Satisfaction with response phase**	EURAC	Actions	Response	Assessment of different aspects during the response phase (information provided, coordination of involved actors, psychological support)- satisfaction linked to the reference event	Community	Yes, if there is a reference event	Yes, high satisfaction =high resilience	Low	Questionnaire	High	Literature, participatory methods

53	**Satisfaction with recovery phase**	EURAC	Actions	Recovery	Assessment of different aspects during the recovery phase (information provided, coordination of involved actors, psychological support)- satisfaction 16 months after the event	Community	Yes, if there is a reference event	Yes, high satisfaction =high resilience	Low	Questionnaire	High	Literature, participatory methods
54	**Satisfaction with reconstruction phase**	EURAC	Actions	Recovery	Assessment of different aspects during the reconstruction phase (information provided, coordination of involved actors, psychological support)- satisfaction 16 months after the event	Community	Yes, if there is a reference event	Yes, high satisfaction =high resilience	Low	Questionnaire	High	Participatory methods
55	**Trust in persons/actors involved in risk management**	EURAC	Resources and Capacities	Socio-political	Personal knowledge of key persons involved in risk management/trust in information and activities among risk management actors	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Expert interview	Medium	Field work

56	**Time needed to activate the local response network**	EURAC	Actions	Response	Time needed to activate the local response network	Community of circumstances	This indicator is broadly/universally applicable	Yes, the lower the value the higher the resilience	High	Expert interview	Medium	Field work
57	**Organisational capacity to experiment and innovate**	KCL	Learning	Experimentation and innovation	Assessment from individual officials or organisational overview	Shapes scope for individual adaptation and risk within the networked community of the vulnerable elderly	Not easy	Yes, ability to challenge existing practices and processes and to suggest alternatives increases resilience	High	Interview data and secondary literature	High	A review of the literature - deductive process
58	**Spaces within the organisational structure for critical reflection - formal and informal**	KCL	Learning	Critical Reflection	Assessment from individual officials or organisational overview	Shapes scope for individual adaptation and risk within the networked community of the vulnerable elderly	Not easy	No	High	Interview data	High	A review of the literature - deductive process

59	**Calibration of risk to organisational mandate**	KCL	Learning	Problematizing risk/loss	Assessment from individual officials or organisational overview	Shapes scope for individual adaptation and risk within the networked community of the vulnerable elderly	Not easy	Yes, increases resilience when risk managers fulfil their mandates	High	Interview data	High	A review of the literature - deductive process
60	**Community has made organisational reform to increase effectiveness of disaster management**	METU	Learning	Experimentation and innovation	Simple yes/no (whether the state has made an organizational reform to increase effectiveness of disaster management)	National/ Regional/ City	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
61	**Persons have been at least once actively involved in participation processes related to hazard management**	UFZ	Actions	Mitigation	Yes/no question	Individual/ Household	Generally yes, requires further research	Yes, weak relation, those involved, suffered more severe consequences	No relevance	Questionnaire	Medium	Based on public discussion and controversies with regard to the role of participation during the 2013 flood

62	**Individuals consider local actor involvement in planning processes surrounding disaster management as important**	UFZ	Actions	Mitigation	Yes/no question	Individual/ Household	Generally yes, requires further research	Yes, weak relation, those who considered it as relevant , suffered more severe consequences	No relevance	Questionnaire	High	Based on public discussion and controversies with regard to the role of participation during the 2013 flood
63	**Existence of integrated and validated emergency business continuity management plans by sector in hazard zone**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Monitoring and review, Problematizing risk/loss	Presence of plans by sector - Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key stakeholder interview/ Survey	Medium	Literature research, Expert/Stakeholder opinion, Participatory methods
64	**Existence of local tested community emergency plan**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Monitoring and review	Presence of plan: Yes = 1, No = 0	Community	This indicator is broadly/universally applicable	Yes, increases resilience	High	Local key-stakeholder interview	Medium	Participatory methods
		EURAC	Actions	Preparedness, Response, Recovery	Existence of a local emergency plan	Community	This indicator is broadly/universally applicable	Yes, existence increases resilience	High	Expert interview	Medium	Field Work

65	**Existence of household emergency plans**	UoN	Resources and Capacities, Actions, Learning	Socio-political, Mitigation, Problematizing risk/loss	Number of plans as % of hazard exposed households - 100% = 1, 0% = 0	Community	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Survey or key-stakeholder derived	High	Expert/stakeholder opinion
66	**Number of formally-constituted community-based planning groups**	UoN	Resources and Capacities, Actions	Socio-political, Mitigation	- not specified -	Community	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	- not specified -	High	Expert/Stakeholder opinion
67	**Presence of cross-departmental local Authority/Municipality staff training programmes related to preparedness, response, recovery and mitigation activities in emergency cases**	EURAC	Actions	Preparedness, Response	Yes/no, number per year	Community	This indicator is broadly/universally applicable	Yes, presence increases resilience	High	Expert interview	Medium	Field Work
		UoN	Resources and Capacities, Actions, Learning	Human, Mitigation, Dissemination	Presence of action-domain encompassing training programme - Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Key-stakeholder derived	High	Expert/Stakeholder opinion
68	**Pre-identified buildings for rest-centres/social-support facilities**	UoN	Resources and Capacities, Actions	Place-based, Recovery	Identification of community-appropriate buildings to be used for rest and social support during and after event (e.g. a 'Soup kitchen') - with	Ward	Pre-defined rest centres should be located out of high-risk areas or in physically 'resilient' buildings	Yes, increases resilience	Medium	- not specified -	Medium	- not specified -

					redundancy		(e.g. high seismic integrity)					
	Belief in effectiveness of self in coping with disaster-related adversities	METU	Resources and Capacities	Human	A scale for belief in effectiveness of self in coping with disaster-related adversities	Individual	This indicator is broadly/universally applicable	Yes, high level of self-efficacy indicates higher resilience	High	Questionnaire	Medium	Quantitative survey, literature
69		UFZ	Actions	Preparedness	Yes/no question	Individual/ Household	Generally yes, requires further research	Yes, positive, high values indicate high resilience	High	Questionnaire	High	Based on literature
70	**Adaptive coping strategies (e.g. high level of problem-focused coping & low level of helplessness coping)**	METU	Resources and Capacities	Human	A scale assessing adaptive coping strategies	Individual	This indicator is broadly/universally applicable	Yes, high level of adaptive coping indicates higher resilience	High	Questionnaire	Medium	Quantitative survey, literature
71	**Community cohesion**	UoN	Resources and Capacities, Actions	Socio-political, Mitigation	High cohesion = 1, Low Cohesion = 0	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	High	Survey-item derived	High	Literature Research
72	**Integration in social networks**	UoN	Resources and Capacities, Actions	Socio-political, Mitigation	High social capital = 1, Low Social capital = 0	Ward	This indicator is broadly/universally	Yes, increases resilience	High	Survey-item derived	High	Literature Research

							applicable						
		METU	Resources and Capacities	Human	Simple yes/no (whether the individual has support networks)	Individual	This indicator is broadly/universally applicable	Yes, availability of support networks indicate higher resilience	High	Questionnaire	Medium	Quantitative survey, literature
		EURAC	Resources and Capacities	Human, Socio-political	People they go for help and support in case of an event	Community	This indicator is broadly/universally applicable	Yes, high integration= high resilience	High	Questionnaire	High	- not specified -
73	**Access to carer**	KCL	Resources and Capacities	Human	Quantitative measure - a range of issues including the legal responsibility of the carer, degree of oversight and formality, knowledge of the carer, freedom to act of the carer, power of the vulnerable subject or others to influence and monitor carer actions	Individual and by aggregation community of interest/network	Not easy	No	High	- not specified -	High	A review of the literature - deductive process
74	**Modularity of the community response network**	EURAC	Actions	Response	The modularity of the community response network - balance between	Community	Yes (not hazard or context specific).	No	High	Questionnaire	High	Literature, Field work

					centrality and dispersiveness		The evaluation of the number of nodes is context specific (e.g. depending on the size of the community)					
75	**Social/Mutual trust**	UoN	Resources and Capacities	Socio-political	High social trust = 1, Low social trust = 0	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	High	Survey-item derived	High	Literature Research
		METU	Resources and Capacities	Socio-political	A scale measuring whether or not community members trust each other	Individual/Community	This indicator is broadly/universally applicable	Yes, high level of trust indicates higher resilience	Medium	Interviews, focus groups	High	Interviews, focus groups
76	**Receive of support from others after the hazard event**	METU	Resources and Capacities	Human	A scale for whether or not an individual perceives psychological support from others	Individual	This indicator is broadly/universally applicable	Yes, higher support indicates higher resilience	High	Interviews	Medium	Literature, interviews
		UFZ	Actions	Preparedness	Top three sources of help: family/ friends/ neighbours/ Fire brigade/ Police/ volunteers/ THW/ German Red Cross/ the Army/ Charity/ the council/ the church/ other…	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Medium	Based on own interest

77	**Family/friend support**	KCL	Resources and Capacities	Socio-political	A qualitative description indicating the availability of support from family, friends or neighbours includes access to information and practical support in preparedness and response.	Individual and by aggregation community of interest/network	yes	Yes, close relations increase resilience	High	Qualitative statements	Very high	A review of the literature - deductive process
78	**Trust in authorities**	UoN	Resources and Capacities	Socio-political	Community participation in FRM processes High = 1, Low = 0	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	High	Key-informant derived	High	Literature Research
		EURAC	Actions	Preparedness	- not specified -	Community	Yes, if there is a reference event	No	Medium	Questionnaire	High	- not specified -
79	**Sense of belonging in community**	METU	Resources and Capacities	Socio-political	A scale measuring having a sense of community/belonging	Individual/ Household/ Community	This indicator is broadly/universally applicable	Yes, high level of belonging indicates higher resilience	High	Interviews, focus groups	High	Interviews, focus groups
		UoN	Resources and Capacities	Socio-political	High = 1, Low = 0	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	High	Survey-item derived	High	Expert/Stakeholder opinion
80	**Place attachment**	UoN	Resources and Capacities	Socio-political	High = 1, Low = 0	Ward	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Survey-item derived	High	Literature Research

		EURAC	Resources and Capacities	Human, Socio-political	Number of years living in the community	Community	This indicator is broadly/universally applicable	Yes, higher number of years of residence = higher resilience	Medium	Questionnaire	High	- not specified -
81	**Knowledge of the territory**	WSL	Resources and Capacities, Actions	Human, Preparedness, Prevention, Response	Length of stay in years	Household	- not specified -	Yes, high value indicates high resilience	- not specified -	No data were collected	- not specified -	1. Expert interviews, 2. Empirical data analysis, 3. Thinking
82	**Knowledge of the territory (language)**	EURAC	Resources and Capacities	Human, Socio-political	Language (ladin, german or italian)	Community	This indicator is hazard / context specific	No	High	Questionnaire	High	- not specified -
83	**Number of buildings with protection measures as % of all hazard exposed buildings**	UFZ	Actions	Preparedness	Yes/no question, open question, date	Individual/ Household	Generally yes, requires further research	Yes, robust relation, those who employed measure have a lower resilience than those who did not employ measures (interpretation: those households who suffered severe and repeated	High	Questionnaire	Medium	Based on literature and previous research

								consequences, are also implementing measures, but also suffer high damages etc.)				
		UoN	Resources and Capacities, Actions, Learning	Physical, Mitigation, Problematizing risk/loss	100% = 1, 0% = 0	Community	Flood specific, but could be generalizable	Yes, higher number = higher resilience	Medium	Survey-item derived	High	Literature research
84	**% of flood-hazard exposed properties protected by structural (flood defence) measures (e.g. levee)**	UoN	Resources and Capacities, Actions, Learning	Physical, Mitigation, Problematizing risk/loss	100% = 1, 0% = 0	Community	Flood specific, but could be generalizable (e.g. avalanche protection measures)	Yes, 100% = maximum resilience	High	GIS-derived	Medium	Literature research
85	**Knowledge about existing protection measures**	EURAC	Actions	Preparedness	Number of ticks given a list of existing protection measures, safety feeling from 1 to 5	Community	This indicator is broadly/universally applicable	Yes, increases resilience	Medium	Questionnaire	High	Literature
86	**Property of house**	UFZ	Resources and Capacities	Physical	Multiple choice	Individual/ Household	Generally yes, requires further research	Yes, high correlation, property owner have lower resilience	High	Questionnaire	Low	Classical socio-demographic-economic indicators

87	**Dwelling size**	UFZ	Resources and Capacities	Physical	Metres squared	Individual/ Household	Generally yes, requires further research	Yes, but decisive variable is property	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
88	**Dwelling type**	KCL	Resources and Capacities	Physical	Bed room ventilation, orientation, floor number - nominal	Individual and by aggregation community of interest/ network	Yes	Yes, access to and ability to modify dwelling form increases resilience	High	- not specified -	High	A review of the literature - deductive process
89	**Number of people living in the dwelling**	UFZ	Resources and Capacities	Physical	Number of people	Individual/ Household	Generally yes, requires further research	Yes, but decisive variable is property	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
90	**Number of children (< 12) living in the household**	EURAC	Resources and Capacities	Human, Socio-political	Information if children above 12 are part of the family/living in the household	Household	This indicator is broadly/universally applicable	No	No relevance	Questionnaire	High	Literature
		UFZ	Resources and Capacities	Physical	Number of children	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Medium	Classical socio-demographic-economic indicators
91	**Bedroom Layout**	KCL	Resources and Capacities	Physical	Ability to control temperature in dwelling by opening windows, thermostat control, positioning bed,	Individual and by aggregation community of interest/network	Yes	Yes, increases resilience	High	- not specified -	High	A review of the literature - deductive process

					blinds, trees - nominal							
92	**Amount of people with disabilities who live in the dwelling**	UFZ	Resources and Capacities	Physical	Number of people with disabilities	Individual/ Household	Generally yes, requires further research	Yes, weak correlation, People with disability indicate lower resilience	No relevance	Questionnaire	Medium	Classical socio-demographic-economic indicators
93	**Individual's relationship to the other people living in the dwelling**	UFZ	Resources and Capacities	Physical	I live alone/ I am a single parent/ I live with my partner without children/ I live with my partner with children/ I live in a share-flat/ I live with my parents/ I live with my children/ other…	Individual/ Household	Generally yes, requires further research	Yes, but weak correlation, people with disability indicate lower resilience	No relevance	Questionnaire	Medium	Classical socio-demographic-economic indicators
94	**Type of housing (free-standing, apartment, etc.)**	UFZ	Resources and Capacities	Physical	Multiple choice	Individual/ Household	Generally yes, requires further research	Yes, but decisive variable is property	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
95	**Provision of temporary housing**	METU	Resources and Capacities, Actions	Socio-political, Physical, Response	A scale for whether or not temporary housing is provided in a timely and adequate manner	Institutional	This indicator is broadly/universally applicable in the case of earthquakes	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups

96	**Provision of permanent housing**	METU	Resources and Capacities, Actions	Socio-political, Physical, Response	A scale for whether or not permanent housing is provided in a timely and adequate manner	Institutional	This indicator is broadly/universally applicable in the case of earthquakes	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
97	**% of buildings inspected and built according to the recent earthquake code**	METU	Resources and Capacities	Physical	Proportion of buildings inspected and built according to the recent earthquake code	Neighbourhood / City	This indicator is hazard / context specific	Yes, 100% = maximum resilience	High	Interviews, focus groups	Medium	Interviews, focus groups
98	**Individuals have considered resettling as a result of previous hazards**	UFZ	Learning	Critical Reflection	Yes/no question	Individual/ Household	Generally yes, requires further research	No correlation	High	Questionnaire	High	Own interest and public debate about it
99	**Type of physical connection of community (e.g. multiple access routes, ports, etc.)**	UoN	Resources and Capacities, Actions, Learning	Place-based, Mitigation, Problematizing risk/loss	Counting of primary-route access into area Provisional method 1 = 0, 2 = 0.5, 3+ = 1	Community	Flood specific in this case, but principle relates to all hazards (e.g. seismic maps would provide similar mapping potential for earthquake exposure)	Yes, multiple access routes increase resilience	High	GIS-derived	Medium	Participatory methods
		METU	Resources and	Physical	A scale for whether or not the city is	Regional/ City	This indicator is	Yes, multiple	Medium	Focus groups	Medium	Focus groups

			Capacities		connected to other cities / has ports		broadly/universally applicable	access routes increase resilience				
100	**Community engages in renewal and transformation processes**	METU	Learning	Experimentation and innovation	A scale measuring level of urban renewal and transformation activities that the government engages in.	National/ Institutional	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
101	**% of persons with mandatory insurance**	METU	Resources and Capacities, Learning	Financial, Problematizing risk/loss	Simple yes/no (whether the individual has earthquake insurance for his/ her household)	Individual/ Household	This indicator is hazard / context specific	Yes, 100% = maximum resilience	High	Interviews, focus groups	Low	Interviews, focus groups
		UFZ	Actions	Preparedness	Yes/no question	Individual/ Household	Generally yes, requires further research	Yes, partially positive, more often similar or better off after the flood even than without insurance	Low	Questionnaire	Medium	Based on literature
102	**Belief that mandatory insurances to natural hazards are reasonable**	UFZ	Actions	Preparedness	yes/no question	Individual/ Household	Generally yes, requires further research	Yes, high indicator value indicate low resilience	Medium	Questionnaire	High	Based on literature

103	**% of hazard-exposed properties that are insurable at 'affordable' premium cost**	UoN	Resources and Capacities, Actions	Financial, Mitigation	Insurance affordable - 100% = 1, 50% = 0.5, 0% = 0	Community	This indicator is broadly/universally applicable	Yes, high insurance penetration increases resilience	High	Survey-derived	Medium	Participatory methods
104	**Household received financial support for previous hazards & source**	UFZ	Learning	Problematizing risk/loss	Yes/no question, source	Individual/ Household	Generally yes, requires further research	No correlation	High	Questionnaire	Medium	Based on own interest
105	**% of total damage covered by external financial support for previous hazards**	UFZ	Learning	Problematizing risk/loss	The percentage of the total damage covered by external financial support	Individual/ Household	Generally yes, requires further research	No correlation	High	Questionnaire	High	Based on own interest
		METU	Resources and Capacities	Financial	A scale for whether or not adequate aid is provided by external resources in the post-disaster phase	Regional/ City	This indicator is broadly/universally applicable	Yes, high level of satisfaction increases resilience	High	Interviews, focus groups	Medium	Interviews, focus groups
106	**Satisfaction with external financial support received**	UFZ	Learning	Problematizing risk/loss	Score of 1 = not content then positive score of 2, 3, 4 and 5 depending on how content the individual felt in regards to the amount of external financial support	Individual/ Household	Generally yes, requires further research	Yes, high correlation, high degree of satisfaction indicates high resilience	High	Questionnaire	High	Based on own interest

					they received after a flood event.							
107	**Presence of a formal process through which locally-affected communities can draw on government support**	UoN	Resources and Capacities, Actions	Financial, Recovery	Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, presence increases resilience	High	Expert opinion/document-review derived	Low	Literature Research
108	**Presence of a 3rd sector community disaster-loss compensating funding mechanism**	UoN	Resources and Capacities, Actions	Financial, Recovery	Presence of a 3rd sector community disaster-loss compensating funding mechanism: Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, increases resilience	High	- not specified -	Medium	Participatory methods
109	**Presence of county-/municipality-level community funding organisation, capable of collecting donations and distributing emergency and mitigation-related grants**	UoN	Resources and Capacities, Actions	Financial, Recovery	Organisation present - Yes = 1, No = 0	County	This indicator is broadly/universally applicable	Yes, presence increases resilience	High	Key-stakeholder derived	Medium	Participatory methods

110	**Agri-grant scheme funding which can be redeployed to enable recovery activities**	UoN	Resources and Capacities, Actions	Financial, Recovery	No. of Farms enrolled in scheme (GIS layer) or at-risk areas in which scheme is active	Community	Flood specific, but could be generalizable	Yes, presence of scheme increases resilience	Medium	- not specified -	Medium	Expert/Stakeholder opinion
111	**Number of sources from which community-capacity building grants and programmes are funded**	UoN	Resources and Capacities, Actions	Financial, Recovery	Total number of funding sources: 1 – Low, 5 – Med, >10 – High	County	This indicator is broadly/universally applicable	Yes, diversity increases resilience	Medium	- not specified -	High	Expert/Stakeholder opinion
112	**Being content with available resources**	METU	Resources and Capacities	Socio-political	A scale assessing the extent to which community members are content with sources at hand	Individual/ Household/ Community	This indicator is broadly/universally applicable	Yes, high level of contentment indicates higher resilience	Medium	Interviews, focus groups	Medium	Quantitative survey, literature
113	**Gender**	METU	Resources and Capacities	Human	Female/Male	Individual	This indicator is broadly/universally applicable	Yes, male indicates higher resilience	Medium	Questionnaire, interviews	Low	Interviews, Quantitative survey, literature
		KCL	Resources and Capacities	Human	Female/Male - nominal	Individual and by aggregation community of interest/ network	yes	Yes, woman are disproportionately present in the most at risk age group of 75 year olds	High	- not specified -	High	A review of the literature - deductive process

								and above when considering heat waves.				
		UFZ	Resources and Capacities	Human	Female/Male	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
		KCL	Resources and Capacities	Human	quantitative measure - nominal	Individual and by aggregation community of interest/ network	yes	Yes, older age decrease resilience	high	- not specified -	high	A review of the literature - deductive process
114	**Age**	UFZ	Resources and Capacities	Human	Birth year	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
115	**Personality characteristics (neuroticism, extraversion, optimism, etc.)**	METU	Resources and Capacities	Human	Scales for assessing personality characteristics	Individual	This indicator is broadly/universally applicable. Yet, there might be cultural differences in their relation to resilience.	Yes, depending on characteristic	Medium	Questionnaire	Medium	Literature, interviews, focus groups, quantitative survey

		METU	Resources and Capacities	Human	Monthly or annual household income	Individual/ Household	This indicator is broadly/universally applicable	Yes, higher income indicates higher resilience	High	Questionnaire	Low	Quantitative survey, literature
116	**Income**	UFZ	Resources and Capacities	Human	Level of income	Individual/ Household	Generally yes, requires further research	No correlation	- not specified -	Questionnaire	Low	Classical socio-demographic-economic indicators
117	**Years of education**	METU	Resources and Capacities	Human	Years of education	Individual/ Household/ Community	This indicator is broadly/universally applicable	Yes, more years of education indicates higher resilience	High	Questionnaire, focus groups	Low	Literature, focus groups, quantitative survey
118	**Level of school education**	UFZ	Resources and Capacities	Human	Level of school education	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
119	**Level of tertiary education**	UFZ	Resources and Capacities	Human	Level of tertiary education	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators
120	**Type of employment**	UFZ	Resources and Capacities	Human	Type of employment	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionnaire	Low	Classical socio-demographic-economic indicators

121	**Job title**	UFZ	Resources and Capacities	Human	Job title	Individual/ Household	Generally yes, requires further research	No correlation	No relevance	Questionn aire	Low	Classical socio-demograph ic-economic indicators
122	**Peace and equality in the country/region**	METU	Resources and Capacities	Socio-political	A scale for whether or not there is peace and equality in the country/region	Regional/ National	This indicator is broadly/univ ersally applicable	Yes, high level of peace and equality increases resilience	High	Interviews, focus groups	High	Interviews, focus groups
123	**Endorsement of traditional values in the community**	METU	Resources and Capacities	Socio-political	A scale for whether or not the community endorses moral and cultural traditional values	Community	This indicator is broadly/univ ersally applicable	Yes, high level of endorseme nt increases resilience	Medium	Interviews, focus groups	High	Interviews, focus groups
124	**Climate conditions facilitating effective /timely disaster response**	METU	Resources and Capacities	Natural/Pla ce-based	A scale for whether or not climate conditions facilitated effective /timely disaster response	Regional	This indicator is hazard / context specific	Yes, favourable conditions increase resilience	Medium	Interviews, focus groups	Low	Interviews, focus groups

125	**Storage heat flux**	University of Reading	Resources and Capacities	Natural	Biophysical model to calculate (SUEWS) - Comparing model against previous measurements to ensure the model produces reasonable values across of conditions	Neighbourhood /City	This particular indicator is specific for heat wave - but other parts of the development and evaluation - could apply to other hazards (e.g. flood, drought) but not to (volcanic, earthquakes etc.)	Yes	High	- not specified -	Once the model is evaluated, a city ideally would be able to undertake the modelling (we are trying to build a tool). But currently needs support of experts - but developing materials to make interested parties able to perform analysis	Analysis of flux measurements and heat wave conditions to identify if this is what is physically changing when a heat wave occurs. The evaluating the model (SUEWS) ability to model the flux
126	**Satisfaction with life**	METU	Resources and Capacities	Human	A scale for measuring life satisfaction	Individual	This indicator is broadly/universally applicable	Yes, higher satisfaction indicates higher resilience	High	Questionnaire	Medium	Quantitative survey, literature

127	**Being used with hardships**	METU	Resources and Capacities	Human, Socio-political	A scale assessing previous coping capacity/history with hardships	Individual/Community	This indicator is broadly/universally applicable	Yes, high level of coping with previous hardships indicates higher resilience	Medium	Interviews, focus groups	Medium	Interviews, focus groups
128	**Having an effective system for the provision of post-disaster aid and services**	METU	Resources and Capacities, Actions	Socio-political, Response	A scale assessing adequacy and timing of aid and services	Institutional	This indicator is broadly/universally applicable	Yes, increases resilience	High	Interviews, focus groups	High	Interviews, focus groups

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This study has been funded by the

European Commission on the 7th Framework Programme

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