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The capability concept - on how to define and describe capability in relation to risk, vulnerability and resilience

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Abstract

Capabilities-based planning and capability assessment are high on the agendas of several countries and organisations as part of their risk management and emergency preparedness. Despite this, few definitions of capability exist, and they are not easily related to concepts such as risk, vulnerability and resilience. The aim of the present study was thus to broaden the scientific basis of the risk field to also include the concept of capability. The proposed definition is based on a recently developed risk framework, and we define capability as the uncertainty about and the severity of the consequences of an activity given the occurrence of the initiating event and the performed task. We provide examples of how the response capability for a fictive scenario can be described using this definition, and illustrate how our definition can be used to analyse capability assessments prepared according to the Swedish crisis management system. We have analysed the content of 25 capability assessments produced in 2011 by stakeholders on local, regional and national level. It was concluded that none addressed uncertainty to any appreciable extent, and only a third described capability in terms of consequences and task, making it difficult to relate these capability assessments to risk assessments.

Keywords: capability assessment, capacity assessment, risk and vulnerability assessment, resilience, emergency management, definition

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1 Introduction

Modern societies are becoming increasingly complex [1,2]. The systems that society depends on, such as the transport system, financial systems and the electricity distribution system, are becoming more interconnected [3,4] and are being transformed into a so-called 'system of systems' that covers vast geographical areas, sometimes crossing national boundaries or continents. At the same time, the management of these systems is becoming increasingly fragmented [5]. Since the actors involved may have different objectives and concerns, the management of risk in the context of complexity, uncertainty and ambiguity poses a considerable challenge [6,7]. Increased dependencies and institutional fragmentation mean that the assessment of the ability of society to deal with disruptions is becoming practically, as well as methodologically, more difficult.

Increased attention to strengthening our ability to deal with, adapt to, and recover from disruptions also influences the management of risk. Concepts such as societal safety [8], resilience [9,10] and the establishment of national security strategies with a whole-of-government approach [11] exemplify this development. This means that actors focus on both assessing the immediate effects of undesirable events and on how society can deal with secondary effects and continue or resume their vital functions. Moreover, in order to prepare for a wide variety of threats and risks, instead of simply preparing for specific scenarios [12], several countries have adopted a capabilities-based planning approach and have implemented capability assessment as part of their risk management efforts [13–17]. However, it is not clear how capability assessment is related to other risk management activities such as the assessment of risk, vulnerability and resilience. Moreover, most of the definitions of capability seem to have no established relation to important concepts such as risk, vulnerability and resilience. The aim of the present study was, therefore, to investigate these relationships.

We believe that the *concept* of capability and the way in which it is related to other important concepts such as risk, vulnerability and resilience, must be investigated, and that we should study how the *methods* of capability assessment are related to methods of risk assessment (and the assessment of vulnerability and resilience). The present study deals with the first of the two issues mentioned above, with the aim of broadening the scientific basis in the field of risk to include the concept of capability. The second issue has been investigated in a previous study [18].

We start by analysing previously suggested definitions of capability. Based on these, we then suggest a new definition of capability that is in line with current definitions of risk and other key concepts. A very important aspect of our proposed definition is that capability is always related to something that one wants to achieve. That is not the case for many of the other definitions. We then exemplify the suggested definition, and illustrate how it can be used to analyse real capability assessments produced in Sweden. Assessments produced by twenty-five actors on all administrative levels in Sweden (local, regional and national) are included in the empirical material. Finally, we present and discuss the conclusions of our findings.

2 Review of the definitions of capability

The concept of capability is used frequently in scientific literature. A search in the worldwide abstract and citation database Scopus [19] in May 2014 with the query *capability* yielded some 500,000 results, while *capability AND risk* yielded nearly 34,000

results. However, despite the fact that researchers and practitioners frequently use the concept of capability, they rarely seem to define it. Some of the definitions of capability related to risk and emergency management found in the scientific literature, legislation and guidelines are given below.

1. Capability are the characteristics, abilities and resources that facilitate a specific, or predictable response [20, p. 13].
2. Capability is defined as a special type of resource – specifically, an organizationally embedded nontransferable firm-specific resource whose purpose is to improve the productivity of the *other* resources possessed by the firm [21, p. 389].
3. Capability refers to the resources, systems, structures and processes necessary to deliver – currently and in the future – the required level of performance in fulfilment of the mandated objectives [22, p. 403].
4. Capability is the framework an organization needs to make use of assets and skills (assets being resources, competence and knowledge, and skills being the capacity an organization has to manage external conditions or events) [23].
5. Capability are the attributes of an organization, such as financial, physical, and individual/organizational capital, that enable it to exploit its resources in implementing strategies [24, pp. 439-440].
6. Capabilities refer to a firm's capacity to deploy resources, usually in combination, using organizational processes, to affect a desired end [21 p. 388].
7. Capability is the ability and capacity to attack a target and cause adverse effects [25, p. 293].
8. Capability is crisis management capacity and the ability in societal functions to withstand serious disruptions [26, p. 77].
9. Capability is a demonstrable ability to respond to, and recover from, a particular threat or hazard [27, p. 4].
10. Capability is defined as capacity, and in terms of the financial, technical, effective policy, institutional, leadership, and human resource capacities that local government bodies must have in order to perform activities in all stages of routine emergencies [24, pp. 440-441].
11. Capability stands for all possible factors with which the final outcome of disasters and crises can be influenced positively [13, p. 13].
12. Capability are distinct critical elements necessary to achieve the National Preparedness Goal [15, p. A1].
13. Emergency response capability can be seen as a set of triplets corresponding to the three questions: What can happen when an actor is performing a specific task, given a specific context?, How likely is it?, What are the consequences, for the performance measures defined for that particular task? [28].

From the above definitions, five trends emerge regarding the definition of capability: (1) capability is equated to resources, (2) resources constitute an important component of capability, (3) capability describes the ability to do something, (4) capability is a capacity, and (5) capability is a factor affecting an outcome or goal. Some of the definitions contain only one of these characteristics, whereas others contain several. For example, according to definition 1, capability is equated to resources *and* is the ability to do something. Definition 2, on the other hand, only states that capability is the same as resources. In summary, in definitions 1-3 capability is equated to resources, definitions

4-6 state that resources constitute an important component of capability, definitions 1, 7-9 and 13² state that capability is the ability to do something, definitions 6-8 and 10 state that capability is a capacity, and definitions 3, 6, 11-12 state that capability is a factor affecting an outcome or goal.

In terms of the usefulness of the definitions, the first two groups appear to be easy to comprehend and use, since describing the available resources is usually not particularly difficult. However, they are problematic since it is difficult to relate such lists of resources to the key concepts of risk, vulnerability and resilience. The fourth group implies that capability is a capacity, and capacity is often used in the same context as, or as a synonym for, capability. The United Nations Office for Disaster Risk Reduction (UNISDR), for example, has capacity development high on their agenda [29,30]. In this context, capacity refers to the ability to prepare: for example, the ability to perform risk assessments, to plan, and to carry out training exercises. The ability to prepare (capacity) affects the ability to respond (capability), and we believe that the field of risk would benefit from including the concept of capacity explicitly in existing frameworks. However, this falls outside of the scope of the present paper, which deals with the ability to respond (capability).

Since capabilities-based planning is gaining ground all over the world, we believe it is important to be able to relate the concept of capability to the concepts of risk, vulnerability and resilience. Moreover, it seems reasonable that the capability to respond should include more than simply the available resources. Resources may suffice in the case of a mild event (high capability) but they may not following more serious events (low capability). Thus, capability depends on the event, and what must be done with the resources in response to that event. This is in line with the third group of definitions – the ability to do something. This is also in line with the dictionary definition of capability: “*the power or ability to do something*” [31]. In our view, this group constitutes the best basis for further development, and was used as a starting point for our definition, which extends beyond a list of resources, and is related to already established definitions of risk, vulnerability and resilience.

3 Definition of capability

There are several definitions of risk, vulnerability and resilience, see for example [32,33] for lists of definitions. Since definitions of risk, vulnerability and resilience are often used together in a risk management context, Aven [34] has created a framework that relates these key definitions to each other. The cornerstones of this framework are events (A), consequences (C) and uncertainties (U), which we consider to be important in relation to capability. As discussed in Section 2, events are important as they determine, for example, whether the capability to deal with them is high or low. Capability is closely related to consequences in the sense that the capability will affect the outcome of an event – high capability leading to milder consequences, and vice versa. Since we are interested in future events, uncertainties play a central role. The ACU framework thus offers the opportunity to incorporate capability. In fact, the definitions

² Definition 13 does not explicitly use the expression “the ability to [do something]”. However, the first question asked in the definition is closely related to the ability of doing something.

of risk, vulnerability and resilience in this framework implicitly include capability through the consequences, as these are said to depend on performance barriers (e.g. resources, level of competence and management attitude) [34]. However, since capability is assessed separately or in parallel with risk and vulnerability assessments (as opposed to being an integrated part of risk and vulnerability assessments) in some countries [13,16], we believe it is important to explicitly define and operationalize the concept of capability in order to strengthen the value and usefulness of such assessments.

3.1 Capability and the ACU framework

According to the ACU framework, risk, vulnerability and resilience are defined as follows [34, p. 518]:

- risk is the uncertainty about and severity of the consequences of an activity,
- vulnerability is the uncertainty about and severity of the consequences of the activity given the occurrence of the initiating event A: vulnerability = (C, U | A) and
- resilience is the uncertainty about and severity of the consequences of the activity given the occurrence of any type of A: resilience = (C, U | any A, including new types of A).

To define capability and relate it to these definitions, we use a set of assumptions as our point of departure. First, we associate capability with an *agent* (an organisation, a person, a technical system or anything, the capability of which we wish to describe). Thus, when we speak of capability, we must say *the capability of [the agent]*. Secondly, as discussed above, we should relate an agent's capability of *doing something*. Thus, we cannot simply talk about *the capability of the agent*, but should say, *the capability of the agent to [do something]*. We call this the task (T). Thirdly, since we are focusing on the capability to respond to emergencies and disturbances, capability should be related to some type of event. Moreover, we assume that the agent performs the task with one or several purposes in mind, and that the consequences (C_T) reflect the effect of performing the task in the event. Based on these assumptions, we define the capability of an actor to perform the task in an event as:

$$\text{Capability (definition)} = (C_T, U | A, T),$$

which can be interpreted as the uncertainty about and the severity of the consequences of the activity given the occurrence of the initiating event and the performed task. The uncertainties reflect that we do not know what the consequences associated with the performed task will be. The consequences associated with the performed task reflects both the capability to perform the task (the degree of success) and the incapability of performing the task (the degree of failure). The difference lies in focusing on what *can* be done that will affect the consequences (capability), rather than on what cannot be done (incapability). Say, for example, that we want to assess the capability of an agent to evacuate people due to a flood. We should then express the consequences in relation to the capability as a potential measure of magnitude related to the successful evacuation of people. This could be the fraction of people evacuated within a certain time. If we want to express the incapability, we would express the consequences in relation to the number of people not evacuated. Other consequences not associated with that specific

task, for example, the extent of a power failure as a result of the flood, are irrelevant, since they are not affected by performing the task of evacuation.

Recalling the list of definitions of capability in Section 2, we can see that only three of the reviewed definitions (1, 9, 13) indicate that capability must be associated with an event, whereas the other definitions refer to a general capability, or completely disregard the issue. Furthermore, six of the definitions (3, 6-7, 11-13) contain some element that refers to the consequences, for example, through expressions such as effect, goal or outcome. Only two definitions contain elements regarding uncertainty (3, 13). Thus, several of the reviewed definitions resemble ours in *some* aspects, but none of them includes *all* the components necessary for the definition to be incorporated into a risk framework, except definition 13 presented by Jönsson, Abrahamsson and Johansson [28], which uses the risk definition of Kaplan and Garrick [35] as the point of departure. Our proposed definition resembles theirs in some respects: both definitions acknowledge events (scenarios), uncertainties (probabilities), consequences and tasks as core components. However, the underlying risk frameworks constitute a fundamental difference. Kaplan and Garrick model risk as a quantitative concept, where probabilities represent the uncertainties. In our definition, we can describe the uncertainties quantitatively as well as qualitatively.

4 Description of capability

In order to assess capability, it is necessary to describe it. A description of capability based on our definition includes descriptions of the initiating event, the performed task, the consequences associated with the performed task, the uncertainties concerning these consequences (Q) and the background knowledge (K), which form the basis for these descriptions. A description of capability can thus be expressed as:

$$\text{Capability (description)} = (C'_T, Q, K \mid A, T).$$

The uncertainties may be expressed in several ways, and the description of the uncertainties may take various forms. As pointed out by Aven [36], the most common tool used to describe uncertainties is the subjective (knowledge-based, judgmental, Bayesian) probability (P), interpreted by an urn standard [37]; i.e., if the probability is 0.1, the assessor has the same uncertainty (degree of belief), as drawing a particular ball out of an urn containing ten balls under standard experimental conditions. The measure P describing the uncertainties is subjective, and is dependent on the assessor's background knowledge. A description of capability following this approach thus involves the use of subjective probabilities to describe the uncertainty regarding the consequences associated with the performed task conditional on the fact that the event occurs and the task is performed. Moreover, it also involves the description of the background knowledge that forms the basis for the assessment. Similarly to descriptions of risk and vulnerability [cf. 34], the background knowledge is an integral part of the description of the capability. In producing representations or descriptions of uncertainties and consequences, it may be necessary to use various assumptions, for example, models, previous experience and/or logical reasoning. Such information is crucial for our understanding of capability, and should be included in its description. Other ways of describing probabilities for this purpose are frequentist probabilities and probability models based on such probabilities, but they should be considered to be aspects of the consequences associated with the performed task.

A simplified example is given below, which describes the capability of the rescue services to protect people in the case of severe flooding. The example is discussed in Section 4.2, and important aspects of the descriptions of capability are highlighted.

4.1 Example of the description of capability

In this example, it is assumed that two residential areas located close to a river might be flooded if the water level rose suddenly. The consequences of a flooding event will vary depending on whether the local rescue services are successful in protecting the areas using mobile flood barriers, or in evacuating the residents. It is also assumed that, given the current equipment, manpower and training, the rescue services can only protect one of the areas using mobile flood barriers. Area 1 has 2,000 residents compared to area 2 with 1,000 residents and, therefore, the rescue services will attempt to protect area 1 using barriers. Simultaneously they will attempt to evacuate the residents from area 2, and the residents from area 1, should the attempt to protect that area using barriers fail. Below we provide a description of the rescue services’ capability to protect the residents in areas 1 and 2 and the description is illustrated in Figure 1.

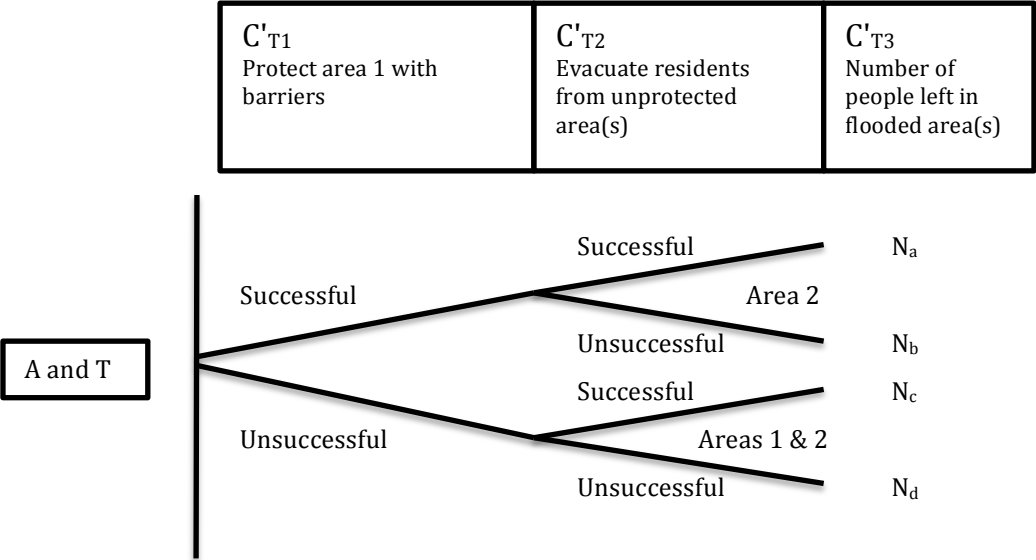


Figure 1. Illustration of the description of the capability of the rescue services to protect people in the case of severe flooding.

In this example, the event is flooding, and the task is that of protecting the residents. These are “fixed” components determining the description of the capability. The two fixed components can be described as follows.

- A:** The water level in the city rises 2 metres above the mean water level. Two residential areas (areas 1 and 2) located close to the waterfront are flooded.

T: The task, which will be performed if the event occurs, is to protect the residents in the threatened areas against flooding. This can be achieved by erecting mobile barriers or by evacuating the residents.

Let us now consider the consequences associated with the performed task. In the present example, three aspects of the consequences are deemed sufficient to reflect the effect of the efforts of the rescue services: whether they succeed in protecting area 1 from flooding using mobile flood barriers; whether they succeed in evacuating the residents from flooded areas; and how many people are left in flooded areas. The description of the consequences associated with the performed task is more complex than those of the event and the task since we cannot know beforehand what the consequences will be. It is, therefore, necessary to describe the various consequences that might occur as a result of the event and the performed task.

C'_T: The consequences associated with the task of protecting the residents from flooding can be expressed in terms of: whether area 1 is successfully protected with barriers or not, C'_{T1} , whether the residents in unprotected areas are successfully evacuated or not, C'_{T2} and the number of people left in flooded areas, C'_{T3} .

If the rescue services are successful in protecting area 1, and the evacuation of area 2 is successful, no people (N_a) will be left in area 2 when it is flooded.

If the rescue services are successful in protecting area 1, but the evacuation of area 2 is unsuccessful, approximately 300 people (N_b) will be left in area 2 when it is flooded.

If the rescue services are unsuccessful in protecting area 1, but the evacuation of both areas is successful, then no people (N_c) will be left in areas 1 and 2 when they are flooded.

If the rescue services are unsuccessful in protecting area 1, and the evacuation of the areas is also unsuccessful, then approximately 800 people (N_d) will be left in areas 1 and 2 when they are flooded.

The description of the consequences thus includes consequences directly related to the task at hand (C'_{T1} and C'_{T2}) and consequences related to the reason for performing the task (C'_{T3}). In the present example, the reason the rescue services perform the task is that they want to protect people from flooding (we disregard the fact that they might also want to protect property). As a *means* of fulfilling that purpose, they need to build barriers and evacuate people.

In addition to describing the consequences associated with flooding and the rescue services' attempt to protect the residents, the uncertainties must also be described. Here we have chosen to use probabilities to express the uncertainty associated with the consequences.

Q: The probability of the rescue services succeeding in protecting area 1 given the occurrence of the scenario in question is assessed to be 0.9.

The probability of successful evacuation given that the rescue services only need to evacuate one of the areas is assessed to be 0.8.

The probability of successful evacuation given that the rescue services need to evacuate both areas is assessed to be 0.5.

The probability that 0 people will be left in flooded areas, given *successful evacuation* of area 2 when area 1 is *successfully protected* by barriers is assessed to be 1.

The probability that 300 people will be left in flooded areas given *unsuccessful evacuation* of area 2 when area 1 is *successfully protected* by barriers is assessed to be 1.

The probability that 0 people will be left in flooded areas given *successful evacuation* of both areas 1 and 2 when area 1 is *unsuccessfully protected* by barriers is assessed to be 1.

The probability that 800 people will be left in flooded areas given *unsuccessful evacuation* of both areas 1 and 2 when area 1 is *unsuccessfully protected* by barriers is assessed to be 1.

Finally, the description of capability in this scenario should include a description of the background knowledge that was used in the assessment, for example assumptions, previous experience and judgments. The quality of the background knowledge can vary, and this will affect the quality of the description of the capability.

K: The probabilities presented above are based on assumptions and previous experience.

The probability that the rescue services succeed in protecting area 1
The rescue services have experience of protecting residential areas from floods. In two previous flooding situations (2004 and 2009) the mobile flood barriers were successfully deployed in a situation similar to the present scenario. Moreover, when asked to assess the probability that they would be able to successfully protect area 1 in the present scenario, personnel from the rescue services stated a value of 0.9.

The probability that the residents will be evacuated prior to the area being flooded

Although there is experience of evacuating small parts of the city, areas 1 and 2 have not previously been evacuated. Nor have there been any exercises in which real evacuation of residents was included. Nevertheless, in a table-top exercise (performed 5 April, 2011) where the participants from the rescue services were asked to estimate the probability that the areas would be successfully evacuated, they assessed the probability to be

0.8 if only one area was evacuated at a time, and 0.5 if both areas were evacuated at the same time.

The probability that a certain number of people will be left in flooded areas

In the same table top-exercise the rescue services were also asked to estimate the number of people that would be left in the flooded areas if evacuation was either successful or unsuccessful. They were very confident, and assessed the probability to be 1 that:

- 0 people would be left in flooded areas if *evacuation of area 2 was successful* and *area 1 was successfully protected* by barriers.
- 300 people would be left in flooded areas if *evacuation of area 2 was unsuccessful*, and *area 1 was successfully protected* by barriers.
- 0 people would be left in flooded areas if *evacuation of both areas 1 and 2 was successful*, and *area 1 was unsuccessfully protected* by barriers.
- 800 people would be left in flooded areas if *evacuation of both areas 1 and 2 was unsuccessful*, and *area 1 was unsuccessfully protected* by barriers.

4.2 Changing the perspective of a capability description

Since our definition of capability is conditional on an event and task, we can change the description of capability without changing the physical system of interest, by specifying the event and the task differently. Thus, the capability of the rescue services to respond to flooding could be described in the way illustrated in the example above, but the event could also be described in more detail. Instead of specifying the water level and the threat to areas 1 and 2 in the description of the event, we could also include “the rescue services were *successful* in protecting area 1 by erecting barriers before the water level rose 2 metres above the mean level”. Thus, instead of being an aspect of the consequences, this becomes an aspect of the event, and there is no longer uncertainty in the description as to whether area 1 will be protected. The only uncertainty remaining (assuming the same conditions as in the example above) is whether the rescue services will be successful in evacuating the residents from area 2, and how many people will be left in area 2 when it is flooded. The new description of the capability can be illustrated in the same way as in Figure 1. The dashed lines in Figure 2 represent the consequences in the example above that are now excluded due to the extended description of the event and the task.

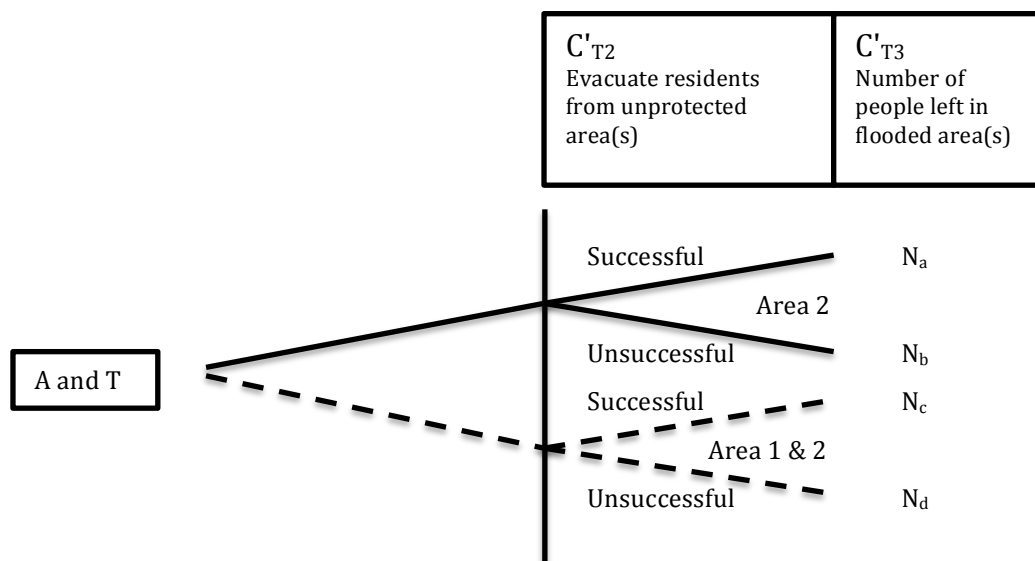


Figure 2. Illustration of a description of the capability of the rescue services to protect people in the case of severe flooding, assuming that area 1 is successfully protected by barriers.

The descriptions of the event and the task can be even more detailed, for example, by including “the rescue services were *unsuccessful* in evacuating residents from area 2” in the event. In this case, little uncertainty remains with respect to the consequences, compared with the example shown in Figure 1, as can be seen in Figure 3, where this new description of the capability is illustrated.

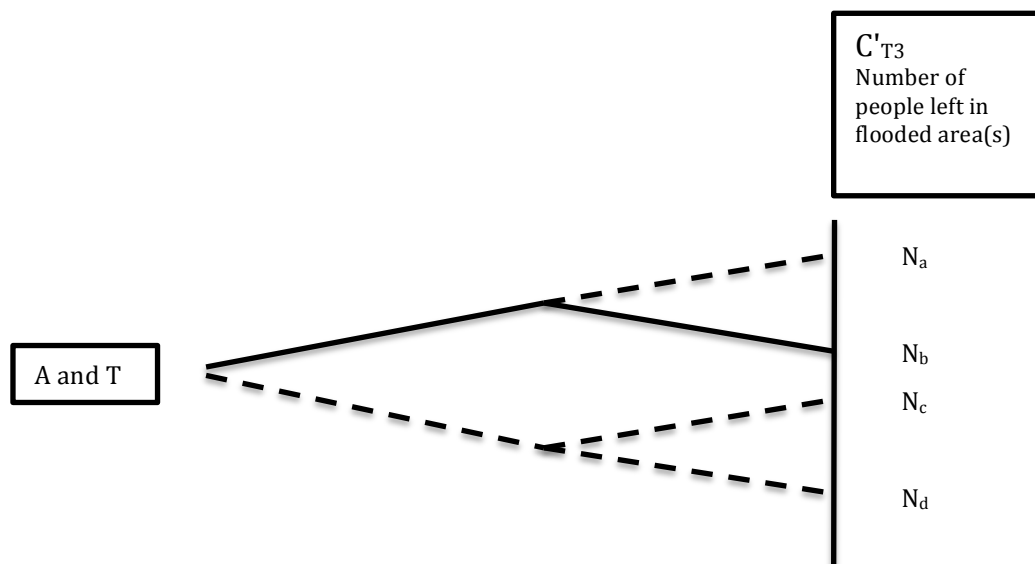


Figure 3. Illustration of a description of the capability of the rescue services to protect people in the case of severe flooding, assuming that area 1 is successfully protected by barriers, and that the rescue services are unsuccessful in evacuating the residents from area 2.

Being able to change the description of the capability by changing what is included in the event and the task is important in practice for at least two reasons. Firstly, producing a capability description that is conditional on a specific scenario, where many details in the event and the task are included, might cause people to believe that the description is

also valid for a broader range of scenarios. If, for example, the capability of dealing with the flooding situation assumed in the example above is described, and one assumes that the power distribution system is operational and that it is possible to use the roads, for example, for moving equipment, one might be tempted to assume that the description would be valid for all flooding scenarios. However, if flooding is caused by a hurricane, it is likely that the power distribution system and the roads would also be affected. To overcome this, it is advisable either to be less specific about the event and the task, and not to assume that the roads are open and the power distribution system is working, or to perform complementary assessments where the roads and the power distribution system are assumed to be affected. Secondly, in practice actors often depend on each other when performing their task during an emergency. For example, the rescue services might be dependent on the police to make sure that it is safe to enter a specific neighbourhood before they can start fighting a fire. Therefore, there is a need for multi-actor capability assessments. If such assessments are to be successful, it is important that the actors conduct their individual capability assessments so that they are compatible with each other. The following example clarifies what we mean by this.

If two actors set out to perform a joint capability description for a flooding situation, using their individual descriptions as a point of departure, it will be difficult if one description assumes that the power supply system is working and the other that it does not. Moreover, if the capability of Actor A is highly dependent on the performance of Actor B, it is important that the consequences of Actor B's actions are reflected in the conditions used in Actor A's assessment. Assume, for example, that Actor A is the rescue service and Actor B is a hospital. In the case of a serious fire, the capability to save the lives of people trapped in the burning building depends on the performance of both actors. One important consequence of this scenario could be the number of fatalities due to the fire. Clearly, in assessing the number of fatalities, the hospital's capability to treat the people exposed to heat and smoke is important. However, the hospital's capability to treat victims is highly dependent on the condition of the patients when they arrive at the hospital, which is in turn dependent on how quickly they can be rescued from the burning building. Thus, the hospital should not assume that the condition of the patients saved by the rescue services and transported to hospital is better than the rescue services are capable of. Therefore, for a joint capability description to be successful, the rescue services must include the consequences associated with the condition of the rescued victims when they arrive at the hospital. Moreover, the hospital's capability description should use the rescue services' capability description as its point of departure, so that the consequences in terms of the condition of the patients arriving at the hospital are used as a prerequisite (i.e., are included in the description of the event) in the hospital's capability description.

Several of the produced capability descriptions will probably be used for decision-making, for example, to determine whether the present level of resources, training, and so on, is acceptable. Using a capability description to support decision-making will probably involve constructing various measures of capability and ways of evaluating it. However, the determination of what constitutes sufficient capability is outside the scope of this paper.

5 Study of Swedish actors' capability assessments

In Sections 3 and 4 a definition of capability is proposed and a way of describing capability based on the proposed definition. In our discussion of capability descriptions we have employed a normative perspective to exemplify descriptions of capability. However, the definition of capability can also be used descriptively to study existing capability assessments. The Swedish system for risk, vulnerability and capability assessment will be used to exemplify how this can be achieved. The Swedish system will first be presented, followed by examples of descriptions of capability. These are then related to our proposed definition of capability. In the following discussion we also address problems concerning the most common ways of describing capability in Sweden.

5.1 Risk, vulnerability and capability assessments in a Swedish context

In Sweden, risk and vulnerability assessments, including capability assessments, are carried out by 290 local municipalities, 21 regional county administrative boards and 23 governmental agencies [16,17,38,39]. These actors are required to assess emergency management capability and their capability to cope with severe disturbances in critical infrastructure, according to a four-level ordinal scale: (1) good capability, (2) reasonably good capability, (3) some capability, but inadequate and (4) no or very inadequate capability. To facilitate the assessment, the statutory guidelines list indicators and sub-indicators that the actors must take into account (see Table 1). In addition, the Swedish Civil Contingencies Agency (MSB) performs an annual national capability assessment. In order to obtain input for this assessment, MSB constructs scenarios, sends them to selected regional and national actors, and asks them to perform capability assessments for these specific scenarios, based on the indicators and assessment scale mentioned above.

Table 1. Indicators that Swedish actors are to use when assessing emergency management capability and the capability to cope with severe disturbances in critical infrastructure. The numbers in parentheses indicate the number of sub-indicators provided for each indicator.

<p>Emergency management capability</p> <ul style="list-style-type: none">• Command and control, cooperation and information (6)• Information security (1)• Alert (2)• External monitoring (1)• Material resources (2)• Personnel resources (2)• Practical experience (2)
<p>Capability to withstand severe disturbances in critical infrastructure</p> <ul style="list-style-type: none">• Information security (2)• Security and robustness in critical infrastructure (1)• Auxiliary power (1)• Ability to move critical infrastructure to another location (2)• Material resources (2)• Personnel resources (2)• Cooperation (1)• Practical experience (2)

5.2 Selection of actors

We have studied the risk and vulnerability assessments, including the capability assessments, performed by 15 municipalities, 5 county administrative boards and 5 governmental agencies. Swedish legislation requires municipalities to submit assessments every four years, and the other actors every year, and in 2011 these coincided. Therefore, the assessments submitted in 2011 were included in this study. The five counties were chosen so as to obtain a good geographical distribution: two in the southern part, two in the central part and one in the northern part of Sweden. Three municipalities were chosen in each county based on the size of the municipality: a small one, with less than 15,000 inhabitants, a medium-sized one with 15,000-90,000 inhabitants, and a large one with more than 90,000 inhabitants. Five governmental agencies were chosen to represent different areas of expertise.

5.3 Study approach

The 25 documents were classified into one of five categories (see Table 2) based on how the actors described their capability.

Category A was defined as reports that contained no capability assessment or no risk and vulnerability assessment, despite the legal requirements. Category B included assessments in which the agent's capability was expressed on a scale of 1-4, as set out in the guidelines (see above). Assessments in categories A and B do not provide any information that could be associated with the definition of capability proposed in this paper.

The third category (C), was defined as assessments in line with definitions 1-6 in Section 2, where available resources and procedures were presented without indicating what could be done with these resources. In terms of the definition proposed here, such information can be useful in assessing the uncertainty and consequences associated with various events and performed tasks. Therefore, this information should be part of the background knowledge. However, background knowledge should refer to information that is *actually* used to produce assessments of uncertainty and consequences associated with the performed task. In category C, however, these are missing. Nevertheless, descriptions in category C still contain more useful information than those in categories A and B.

Category D includes assessments containing most of the components in the definition of a capability description proposed in this paper. In this category, descriptions of the events, the task performed and the consequences associated with the performed task, are given, but not the uncertainties. Descriptions of equipment, procedures, etc., can be included, which we consider to be part of the background knowledge. However, the way in which background knowledge is used to arrive at estimates of the consequences is not explicitly explained.

The fifth category (E) includes assessments where the capability is fully described, according to our proposed definition; i.e., descriptions of the event, task, consequences associated with the performed task, uncertainties and background knowledge. They also

include better explanations of how the background knowledge was used to arrive at the descriptions of consequences associated with the performed task and the uncertainties.

Table 2. The five categories used for analysing the 25 descriptions of capability.

Category	Capability description
A	The risk and vulnerability assessment contains no capability assessment, or a risk and vulnerability assessment was not submitted at all.
B	The actor presents the result of the capability assessment according to the ordinal scale (1-4), but provides no additional information that can be related to our definition.
C	Capability is described by presenting examples of available resources and procedures, for example, through the use of the guideline's indicators (knowledge base).
D	Capability is described by presenting the task that will be carried out in the case of an event, and the outcome of this task. A description of available resources and procedures is also often included (knowledge base).
E	Capability is fully described according to our proposed definition: (C _T , Q, K A, T).

We categorised the capability descriptions by reading the capability assessment sections of each risk and vulnerability assessment, and also searched the documents for the Swedish word for 'capability' in order to find other sections that provided descriptions of capability. A single risk and vulnerability assessment could include descriptions of capability falling into different categories in different parts of the report. Each actor's risk and vulnerability assessment was classified according to the *highest* category identified in the document.

5.4 Results of the study

Only categories A-D were represented in the documents analysed. Thus, no actor described capability according to our proposal. The majority of the assessments were classified as category C (see Table 3). Municipalities were more likely than counties and governmental agencies to describe capability according to categories A and B, whereas assessments made by counties and governmental agencies were more often classified as category D.

Table 3. The results of classification of the twenty-five assessments.

Category	Municipalities	Counties	Governmental agencies	Total
A	4 (27 %)	0 (0 %)	0 (0 %)	4 (16 %)
B	3 (20 %)	0 (0 %)	0 (0 %)	3 (12 %)
C	7 (0 %)	2 (40 %)	1 (20 %)	10 (40 %)
D	1 (6 %)	3 (60 %)	4 (80 %)	8 (32 %)
E	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)
Total	15 (100 %)	5 (100 %)	5 (100 %)	25 (100 %)

To illustrate how the actors described capability according to categories B-D, we present some examples from the risk and vulnerability assessments studied. (Category A is not described since it means that the actor did not submit a capability assessment.)

5.4.1 Category B

The risk and vulnerability assessments from the three actors (all municipalities) that described their capability according to category B are 5-19 pages long, and the capability assessment was 50-180 words long. The following is an example of a complete capability description given by one of the municipalities:

"The capability is good in general, but there are some deficiencies. Better routines for coordinated information to the public and the media are needed. There are no routines for alarms. The personnel resources needed to be able to cope for at least a week must be ensured by a personnel plan." (authors' translation)

This description does not address the available resources and procedures (category C), but only the *lack* of resources and procedures. Furthermore, all three actors presented their capability assessment without any explicit connection to risks and vulnerabilities, and their capability was not related to any scenarios or to the consequences and uncertainties presented in the risk assessment.

5.4.2 Category C

The length of the risk and vulnerability assessments from these ten actors ranged from 11 to 93 pages, and the capability assessments are presented in 1-9 pages. The way in which the actors described their capability varied within this category. Some presented and described capability using values that represent how well prepared they are in terms of a particular aspect, for example, material resources, personnel and auxiliary power. Others presented their general activities and resources for each of the indicators in the form of prose, for example, plans, exercises and education, and concluded by presenting an overall assessment according to the four-level scale. However, they did not relate the assessment to the identified risks presented in other parts of the report.

Only two actors (one municipality and one county) presented a capability assessment for each of the assessed risks, but only by presenting the final result in terms of the grade on the four-level scale.

One municipality included a capability assessment for each of the scenarios in the section on risk assessment, instead of in the capability assessment section of the report, by presenting a distribution of the final results of the capability assessments by local administrations and companies, according to the four-level scale, as given in Table 4. In the capability assessment section the municipality presented general activities and resources for each indicator in the form of bullet lists.

Table 4. Example of a municipality's description of its capability, presented in the risk assessment section for a specific scenario. The municipality presented the distribution of how municipal administrations and companies described their capability for each scenario in the risk assessment, according to the four-level scale.

	1	2	3	4
Total	54 %	36.5 %	7.5 %	2 %
District administration	51 %	46 %	3 %	0 %
Municipal companies	63 %	17 %	14 %	6 %
Business administration	49 %	38 %	11 %	3 %

To conclude, the majority of assessments classified as category C presented resources and general activities for the indicators without referring to any scenarios. Only three actors made some connections to the risks and scenarios presented in other parts of the report. They did not explicitly relate the task they could perform with the help of the resources and functions given in the capability assessment to, for example, the consequences presented in the risk assessment.

5.4.3 Category D

The only municipality that described their capability according to category D submitted a 31-page report, in which the capability assessment was three pages long. The capability assessment was based on three scenarios in the risk assessment, and these scenarios can be regarded as a way of describing the event in our proposed definition. The capability was assessed for each scenario according to the four-level scale. A short comment, 20-40 words, was given on each scenario, focusing mainly on the resources available and not available, as in category C. The actor briefly describes what would be done in the case of one of the scenarios:

"The critical functions that can be relocated will be okay but there are functions that cannot be relocated" (authors' translation)

This could be seen as a way of describing a task, i.e. relocating critical functions, although it was not elaborated on to the same extent as in our examples. Since the capability assessment refers back to the description of the scenario and the consequences in the risk assessment, the consequences described there could be seen as consequences associated with the performed task, although this was not explicitly stated and they could be general consequences. Thus, the description includes the components event, task and consequences associated with the performed task.

The three county administrative boards that submitted risk and vulnerability assessment reports falling into this category, had reports that were 68-82 pages long, and the capability assessment ranged from 2 to 25 pages. The capability assessments addressed two, five and nine scenarios in the risk assessment, and focused mainly on consequences in terms of insufficient resources (e.g. lack of helicopters or lack of emergency diesel generators). The governmental agencies' risk and vulnerability assessments were 21-100 pages long, and the capability assessment 4-33 pages. A few sentences or paragraphs discuss task and consequences associated with the performed task and, together with the scenarios presented in the risk assessment, motivates the classification of the capability description as category D. Two examples are given below from the county administrative boards' and governmental agencies' capability assessments describing task and consequences.

"Information will be prioritized and personnel may be reallocated from other areas." (authors' translation)

"Based to the description of the scenario, the agency will not declare a red level of readiness, but will handle the emergency according to the 'green' (ordinary level of readiness) or the 'yellow' readiness level [...]. If the emergency results in the agency declaring the red readiness level, the agency's emergency organisation will be activated..." (authors' translation)

The capability descriptions that fall into category D have in common that they are based on the risks and scenarios identified in other parts of the report. The capability assessments focus mainly on discussions regarding the indicators, available or insufficient resources and the consequences, similar to the descriptions that fall into category C. In a few sentences the actors explicitly address what task they will perform in the case of certain events, and this qualifies them as category D, although the descriptions of the task could be further elaborated. They do not qualify for category E as it is unclear whether the uncertainties presented in the risk assessment are related to consequences associated with the performed task or only to the consequences in general.

6 Discussion

In the present study, we have discussed the concept of capability and its relation to risk, vulnerability and resilience. Most of the definitions presented in Section 2 bear little or no resemblance to definitions of risk, vulnerability and resilience. Risk, for example, is often defined using concepts such as scenarios, events, consequences, impacts, uncertainties, probabilities and likelihood [13,27,34,35,40], and these aspects were not reflected in most of the reviewed definitions. Our proposed definition of capability makes the relationship to other core concepts explicit, since it is based on the components already used by Aven [34] to define risk, vulnerability and resilience. The definition of capability greatly resembles the definition of vulnerability, the only differences being that the consequences, uncertainties and background knowledge are conditional on both the initiating event and the performed task, and that the consequences should be associated with the purpose of performing the task. Thus, assume that the consequences relevant in a description of vulnerability are influenced by how successfully a certain task (e.g. evacuation) can be completed. For example, the

quicker the evacuation of a certain geographic area can be performed, the less consequences in terms of fatalities. In that case, increasing the capability to perform the task in question would decrease the vulnerability.

Since the definition of capability presented here is easily related to the concepts described above, it can be used to facilitate the integration of the phases of emergency management, i.e. mitigation, preparedness, response and recovery. More specifically, after an emergency it is common to investigate the management of the event in question so that one can learn from it. Information from such investigations can be used to update an assessment of capability by including it in the background knowledge. Assume, for example, that a flood similar to the events described in the example above occurs. The investigation of the rescue services actions and decisions might then reveal circumstances that indicate that the previous assessment of capability was too high or too low. Such information could then be used to adjust the capability assessment and produce a new updated version. Moreover, capability assessments can also be used to indicate which type of scenarios and problems that should be included in future emergency response exercises. For example, a capability assessment might show that there are significant uncertainties regarding the rescue services ability to respond to certain types of scenarios. That could then justify the design of an emergency response exercise with the purpose to gain more information about the rescue services ability to respond to the scenario in question. Thus, the suggested definition of capability provides a means to increase the integration of the activities performed in the different phases of emergency management and therefore it can also serve as a valuable contribution to that field.

Furthermore, the definition suggested here provides opportunities for normative and descriptive research, as well as practical implications for descriptions of capability. If actors want to improve their capability based on its description, it will be important for them to know, for example, the effect of the task they plan to perform. Without knowing the current effect of the task (before interventions), and without being able to assess the effect of potential interventions, it will be difficult to determine the benefits of possible interventions. Recalling our example of the flooding of two residential areas, if an actor was considering assigning more staff to the task of evacuation, it would want to know the effect this would have on the outcome of the potential event. In contrast to our proposed method of describing capability, the current Swedish method focuses on resources and procedures, as do the revised definitions of capability. The problem with this approach is that a list of available resources and procedures says nothing about how the resources will affect the outcome of an event, making it difficult to evaluate the effect of various interventions. Also, as discussed in Section 4.2, our approach allows multi-actor assessments, which are crucial in today's complex society where actors depend on each other's capabilities.

A few of the capability descriptions studied were classified as category D. However, the entire description in the document was not required to fall into that category. This means that major parts of these risk and vulnerability assessments contain descriptions that focus mainly on resources and procedures (category C). They do, however, illustrate the opportunity to express capability partly according to our suggested definition, but further studies are needed to confirm that the actors perceive capability descriptions that

include event, task, consequences associated with the performed task, uncertainties and knowledge base as more useful than simply a list of resources and procedures.

7 Conclusions

We conclude that existing definitions of capability are not related to existing definitions of risk, vulnerability and resilience, but focus mainly on available resources. In order to establish a relationship between the key concepts we have incorporated our proposed definition of capability into the existing ACU risk framework. In addition to the components events, consequences and uncertainties, we have added a fourth component task, and stressed the importance of relating the consequences and effects of that task in the description of capability. We thus define capability as the uncertainty about and the severity of the consequences of an activity given the occurrence of the initiating event and the performed task. We applied this definition in the analysis of the content of Swedish actors' capability assessments and concluded that none of them addressed uncertainty to any appreciable extent, and only a third described capability in terms of task *and* consequences. This makes it difficult to relate these capability assessments to risk assessments. Our definition and method of describing capability not only make it possible to relate capability assessments to assessments of risk, vulnerability and resilience, but also allow for multi-actor assessment, which is crucial in today's complex society where adverse events or disruptions may spread over sectors and national borders. Moreover, the importance of explicitly relating capability to concepts such as risk will increase as capabilities-based planning gains more ground within risk management throughout the world.

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