ARL ACADEMY FOR TERRITORIAL DEVELOPMENT IN THE LEIBNIZ ASSOCIATION

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Resilience / robustness

URN: 0156-559919109

This is a translation of the following entry:

Grieving, Stefan (2018): Resilienz/Robustheit. In: ARL – Akademie für Raumforschung und Landesplanung (Hrsg.): Handwörterbuch der Stadt- und Raumentwicklung. Hannover, 2063-2072.

The original version can be accessed here:
urn:nbn:de:0156-55991910

Typesetting and layout: ProLinguo GmbH
Translation and proofreading: ProLinguo GmbH

Recommended citation:
Grieving, Stefan (2018): Resilience/ Robustness.
https://nbn-resolving.org/urn:nbn:de:0156-559919109.

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Contents

This entry describes the concept of resilience as a measure for the ability of a system to resist interferences or changes without the system losing its fundamental qualities and functional characteristics. In this context, the term robustness is understood as a synonym for resilience.

1 Introduction

According to section 1(2) of the Federal Spatial Planning Act *(Raumordnungsgesetz, ROG),* sustainable ▷ *Spatial development* is a guiding principle of ▷ *Spatial planning (Raumordnung)*. Sustainable spatial development strives to ensure that the social and economic demands on space are reconciled with its ecological functions (▷ *Sustainability*). The aim is to achieve a permanent, largely balanced development and structuring of space in accordance with the principles established in section 2(2) of the Federal Spatial Planning Act.

However, climate change (▷ *Climate, climate change*) and other processes of change, such as ▷ *Demographic change*, require a reassessment or expansion of this guiding principle. Sustainable development naturally reduces certain disposition factors (e.g. the vulnerability to certain aspects of climate change). Yet many extreme weather events are caused by natural events as part of an intact environment, which should be permanently preserved in line with sustainability considerations and even fulfil their function (e.g. flooding or forest fires). This illustrates that the guiding principle of sustainable development focuses on stable ecological functions. The relationship between humans and their environment and/or its functions is undergoing fundamental change.

The European Environment Agency stresses this aspect: 'Socio-economic developments (such as greater wealth, or having more assets in risk-prone areas) play a significant and sometimes dominant role in the exposure and vulnerabilities of regions, economic sectors, populations or nature […]. This is the reason why it is important to take into account societal change in both adaptation planning and disaster risk prevention' (European Environment Agency 2013: 20).

Sustainable development cannot be maintained in the absence of a societal focus on resilience and elasticity in relation to creeping environmental changes and climate or weather-influenced extreme events. Accordingly, spatial structures should be developed in such a way that these natural processes do not lead to an impairment of anthropogenic systems (cf. Greiving 2002).

Jakubowski (2013) concludes that societal development, and thus also ▷ *Urban development*, must continue to take economic, social and ecological considerations into account and that today's generations must take the concerns of subsequent generations into account to a far greater extent. But he also warns against unrealistic expectations of people when they forget that development is always associated with more or less significant setbacks (Jakubowski 2013: 372).

This leads to the notion of resilience, which is by no means intended to replace the existing guiding principle of sustainable development, but may expand it in a meaningful way.

Resilience is therefore a response to these new challenges - a term that is understood to go beyond the promotion of security. The aim of resilience is the acquisition of certain properties and capabilities by a system, which enables it to adapt flexibly to challenges such that past crises lead to learning and stabilisation processes.

2 The notion of resilience

The concept of resilience was initially formulated in psychology/psychiatry (Manyena 2006) and was first used by Holling (1973) in the realm of ecology. Resilience measures the ability of a system to withstand challenges. It describes the system's potential to absorb interferences or changes without losing its fundamental qualities and functional characteristics (Holling 1973: 14). The term *robustness* is understood here as a synonym for resilience and is not explicitly further mentioned in this article.

The term resilience has now been widely adopted in the scientific debate about strategies to adapt to extreme events and is also used in the disaster risk and the climate change communities (cf. Costa/Kropp 2012). It relates to a broad range of social, economic, institutional and ecological threats as well as their interactions and partly describes a generic resilience of social groups or societies (cf. Christmann/Ibert/Kilper et al. 2011; Young 2010).

The same line of argument is also advanced by Christmann and Ibert (2012: 259), who oppose the perception that vulnerability is solely a factual susceptibility, and resilience the factual adaptability of systems, which could even be measurable based on certain indicators. These terminological concepts lack the dimension of a social construct, which states that the stakeholders – even in the case of proven threats – may develop quite different perceptions of a potential threat and of the precautions to be taken. Accordingly, it is also important to look not only at the institutionalised stakeholders but also at the various residents and their organisational forms as relevant in connection with resilience.

Applied to socio-economic systems, resilience describes the capacity of a company to learn and adapt to changed (environmental) conditions. Accordingly, the system does not necessarily have to be robust, but rather adaptable and adaptive to new and unforeseen environmental circumstances in the sense of a reorganisation after a disruption (Birkmann 2008: 10). According to this view, a resilient system or society has a high capacity for adaptation and can proactively (i.e. before an event occurs) adjust to changing environmental conditions.

The notion of resilience also includes organisational, administrative and stakeholder structures in addition to the flexibility and adaptive capacity of systems and infrastructures (▷ *Infrastructure*). In this context, the notion of *adaptive urban governance* must be examined (▷ *Governance*). The proponents of this concept rightly argue that resilient systems require not only adapted physical structures but also planning systems and multi-level governance structures must be designed in such a manner that they can respond adaptively and flexibly to changes and take the concerns of all stakeholders into account (cf. Birkmann/Garschagen/Kraas et al. 2010; Wiechmann 2008; Greiving/Fleischhauer 2008).

The notion of resilience is now also incorporated in planning policy documents. For example, the German Strategy for Adaptation to Climate Change reads: 'Spatial planning, by developing guiding principles for adaptable and resilient spatial structures, can play a pioneering role in ensuring a robust and flexible response to the impacts of all societal change processes on spatial structure' (German Federal Government *[Bundesregierung]* 2008: 42).

Yet it is currently not possible to talk of a uniform understanding of resilience, which would take all stakeholders and dimensions of time into account (ARL 2014: 41). The speakers at an ARL conference devoted to the subject concurred in their assessment that research and practice have not yet been able to achieve the ideal in the sense of complex, integral concepts for the systematic development of regional and urban resilience (ARL 2014: 42).

Jakubowski (2013: 377) summarised some of the unresolved research issues in regard to cities as follows:

- How resilient are our cities to external shocks or significant disruptions in development?
- How do cities differ in their adaptability?
- Which factors determine the adaptability or resilience of cities?
- How can we engage urban societies in moving towards resilience?
- What resources does a resilient city require, and how can the funds be generated for this type of defensive investment?
- How can urban development policymakers initiate a discussion on preventive resilience without stirring up fears of a looming crisis?
- Can we forge public-private alliances for resilient urban development?

3 Resilience and spatial development

Nevertheless, the basic elements of resilient spatial development can be outlined. According to his model of the resilient city, Godschalk (2003) sees resilience as an approach to dealing with uncertainty: 'Because we can rarely predict the frequency and magnitude of hazard agents, and because the vulnerability of community systems cannot be fully known before a hazard event, cities must be designed with the strength to resist hazards, the flexibility to accommodate extremes without failure and the robustness to rebound quickly from disaster impacts' (Godschalk 2003: 138; Fleischhauer 2008: 277).

These requirements also affect guiding principles for planning, which –while anticipating to date the guiding vision for sustainable development (*Compact city*, *decentralised concentration*) – do not yet deal with the requirements for resilient development and can even in part conflict with it, e.g. the concentration principle versus redundancy (cf. Greiving/Spangenberg/Zehetmair 2011). This is in particular the case if (technical) infrastructures are located in close spatial proximity in areas that are at a high risk of extreme events, such as river valleys, to minimise fragmentation effects of nature and the landscape. If an extreme event occurs, several or even all transport providers are equally affected. The failure to incorporate redundancy was also a key reason why, in the wake of the Elbe river flood of 2013, the disruption of the high-speed train route between Hanover and Berlin caused a daily delay of one hour in each direction for about 90,000 passengers for five months (*DKKV* [German Committee for Disaster Reduction] 2015: 38).

The guiding principle of resilient spatial development by no means obviates the need for existing strategies for spatial structures. On the contrary, in particular, the guiding principles of decentralised concentration pursued by spatial planning and the corresponding guiding principle

of compact settlement development at the local level in comparison with other spatial structure policies largely correspond to criteria for resilient development (*BMVBS* [Federal Ministry of Transport, Construction and Urban Development] 2009: 9; Jakubowski 2013: 375). The individual criteria are as follows:

- Efficiency: Reduction of the consumption of resources, waste and traffic avoidance to reduce CO_2 emissions
- Exposure: Minimisation of the expansion of the settlement area to reduce the exposure of the settlement areas to extreme events and climate change. At the same time, it serves to maintain CO_2 reservoirs in open space.
- Diversity: A high degree of diversity in the settlement structure, in particular in the alternation of infrastructure, buildings and green spaces, is a prerequisite for a pleasant urban climate.
- Redundancy: Prevention of mono-structural, urban developments to maintain the functioning of the overall system even if individual parts temporarily fail when they are affected by an extreme event. In addition, decentral networks with multiple nodes offer a condition for the use of decentralised energy production from renewable energy sources to reduce CO_2 emissions.
- Strength: Increase the robustness of newly developed settlement areas to reduce the negative impact of (climate-related) extreme weather events or creeping environmental changes

Accordingly, key cornerstones can be formulated, which are based on the principles of sustainable and resilient spatial development:

- sufficiently high density
- open spaces to be created and maintained
- closely-meshed infrastructure network
- prevention of an excessive concentration of infrastructure.

By and large, the foundations of compact settlement development or of decentralised concentration, which are already established in spatial planning, are generally consistent with the requirements for resilient development. Nevertheless, there is to some extent need for optimisation, as bundled and concentrated infrastructures (traffic routes, supply lines) and/or the lack of alternative options (wide-meshed infrastructure systems) increase the vulnerability to climate consequences (e.g. in case of flooding).

The notion of resilience also deserves special mention due to the current transposition of the EIA amending Directive (2014/52/EU) in the Federal Building Code *(Baugesetzbuch, BauGB)*. The amendment of the EIA Directive provides in Article 3(2) for the consideration of climate change and 'disaster risks' in the EIA. In urban land-use planning, the requirements of the EIA as well as those of the SEA are jointly examined in a comprehensive environmental assessment pursuant to section 2(4) of the Federal Building Code ('integrated solution', Battis et al. 2015). The amendment of the EIA Directive thus also triggers the need for a change in the environmental assessment in the Federal Building Code. The impacts on the climate as a protected resource as designated in section 1(6) no. 7a of the Federal Building Code comprise local impacts of climate change. Pursuant to Annex IV no. 5 lit. f, the Environmental Report must in future include a description

of the 'the impact of the project on climate (e.g. the nature and magnitude of greenhouse gas emissions) and the vulnerability [exposure and resilience, cf. the terms under Recital 15] of the project to climate change'. The original English text of the Directive uses the term 'vulnerability' in Recital 15, while the German version translates this term as *Anfälligkeit*. In addition, the German version translates 'resilience' as *Robustheit*: 'For such projects, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment.'[1]

In each case, in future environmental assessments the means must be found to ensure that resilience or robustness can be operationalised (cf. this section), and/or how planning decisions should be taken given an environmental baseline ('evolving baseline trend', EEA [European Environment Agency] 2013) that is changing due to processes of change, such as climate change, that are difficult to forecast.

4 Resilience as a strategy to cope with uncertainty in planning and decision-making

Time and again, ▷ *Spatial planning (Raumplanung)* is exposed to situations where there are varying degrees of uncertainty about future environmental conditions; accordingly, it cannot be securely determined which planning alternative offers the greatest benefit or entails the fewest disadvantages.

Decisions taken in an environment of uncertainty must generally be included in the decision on the planning strategy and must be specifically embedded in the decision-making as part of the weighing of interests (Greiving 2002: 74; Faßbender 2013: 96). The ▷ *Weighing of interests* takes into account the inadequacies of the formalised conditional programmed decision-making programme, where a mandatory legal consequence is usually derived from a clearly determinable, prerequisite set of facts.

This means *de facto* that there is room for discretion both in selecting the analytical method to be used and in the evaluation of its results and the respective decision-making process. In so doing, the justification of the planning must indicate clearly and in detail the facts and forecasts (▷ *Forecasting*) on which the planning relies and the reasons for relying on them. This step requires more than merely schematic and abstract reasoning from the planning agencies. The assessments and forecasts must be plausibly based on the available empirical materials. The justification must explain the methodical approach of the analysis concerned, and the planning agency must base their consideration on this approach (Faßbender 2013: 103 with reference to *VGH* [Higher Administrative Court] Kassel, judgment of 11 March 2011, case no. 4 C 883/10:N, *ZfBR [Zeitschrift für deutsche und internationale Bau- und Bauvergaberecht]* 2011: 486). In this context, the determination of the factual basis and the consistency of the methodical approaches are of great significance for the legal certainty of the weighing of interests in planning terms, which is based on this methodology.

1 "Es ist wichtig, die Anfälligkeit (Gefährdung und Widerstandsfähigkeit) dieser Projekte für schwere Unfälle und/oder Katastrophen, das Risiko des Eintretens solcher Unfälle und/oder Katastrophen und deren Auswirkungen in Bezug auf die Wahrscheinlichkeit erheblicher nachteiliger Folgen für die Umwelt zu berücksichtigen."

But the ultimate purpose cannot solely be overcoming uncertainty through innovations in the methodologies of analysis and forecasting methods, because the input parameters, such as changing climatic and socio-economic factors, will always remain uncertain. Accordingly, the aim is to find ways in spatial planning to cope with uncertainty through flexible, adaptive strategies that follow the guiding vision of resilience (cf. Hallegatte 2009):

- 'No-regret-strategies' provide added value irrespective of the occurrence of potential changes in the frequency and magnitude of natural disasters or the occurrence of certain climate consequences, because they are designed to be multifunctional. For example, de-sealing measures can serve to retain torrential rain but also to improve the living environment and the residential quality in residential neighbourhoods.
- Reversible strategies: Defining specifications primarily in the sense of impact-oriented parametric steering in such a manner that leaves discretionary room to manoeuvre to subsequent planning levels and defining objectives only where they are necessary for overarching spatial and sectoral considerations (Cools/Fürst/Gnest 2003). Parametric steering in this context serves to preserve or gain freedom to manoeuvre in decision-making as a strategy for the compensation of uncertainty through flexibility (Greiving/Pratzler-Wanczura/Sapountzaki et al. 2012). An agreement on objectives records the result to be achieved (e.g. reducing a flooding risk by a certain percentage by a given point in time). As agreements on the result are entered, the regional and local stakeholders gain greater room to manoeuvre both at the level of their strategies and at the level of the specific measures (Greiving 2009). Keeping options open must be seen in this regard as an independent criterion for the weighing of interests, with which decision-making alternatives are assessed (Hiller 1993). When implementing a sectoral or urban land-use planning measure, a final decision on a suitable strategy must then be taken based on the knowledge available at this time.
- Sequential strategies that reduce the decision horizons and strive for medium-term solutions. Descriptions of urban structural development must be prioritised and – in the case of a projected general condition, about which there was uncertainty at the time of planning (e.g. depending on new knowledge about possible risks from natural hazards in the corresponding neighbourhood) – must be activated as secondary building sites or waived. This requires permanent ▷ *Monitoring* of ongoing developments as is in any event already provided for in the ▷ *Environmental assessment* (Article 10(1) of Directive 2001/42/EC of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment [SEA Directive]). A good example for the sequential realisation of planning is offered by the new climate profile for the construction of dykes in Schleswig-Holstein. The first dyke thus built is located on Nordstrand island. In accordance with the new climate profile, the top of the dyke will not only be higher but also wider than usual. 'If the sea level rises to a higher level than forecast in the current climate projections, subsequent generations can add a top to the dyke at short notice and with little additional costs' (*MELUR* [Ministry for the Energy Transition, Agriculture, Environment and Rural Areas of the Federal State of Schleswig-Holstein] 2013).
- Soft strategies: In the course of processes of cooperative ▷ *Regional development*, consensus can also serve as a functional equivalent for legal normalisation even in the case of decisions taken on the basis of uncertainty: the solution on which the stakeholders have jointly agreed is deemed to be correct (cf. Greiving/Fleischhauer 2008). An example of this is the consensual

definition of a rise in the sea level for the purposes of the Western Pomerania Climate Model Project for Spatial Planning *(KlimaMORO)*, on which the participants agreed in the face of the existing bandwidths in the forecasts as the basis for the further planning of measures (*BMVBS* 2014).

- Safety margin strategies: This approach follows the precautionary principle and focuses on measures with 'safety margins'. Safety margin strategies are envisaged, e.g. in Bavaria in the planning of hydraulic engineering systems, such as flood control dams: they add a 'climate margin' of 15% on the design event (HQ 100) to counteract the potential increase of extreme highwater events as early as possible (*LfU* [Bavarian Environment Agency] 2005).

5 Conclusions

Resilience is a concept established in many scientific disciplines, which is of increasing importance in an environment characterised by growing uncertainty in regard to spatial planning activities. However, there is as yet no uniform understanding of this concept. Spatial planning practice and the range of (formal) spatial planning instruments have hitherto been characterised by a low degree of adaptive flexibility. Preserving the status quo and a perpetuity guarantee for building rights are as much in conflict with principles of resilience as the rigidity of spatial plans and their long continuation cycles. Hence, informal spatial development and flexible, discursive approaches should become more significant with or for the establishment of the concept of resilience.

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Last update of the references: January 2017