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First Draft

Towards a framework for assessing urban resilience
Application to a case study in Lyon (France)

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Abstract

This chapter deals with urban resilience assessment tools. It starts by describing a resilient area as one able to face not only shocks but also stresses and dependency. It then shows the limits of the operational implementation of a Cost-Benefit-Analysis to assess the benefits of resilience actions and the need for an alternative decision-making tool for practitioners. It then outlines an original tool to assess the resilience of an area or public space. It describes the six resilience levers of the tool to encourage resilience momentum. At the end of the chapter, the decision-making tool is implemented to assess the resilience of a planning operation in Lyon, France. The discussion concludes on the role of combined

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technical, social and organizational factors as all contributing to resilience and the importance of involving all stakeholders when using this assessment tool.

-1.

Introduction

Resilience is a polysemous concept that is used in different disciplines such as psychology, materials physics, ecology, geography and economics (Cutter et al. 2008; Hernandez, 2009; De Bruijne, 2010). Several definitions co-exist and are sometimes different or even contradictory (Djament Tran et al. 2011). Resilience can be considered as the ability to function in degraded mode (Pigeon and Rebotier, 2016). It can be seen as the ability to withstand a shock without damage or to absorb and recover from a shock (Timmerman, 1981). It is also defined as the ability to adapt to, or resist a hazard (Holland, 1995). In the field of natural and technological risks, resilience contributes to disaster prevention and reduction, and may reflect the aim of putting an area or development operation back to normal or bringing it into equilibrium (CGDD, 2017). This is because an area or development operation are potentially vulnerable and may be subject to hazards, i.e. the possibility of an extreme event occurring that would cause damage and malfunctions. They are qualified as resilient if, whenever this event occurs, they return to their initial situation or rebuild themselves as they were or differently. Resilience is therefore generally understood as the ability to absorb shocks and maintain integrity, through a return to a state of equilibrium or a process of reconstruction (Holling, 2001). Resilience procures the means to react, absorb shocks, renew and reorganize.

However, an approach to resilience based mainly on shocks does not seem sufficient to address the challenges facing urban spaces. It is of fundamental importance to take into account chronic stresses such as drought, economic decline, the receding coastline (CGDD, 2017) and dependencies such as the dependence of the economy of a mid-mountain ski resort on snowfall or the climate dependence of a farming activity. It is all the more important since these threats may be interdependent. Climate change may, for example, increase water stress in some regions or amplify certain extreme weather events. Where urban spaces are concerned, the example of Paris helps us to understand the complexity that a city faces when it seeks to become resilient, and the variety and interdependence of the issues involved. In its resilience strategy, this city identifies six major issues: 1) socio-economic and spatial inequalities; 2) terrorist risk and its economic and psychological impacts; 3) climate change and its impacts: heat waves, drought, violent storms, floods, stress placed on water resources, with impacts on urban heat zones, air pollution, fragility of transport infrastructure and urban services, excess mortality, especially of vulnerable people; 4) air pollution as chronic stress and its impacts on health, the economy and biodiversity; 5) river disturbances (flooding and subsequent decline in water resources) and 6) local governance (understood as interdependence with the areas surrounding Paris, the suburbs and rural areas for food or catchment areas for water management). These issues are not exhaustive and could also include nuclear risks, pandemics, financial and oil shocks, massive strikes, etc. (Hatchuel et al. 2017). They correspond to shocks, such as terrorist risks and flooding, but also to stresses, such as heat waves, air pollution, inequalities or even dependencies, such as the interdependence of areas for food or water resources.

In an urban setting, it therefore seems important to make a central feature of the design of resilience the ability to anticipate in order to reduce the consequences of a shock, and reduce stress and dependencies. Our way of conceiving resilience therefore emphasizes long-term action, and stresses the logic of anticipation and adaptation or even transformation because it is indeed a question of developing *abilities*, *capacitis* or *capabilitis* (Sen, 1985). Taking time into consideration allows us to embrace a wide range of potential threats: shocks, but also stresses

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and dependencies. We think of resilience in a systemic way because, in our opinion, technical, social, economic and spatial factors have an impact on each other (Cerema, 2019).

Today, and in response to the 2010 UN campaign “*Toward Resilient Cities*” (Revet, 2011 cited by Djament-Tran et al, 2011), city practitioners are seeking to improve the resilience potential of the areas or development operations for which they are responsible, which means assessing this potential.

In economics, cost-benefit analysis (CBA) is used to assess the benefits and costs of implementing resilience measures. However, this analysis is difficult to carry out, particularly since the measures are numerous and systemic. A number of them are even what are known as transaction costs. The benefits are typically assessed in terms of the costs of the damage avoided. The difficulty is therefore to monetize the various positive and negative external factors. However, in the absence of a reference value, (such as in transport where the State decides the monetary value of the deaths avoided or the time saved) the exercise is a difficult one.

In addition, the development operations to be assessed have, above all, urban functions. They are not designed only to combat a hazard or stress, as in the case of a dike that may have co-benefits but whose primary function is related to managing a hazard. It is therefore a question of designing urban developments that perform their own function and are resilient. Assessing them by using cost-benefit analysis is tricky, especially when it is known that: Even if this CBA “assessment tool is becoming popular, the methods, elements and indicators needed to adequately identify the whole of the costs and benefits to be considered are still under development” (Pesaro, 2018, 4).

So while the theoretical basis is not yet stabilized, practitioners need a method that can be used *ex ante* and *ex post* to assess the degree of resilience of a development and consider improving it. The assessment of resilience must therefore be able to determine whether, and to what extent, a development or area is adapted to cope with shocks, stresses and dependencies. In this context, the development of a tool that helps urban planners and developers to design urban developments that can withstand or recover from shocks, stresses and potentially harmful dependencies is highly desirable. Such a tool has been designed by Cerema, a French public expert body on ecological transition and regional cohesion. This assessment tool takes the form of an analysis table.

This chapter presents and tests this tool, designed as a table for analysing the resilience of areas or developments. Known as the “Resilience Framework”, it is easily applied across all urban areas and on all objects within the public space (roads, buildings, etc.): from towns to public spaces via local developments.

We will first present the “Resilience framework” tool designed by Cerema (section 2). We will present the levers on which it is based (section 2.1). We will then explain how we used the framework on a development operation, and the alternative methods that can be used (section 2.2).

Next, we will report on how the tool was applied to a development operation that has now been finalized, to illustrate the assessment possibilities that the tool can actually provide (section 3). We will see that the development work examined was considered particularly resilient, firstly because of its ability to take into account the various stakeholders and to incorporate risks as of the design stage to reduce vulnerabilities, and also because of its ability to anticipate (3.1). We will highlight possible areas for improvement, in particular the ability to strengthen local identity and encourage a culture of risk (3.2). We will conclude with considerations about the tool, the assessment of resilience in general and possible methods of using the tool.

-2-

A collective intelligence tool for territorial resilience: the resilience framework

The purpose of this section is to present the assessment tool developed, known as the resilience framework (2.1) and the method used to administer it (2.2).

2.1. Designing a tool for collective intelligence and analysis of the resilience of an area or development work

The objective is to design a tool that can be used to assess whether urban development or an area, taking into account its own specific issues, is able to continue to perform its urban functions in the event of shock, stress and dependence and then return to functional equilibrium, or even adapt or transform itself. This tool must fulfil several functions. It must help planners and local authorities to make decisions when choosing between different projects for the same development, and also allow the project to be assessed once it has been designed.

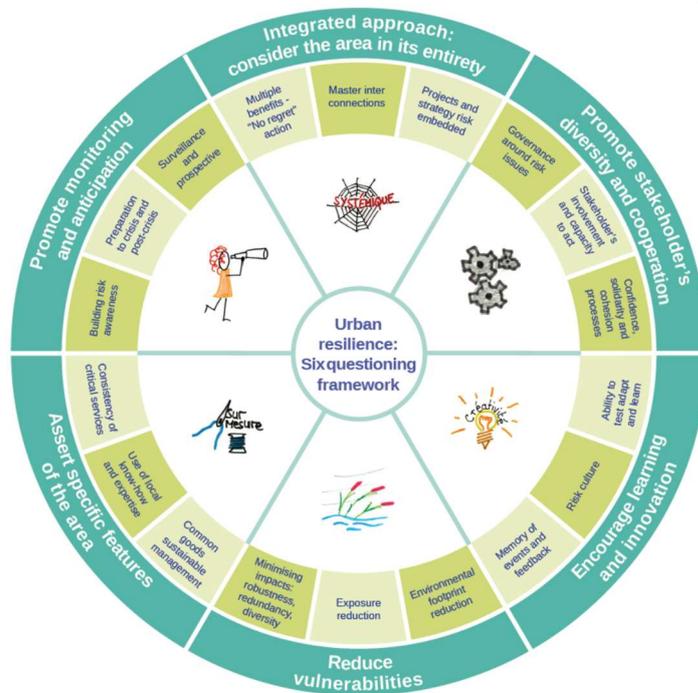
2.1.1 Empirical construction of the framework

The framework is based on six levers. The levers are mainly derived from work carried out and monographs produced by Cerema as part of the “Integrated analysis of territorial resilience” (*Analyse Intégrée de la Résilience des territoires - AIRT*) project led by the French commission for sustainable development of the Ecology Ministry (*Commissariat général au développement durable - CGDD*). They were heralded in the publication “*La résilience des territoires aux catastrophes* (The resilience of regions to disasters)”, (CGDD, 2016). The levers have also been presented to, and developed with, many people working in the field during operational seminars (Cerema 2016; Cerema, 2017; Cerema, 2019). This feedback has led to the emergence of six levers and eighteen sub-components as a common denominator promoting resilience dynamics (see fig. 11.1). This framework applies to all types of regions or public policies in a context of global resilience. It can also be used on more specific developments, across a district for example, on specific themes (mobility, etc.) and within the context of one or more specific risks.

2.1.2 The six levers of resilience

These levers of the resilience framework define, so to speak, the main actions to be carried out across an area or within a project to move towards greater resilience.

Figure 11.1 The resilience framework - ©Cerema



The first lever is the “integrated approach to the area”. Regions are facing many risks, some of which are new. This lever makes it possible to cross-reference sectoral themes such as infrastructure, buildings, the environment and energy. Several scales of time and area are taken into consideration. An integrated approach will take co-benefits into account. For example, nature-based solutions will help combat urban heat zones, reduce runoff, promote biodiversity and improve air quality. These solutions will also contribute to the well-being of users. Introducing actions with multiple benefits in different areas is a sign of resilience. Conversely, protecting against flooding by building a dike, as an isolated project, may have adverse effects by limiting the area of flood expansion, although floods fertilize agricultural land and promote the reproduction of certain fish species. Dikes make wetlands disappear and increase the speed of currents that contribute to erosion, not to mention the maintenance costs that these structures incur. As will have been understood, the difficulty is to assign a value to all the positive and negative externalities. Considering the area in its entirety, integrating risks, opting for cross-disciplinary and multi-benefit approaches and promoting cooperation between regions is the solution adopted.

The second pillar is entitled “Stakeholder diversity and cooperation” (inclusive approaches). Developing a regional approach to resilience makes it possible to offer a framework for dialogue to the various stakeholders, whether these be elected representatives, users, technicians, business representatives or citizens: “Moreover, these actions have to consider the whole of the exposed and damaged components of a community at the same time (non rivalry) without excluding anyone, no matter what gender or social conditions (non excludability)” (Pesaro, 2018, 3). Through dialogue stakeholders will become aware of each other’s

imperatives and the importance of collectively developing responses adapted to the realities on the ground. This makes it possible to overcome blockages and create links based on trust between those involved, who can be called upon in the event of a crisis. Collaborative projects should be encouraged, not isolated ones. If resilience is considered a common good then public governance for the development of a regional approach to resilience is fully justified (Pesaro, 2008). This leads to the recognition that there is a market gap: economic players cannot produce the conditions for resilience on their own; the intervention of public authorities (the State or a local authority) is necessary here. The City of Paris' resilience strategy, for example, was jointly constructed through collective intelligence workshops attended by a total of 800 stakeholders. Institutional and economic entities, associations and citizens have contributed to building an action plan around the “will to build a more inclusive city based on its inhabitants” (Cerema 2019). The approach is also based on cooperation with the network of 100 resilient towns and with neighbouring municipalities.

The third pillar, entitled “Learning and Innovation”, invites stakeholders to engage in a learning process, by asking questions, particularly about past events. But one must be able to break away from this past because the same causes do not necessarily produce the same effects. So we have to ask ourselves the following questions: “Are we able to make different decisions today? Are we safe from making such a mistake again? How can we avoid such damage next time? ” Learning and innovation can be brought into play through calls for projects such as the Rhône Plan. Launched in 2017, the Rhône Plan involved local authorities and organizations to raise awareness of the risk of flooding by the use of tactile models, soundwalks and serious games. The innovations are not only digital, they are also organisational, such as the steering committees of the local flood risk management strategy.

The fourth lever, “Disaster Risk Reduction (DRR)”, is based on explaining the “acceptable risk” resulting from a choice between the cost of protection solutions and the acceptability of a level of damage. We know that not all the people involved will give the same weighting to the acceptability criteria. Infrastructure managers, for example, will be attentive to service continuity or resumption, while emergency services will attach importance to the safety of people and security of property. The resilience exercise for this lever will involve making stakeholders reveal their preferences in order to choose acceptable adaptation and protection measures. Reducing the vulnerability of critical infrastructure and networks is therefore a major lever of resilience during disasters, in particular to help the area recover rapidly. The aim is to reconcile the sometimes conflicting interests of energy, telecommunications, water, sanitation and transport network operators and the relevant local authorities.

The fifth lever, “Identity and specific features of the area”, is based on the fact that an area that relies on its own resources and protects its common goods finds its resilience strengthened, reduces its dependence on the outside and guarantees the survival of its inhabitants. To do this, knowledge of the area and how it works is essential to understand how it was built and what structured it. Local culture, the memory of crises and disruptions are part of its identity: *“This means that, starting from a similar territorial capital, the characteristics and the image of the area may deeply differ, producing different exposure and vulnerability profiles”* (Pesaro, 2018, 1). By setting the area within the context of its history and projecting one or more possible future scenarios for it, stakeholders can take ownership of it and incorporate it within a larger scale, in keeping with the challenges being considered.

The sixth lever, entitled “Monitoring and anticipation”, is based on a forward-looking approach founded on knowledge of the area’s past and present in order to better anticipate any disruptions that may arise and take measures to prevent them. This promotes better organization during major crises and stresses, or optimized trajectories in the face of future change. In the event of

identified threats, such as volcanoes or landslides, this approach is implemented naturally. It is also useful in the event of poorly defined hazards, or to analyse the interdependencies of risks in situations of complexity and uncertainty. The aim is to think about the scope of possibilities when a planned procedure corresponding to a scenario identified in advance cannot be referred to. In France, the role of the *Observatoire régional des effets du changement climatique* (Regional observatory of the effects of climate change) in Auvergne-Rhône-Alpes is to collect and analyse data, and to lead networks of stakeholders so that they incorporate the effects of climate change into their projects.

2.2. Methodology for using the resilience framework

For urban development, the resilience framework can be used *ex-ante* or *ex-post*. It can be used for the same development by the different parties involved in the urban project, in particular inhabitants and/or users. The use of collective intelligence methods is particularly recommended. Not only the developer but also those involved in the economic set-up of the project can be involved: different urban resource management agencies; the project manager; the various companies; the engineering departments of the local authorities in charge of maintaining and managing of the public space in which the development is deployed, such as the road department, the water department; users and residents, or members of neighbourhood life associations.

2.2.1 Ex-post: discussion, assigning points and revealing forgotten issues

In the case of an *ex-post* assessment, the interviewees are asked to list the aspects of the project that do or do not involve resilience for each of the six levers of resilience and each of the three sub-components.

At the end of this examination, the interviewees give one point for each time at least one sub-component is fulfilled by the development carried out. A maximum of three points can therefore be assigned to each lever, even if several aspects contribute to achieving this issue. Conversely, if an aspect shows that one of the sub-components is not taken into account, a minimum of zero points can be assigned. Each lever can therefore receive between zero and three points. The development can therefore receive a minimum rating of 0 and a maximum rating of 18 points. The tool therefore makes it possible to assign a final score to a development. It can also be used to compare it with others. But perhaps the most interesting feature of this tool is its ability to qualitatively assess a development. This is because it shows whether the various initial issues have been reconciled and reveals the complexity of the thinking undertaken.

2.2.2. Ex-ante: laying the foundations for a resilience strategy

The framework can also be used *ex-ante* to lay the foundations for a resilience strategy. Three stages are necessary for this (Cerema, 2017).

The first stage is a shared diagnosis of the area. The aim is to involve the widest possible collective of stakeholders to build a shared vision of the area. The framework is then used to raise awareness of resilience among stakeholders, share knowledge and a representation of the area, identify local risks, threats, weaknesses and strengths, and finally select the main issues.

The second stage aims to build a unifying resilience strategy, through a hierarchical action plan that responds to the issues identified in the first stage. Each action or initiative should make use of as many resilience levers as possible, integrate and/or synergize sectoral projects and choose a few flagship projects.

The third and final step is to implement, monitor and assess the planned actions in a cross-cutting manner, while linking them to the running of sectoral projects. The control of communication about the project, and the monitoring and assessment process for the approach will be based on a choice of indicators.

-3-

The resilience of Place de Francfort in Lyon: an integrated approach, diverse stakeholders and Disaster Risk Reduction (DRR)

The resilience framework was used to make an *ex-post* assessment of the level of resilience of a recent development in Lyon: the requalification of Place de Francfort (3.1). We chose to use the resilience framework, given the difficulty of carrying out a cost-benefit analysis of the development. This is because it is extremely difficult to monetize the reduction of urban heat zones and the reduction of runoff. Following an interview with the operation managers of the *Société d'aménagement de la Part Dieu*, responsible for designing and managing the development of this public space, the framework was used in-house at Cerema by four of the co-authors of this section. The method revealed that this urban development had a high level of resilience (3.3).

3.1 Place de Francfort: a gateway to Lyon's metropolitan area with high urban challenges

Place de Francfort measures 8,500 m². It is the gateway to the Lyon metropolitan area for airport and rail passengers. It is an integral part of the multimodal interchange hub of the Part-Dieu railway station, one of the busiest in France with more than 31 million passengers per year. Over 30,000 pedestrians pass through it daily and it features many hardscape materials that make it a major urban heat zone in the very heart of Lyon. As a result, quality of life and comfort of use are significantly affected during heat waves that tend to occur more and more regularly as a result of climate change. In addition to improving connections between the various means of transport (connections with the bus station, the tramway, the railway station, etc.), improving how it operates and serves all users (passengers in transit, residents, local employees and tourists), the redevelopment of the square must also improve the comfort of pedestrians. The square is divided up into several distinct uses that connect with each other: a drop-off car park for private vehicles, which will eventually be occupied by buildings; a bus station for coaches and a pedestrian square measuring nearly 4,300 m².

Figure 11.2 Place de Francfort ©cerema



3.2 Innovative developments to adapt to climate change

One of the main focuses of the requalification operation was to improve the bioclimatic atmosphere of the square by combining three actions. Action 1 consisted in limiting surface temperatures by using light grey granite paving stones with a higher albedo¹ than black asphalt, the initial surface covering. Action 2 enabled the efficient use of rainwater through an alternative rainwater management system by helping water to infiltrate through a German-made porous joint between the paving stones and preparing a subsoil with a high water absorption capacity, helping to irrigate the trees. Action 3 is based on dense planting of 93 trees separated from each other by 5 m steps and planted in a single container so that their roots can communicate. The tree species were chosen to withstand extreme hot temperatures. Each tree is inserted into a ring that allows people to move around as close as possible to the tree. This ring is designed to expand as the tree grows.

3.3 The development Place de Francfort: relatively well-reconciled objectives

We (four of the five people who signed this paper) made an *ex-post* assessment of the layout of Place de Francfort using the Resilience framework. We have listed the factors pertaining to resilience for each of the six levers of resilience and each of the three sub-components. Our assessment revealed a number of points and a very positive overall evaluation.

Concerning lever 1, “Consider the area in its entirety”, we consider that the development carried out takes into account the benefits and co-benefits and that the action is “no regrets” because it benefits the area, apart from the fact that it has also been designed to meet the challenges of climate change. We identify no particular dependency. In our opinion, the risks were properly taken into account in the design, since an experimentation table was installed to test several

¹ Albedo is the power of a surface to reflect sunlight.

innovative surface covering and planting solutions. The materials were subjected to hot temperatures and various uses, including the movement over them of people with reduced mobility. Soil studies (permeability and groundwater level) highlighted the feasibility of rainwater infiltration and contributed to the design of the structures. And urban security issues, including the risk of terrorism, led to a choice of tree species that do not hide cameras. Our assessment is therefore 3/3 for this lever.

For lever 2, “stakeholder diversity and cooperation”, we give a positive assessment of the work that the developer has done upstream with the departments that will carry out maintenance of water, roads and green space, and that done with associations of users with reduced mobility. For tramway crossings, the same surface covering as in Place de Francfort was used to guide users to the bus station. For these reasons, we gave a score of 3/3 for this lever.

Concerning lever 3, “Encourage learning and innovation”, we consider that the developer could have done more by displaying informative posters on the site. We know that when knowledge is non-existent or incomplete, it is necessary to experiment, and to adopt flexible means of action, which can be adapted over the long term according to unforeseen events. The developer was able to adapt and manage uncertainty by testing the albedo of the paving stones, modelling the urban heat zone, or assessing the comfort of wheelchairs running on the materials used. It strongly encouraged its suppliers to innovate. Our assessment is 2/3.

For lever 4, we believe that disaster risk and exposure have been reduced. This is because in the event of runoff, soil studies have demonstrated the feasibility of rainwater infiltration and have helped to design the structures. In addition, in the event of heavy rains, the square works because of a slope that discharges water into the drains. However, we highlighted certain concerns, such as the possible case of joint clogging because of stress, dirtying of the ground that will become darker or trees falling in the event of a storm. How responsive would the services be? Nevertheless, technical robustness is quite good because the solutions are not based on a complex technological system. Redundancy concerns the possibilities of shifting flows in the event of the square being closed and the fact of their being two different entrances to the station. Our rating is therefore 2.5/3.

For lever 5, “Assert specific features of the area”, we regret the fact that no aspect affirms the local features of the place, especially since the paving stones come from Germany. We know that resilience also depends on the preservation of local commons. Here the groundwater table is replenished by rainwater infiltration and the ground is designed to retain large particles of pollution which is very positive. Our rating is therefore 2/3.

Concerning the 6th and final lever, “promote monitoring and anticipation”, our assessment is very positive and we give a rating of 3/3. This is because many diagnoses of the area have been carried out in order to design actions suited to the environment where they will be carried out: urban heat zones and the choice of trees that can withstand heat. Runoff studies to select joint permeability with an estimate of the level of rainfall intensity with which the site is potentially confronted have been carried out. In addition, consideration has been given to crisis and post-crisis preparedness. If there is a shock on Place de Francfort, pedestrians could be re-routed.

Fig.11.3 Assessment of Place de Francfort in Lyon using the Resilience framework tool @cerema

	Consider the area in its entirety (integrated approach)	3/3		Reduce vulnerabilities	2.5/3
	Stakeholder diversity and cooperation (inclusive approach)	3/3		Assert specific features of the area	2/3
	Learning and innovation	2/3		Promote monitoring and anticipation	3/3

The *ex-post* assessment of the requalification of place de Francfort using the Resilience framework gives a score of 15.5/18.

-4-

Conclusion

Our primary objective was to produce a tool to help better understand the levers that promote resilience dynamics.

We achieved this by means of a framework that was administered in-house at Cerema and with the help of the operations managers of the Part Dieu development company in Lyon. On the basis of this first assessment work, we are able to present the factors that make up the resilience of the Place de Francfort.

This assessment is only one illustration of what can be done with the resilience framework. The tool was not used according to the methods of collective intelligence, which would have allowed the various stakeholders to compare their points of view. All these steps should be carried out in order to complete the assessment of Place de Francfort. A “world café” type workshop could be useful. During this workshop, each of the six levers would be presented on six different tables. The various stakeholders would share their assessment of the development with respect to each of the levers by moving from one table to another. A group leader could report on the proposals made by the previous group, thereby allowing those present to draw inspiration, to react, and go into the assessment and proposals for improvement in more depth.

The results obtained using the resilience framework confirm our approach. We believe that conducting an assessment requires indicators to be produced in order to objectify resilience. Insofar as there is no standard or reference value, apart from regulation, on the levers identified by this tool, the assessment conducted here can produce only a discourse, or qualitative assessment. Nevertheless, the resilience framework remains operationally relevant. The tool has a hermeneutic function. It is there to question upstream or downstream. It also makes it possible to share knowledge and clarify political decisions as to the degree of risk, stress or dependency accepted for the development of the operation in question. In this way, it makes it possible to objectify decisions.

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