RESIN

SUPPORTING DECISION – MAKING FOR RESILIENT CITIES

State of the Art Report (1) Urban Critical Infrastructure Systems

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Executive Summary

This report aims to review the state of the art with respect to (urban) critical infrastructure systems (UCIS) and critical infrastructure protection (CIP). We revisit different viewpoints and definitions and explain important concepts such as ‘critical infrastructure’ (CI), ‘urban’ and ‘system’. The notion of ‘urban critical infrastructure systems’ does not have a standard definition and is not well researched. Therefore, RESIN will have to find an own definition that takes into account that the urban system is embedded into a greater context. This will be part of the activities towards developing a conceptual framework for RESIN. The report identifies the social-ecological systems approach as one framework for investigating systems in their context (and not in isolation).

For the area of CI, the report reviews the European definition and definitions of CI in Member States. In this report, we propose a definition of urban CI that is a slightly altered version of the European definition. The report also reviews the State of the Art in a core CI topic, namely their interlinkages. These interlinkages or dependencies of CI may lead to cascading failures, which would need to be considered in vulnerability analysis. The report briefly explains the state of identification of CI dependencies and ways of investigating them. CIP follows an ‘all hazards’ approach, implying that climate change (CC) related hazards are just one threat in a multitude of threats to CI. In CIP, more ‘immediate’ threats like terrorist attacks gain more importance than CC related hazards, which poses a challenge to a more comprehensive and integrated approach to vulnerability assessment and adaptation. The report names also the main categories of stakeholders in CI and CIP, introduces basic concepts in CIP, and explains essential limitations and obstacles for investigating, modelling and assessing the vulnerability of UCIS.

This report also briefly compares characteristics of activities in CC Adaptation (CCA) and CIP, like time scale, threats, vulnerability, policy development, stakeholders, and research topics. Lastly, the report names the most important issues for the RESIN project, including the conceptualisation of urban areas and harmonisation of approaches in CC, CIP and social-ecological systems, and proposes some ideas and approaches that RESIN could adopt. The report concludes by identifying the next steps to be undertaken and points out the identification of interlinkages between technical, built, blue and green infrastructure as a new research topic. Final sections and annexes of this report include a glossary of key terms, a short list of key resources, lists of references and examples of CI sectors and CI in European member states.

One finding of the report is, that the way that urban areas/cities are defined has significant implications for understanding climate change risks and adaptation responses. This is also true for our city cases in RESIN. We have to take care how we define their specific urban area and their UCIS. Another finding is the importance and the inherent difficulties of identifying the dependencies of infrastructure elements in the city, and the potential need to incorporate besides the traditional grey (built-up) infrastructure also blue and green (natural) infrastructure in the analysis. A glossary of key terms is also outlined in section 5.

Introduction

This report aims to clarify the state of the art in critical infrastructure systems (CIS) and, specifically, in **urban** critical infrastructure systems (UCIS). It should enable the reader to understand the terms and concepts for CIS and UCIS from different perspectives relevant for the RESIN Project. This is also a contribution to the RESIN Conceptual Framework (RCF), which will guide the whole project.

The main challenge is the concept of **urban** critical infrastructure systems, as this is not a well-researched topic. This report therefore starts with a discussion of the term infrastructure and the different types of infrastructures: Technical infrastructure (including critical infrastructure), built infrastructure (which overlaps with other types of infrastructure), social infrastructure and blue and green infrastructure. Virtually the only attempt to link all these elements into a greater systemic picture (Figure 7) that we found was provided by the European Environment Agency (EEA, 2015a), who adapted a scheme from Bai et al (2011).

The question of what makes an infrastructure critical is then raised. Different insights on criticality criteria are discussed and the differential views of European member states on critical infrastructure and critical infrastructure sectors are shown. The report then tackles the notion of ‘urban’ in the term urban critical infrastructure. This is followed by a more systemic view on urban systems and urban infrastructure systems. The remainder of the report gives an overview over the state of the art in the critical infrastructure protection community. As we deal with the effects of climate change, a section is engaged with the question of ‘harmonizing’ the critical infrastructure protection and the climate change approach. At the end of the report some preliminary conclusions are drawn. The report has two annexes which contain examples of CI definitions and CI sectors of some European member states.

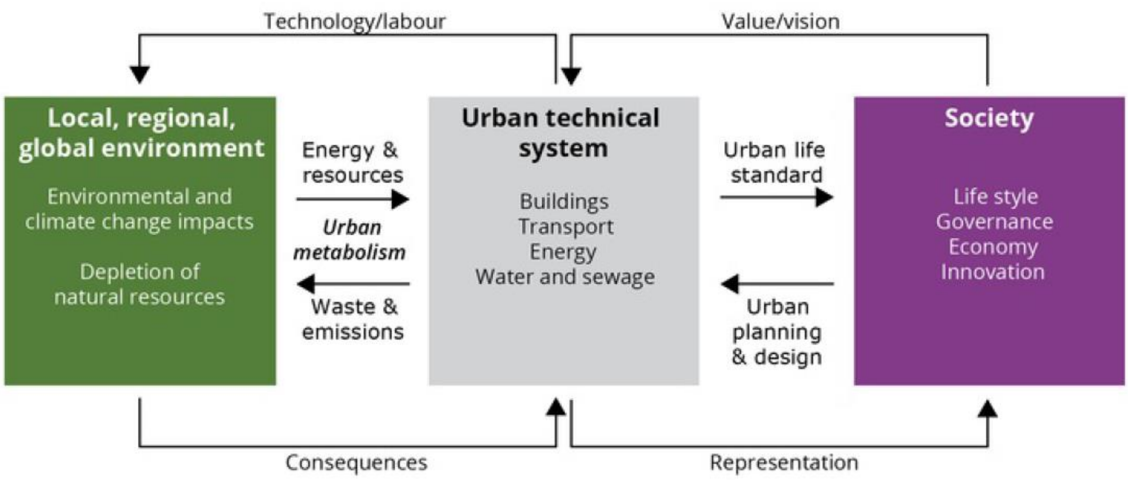

Figure 7: The Urban System (Source: EEA 2015a)

2. Key topics and issues

2.1. Infrastructure, Critical Infrastructure and Critical Information Infrastructure

For this report it is essential to explain the key terms CI, CII. Before we present some formal definitions we want take a more general view. For the understanding of 'critical infrastructure' it is advisable to look at the term 'infrastructure' first. Infrastructures are all public and private facilities that are considered to be necessary for adequate public services and economic development. In most cases, the infrastructure is divided into technical infrastructure (e.g. transport and communications facilities, energy and water supply or wastewater disposal) and social infrastructure (e.g. schools, hospitals, shopping or cultural facilities).[1] In a non-physical view some authors see institutional arrangements and policies as social infrastructure (for example Chappin and van der Lei 2014 and EEA 2015a). Another common distinction is between grey, green and blue infrastructure (EEA, 2013). Grey infrastructure is the conventional engineered (urban) infrastructure that surrounds us, i.e. streets, bridges, streetlights, sewer systems etc. Green infrastructure is the natural landscape within and surrounding a city, which supplies ecosystem services for people. The European Commission define green infrastructure as '…a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings' (EC, 2013). Blue infrastructure may be considered to be part of green infrastructure, but has a specific emphasis on water. Figure 8 depicts the range of infrastructure of the Urban System.

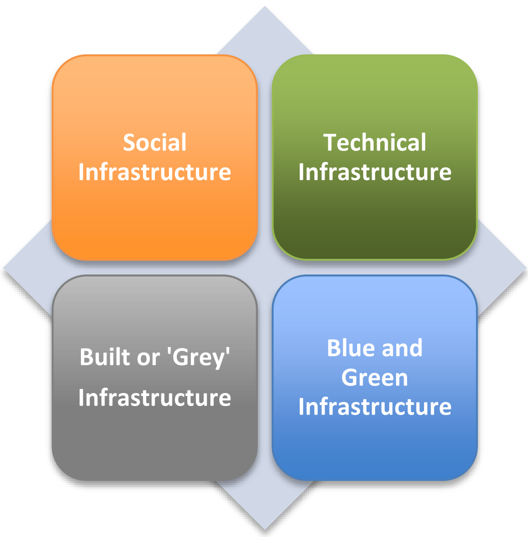

Figure 8: Infrastructure of the Urban System

[1] Unpublished working glossary of UP KRITIS and BSI, 2014

The main question arising is: what makes an infrastructure critical? The assessment of this 'criticality factor' is often specific to the appraiser. All infrastructure could be critical, independent of its classification as technical, social, grey or green. Scientific concepts and criteria for the identification of the criticality of infrastructure vary wildly, employing impact and economic assessment, social vulnerability concepts, resilience studies, risk parameters, and so on. A general approach is not evident (Fekete 2011). In the critical infrastructure literature the two most common aspects of criticality are (in non-formal terms) 'relevance' and 'risk'. This can be seen in the definition of the European Council Directive 2008/114/EC, which defines CI as 'an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people *['relevance']*, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions [*'risk'*].' Criticality is often linked to a certain threshold: that is, an infrastructure is critical if the relevance and risk is over a specified threshold (Fekete 2011). Studies usually analyse infrastructure in two different operational states: normal and failure. The extent of impacts and consequences in a failure state, in contrast to the normal state, is an often-used criterion for the assessment of criticality. Both quantitative and qualitative methods are used for the criticality assessment, for example expert interviews with infrastructure operators and other stakeholders, mathematical calculation models and simulation models.

It is unusual in the critical infrastructure literature to consider green infrastructure as critical. However, there are a number of recent proclamations that hint at its criticality. Green infrastructure provides many societal functions such as community cohesion, economic opportunities and health benefits as well as helping cities adapt to a changing climate (Gill et al., 2007; Tzoulas et al., 2007; Shäffler and Swilling, 2013; Armour et al., 2014). However, green infrastructure may compose part of a flood resilience system. It is precisely for this reason that the US Department of the Interior, following Hurricane Sandy, wrote that 'we would consider some types of 'green infrastructure' as critical such as a dune line that directly protects a community' (US Department of the Interior, 2013, p. 1). Similarly, the Greater Manchester Spatial Framework (Consultation Draft) considers green infrastructure to be critical (GMCA 2015) and, at a national level, the UK's Royal Town Planning Institute (RTPI) believes that green infrastructure has moved from 'something nice to have to a critical infrastructure, vital for sustainable places' (RTPI 2013, p. 5)

Another important characteristic is the interconnectedness of the infrastructure. Infrastructures as the power supply system or the telecommunication system are highly interconnected with many other infrastructures. Due to the interconnectedness a failure can lead to so called cascading effects (or domino effects), where the failure propagates to the connected infrastructures (Rinaldi 2001). This is especially important for information infrastructure, so there are often specific definitions for critical information infrastructures (CII). The CII definition of the OECD (2008) is: 'Critical information infrastructures ('CII') should be understood as referring to those interconnected information systems and networks, the disruption or destruction of which would have serious impact on the health, safety, security, or economic well-being of citizens, or on the effective functioning of government or the economy.' In our modern society IT systems are omnipresent. The information infrastructure is critical for the functioning of many other infrastructures and economic sectors. A failure in one part of the CII can lead through very fast cascading effects to failures to widespread effects in a short timeframe. Therefore the CII is often seen as especially critical. The current approaches for modelling dependencies and cascading effects are summarized in section 3.5.

2.1.1 Critical Infrastructure in European Member States

As stated before the specification of infrastructure as critical is depends on who does the appraisal. This circumstance is reflected by the different national definitions for *their* national CI (see Table 1). CI definitions from the involved nations in RESIN are listed in detail in Annex I. As they are based on the European definition they show many similarities. The main difference is whether the physical infrastructure or the services that the infrastructure provides is emphasized. The definitions of France, German, Poland are focussing more on the actual infrastructure whereas the definitions of Netherlands, Spain and UK are more service focussed. *In addition to the European and national definitions, there is an ISO standard definition for CI:* 'Organizations and facilities that are essential for the functioning of society and the economy as a whole' (ISO/IEC TR 27019:2013). This standard is adopted by many national standardisation bodies in Europe (for example DIN SPEC 27019:2015-03 in Germany and NBN ISO/IEC TR 27019 in France).

The EU Member States have defined sectors which they perceive critical for their nation. These are shown in Table 2 and listed in more detail in Annex II.

Sector	DE	ES	FR	NL	PL	SK	UK
Chemical Industry		x		x	x		
Emergency services			x	x	x		x
Energy	x	x	x	x	x		x
Finance & Insurance	x	x	x	x	x		x
Food	x	x	x		x		x
Government, Administration	x	x	x	x	x		x
Health	x	x	x		x		x
ICT	x	x	x	x	x		x
Jurisdiction	x		x				
Media & Culture	x						
Nuclear Industry		x			x		
Research		x	x	x			
Space		x	x				
Transport &Traffic	x	x	x	x	x		x
Water	x	x	x	x	x		x

Table 2: CI sectors of RESIN partners' nationalities (no data for Slovakia available so far)

There is common ground for the basic supply sectors energy, food and water, but also in sectors who are important for modern societies like Finance, Government, ICT and Transport & Traffic. But there are also national differences: notable differences are the spin-off of the nuclear industry from the energy sector in some nations and the inclusion of other sectors like media & culture in Germany and space in France and Spain.

At this point it should be mentioned that in some European nations CI is called vital infrastructure. This term is also incorporated in the IVAVIA acronym (impact and vulnerability analysis for vital infrastructures and built-up areas) in the RESIN project. Although we use the more established term CI in RESIN we should take care in stakeholder interactions. In conversations with infrastructure providers it might be advisable to use 'vital', which is considered to have more positive connotations than 'critical'.

As shown above there is a lot of common ground in the definitions of the European Member States but there are also some differences. It could be much more diverse at city level. In the end every city has to determine which of its infrastructure is critical for the city. The relevant national definitions and critical sectors are a good starting point for a more in depth analysis.[2] For the latter RESIN can give guidelines and tool support (see SOTA Decision Support) by supplying an assessment method/framework with criteria to determine the criticality of the infrastructure in the city (see SOTA Vulnerability). This assessment should not be restricted to the traditional grey infrastructure. As noted above, blue and green infrastructure could be equally critical for the city and vulnerable to the effects of climate change.

2.1.2 Section summary

In this section we clarified the terms Infrastructure, Critical Infrastructure and Critical Information Infrastructure and related them also to social, grey, and blue and green infrastructure. It is important to know that there are different interpretations of these terms, i.e. a more technical view vs. more institutional perspective, and that the categories designated by these terms do have some overlap. Another result is that the criticality of infrastructure depends on the specific conditions of the cities. 'Risk' and 'relevance' are important characteristics to determine the criticality of an infrastructure. The selected critical sectors in the different MS can serve as guidelines for the evaluation.

2.2. Urban Critical Infrastructure, Urban Area and Urban System

We will now take a look at the urban dimension of CI. If we look at the term 'urban critical infrastructure' (UCI) it entails that the infrastructure is located in an 'urban area'. But what is an urban area and how to specify it? There is no general agreement upon a definition of this term (OECD 2010, p. 40). An essential characteristic of the usual understanding of urban is 'non-agricultural', i.e. there is a dichotomy between rural and urban (Weeks., 2010, p.34). But this simple conceptualisation comes somewhat short as the concept of urban is more complex: Weeks (2010, p.34) writes that 'urban' 'is a function of (1) sheer population size, (2) space (land area), (3) the ratio of population to space (density or concentration), and (4) economic and social organization.' This complexity is highlighted by the study of Brockerhoff (2000) in which he counted the different concepts of urban of 228 countries of the United Nations. Roughly half of these use administrative considerations, 51 use population size and density,

[2] It is advisable to check for changes in the national definitions during the course of the project.

39 use functional characteristics such as main economic activity, and 22 have no definition of urban at all. In OECD publications, the administrative boundaries combined with population density were used to distinguish rural areas from urban areas. But the OECD, as well as the EC, recognise that 'the administrative boundaries of cities no longer reflect the physical, social, economic, cultural or environmental reality of urban development' (European Commission Directorate General for Regional Policy, 2011). To redefine urban areas the OECD and EC endorse now the use of population and land use data on a 1km² grid (Eurostat 2011 and Piacentini & Rosina, 2012). These methods are mostly designed for large-scale cross-country comparison of urbanisation processes, but could also be useful on a smaller scale. Some authors divide the urban area in three sub areas: the city centre, the metropolitan region and the daily urban system, which includes the commuting areas around the city (Archibugi, 1998; Pumain, 2004). This could be a good concept for RESIN, as it would include the infrastructure which is essential for the commuters.

As the definition of an urban area has implication for the understanding of climate change risks and the identification of adaptation options (Perks 2013), we have to carefully select the methodology. As the scope of RESIN is on the urban level we have to deal with dependencies from the urban surroundings. For every city case, we have to define clear borders of the urban area and identify the dependencies inside the urban area and from the inside to the outside of the urban area. As CI is often dependent on other CI there are 'border crossing' interlinkages, which are critical for the functioning of urban CI. In the modern world there is only very seldom a region with a closed loop. So we have to take CI into account that is very important for a city case but is not located in the urban area. For instance this could be the well of the water source of an urban area, which is not in the defined borders. Other examples include an important airport outside the city limits, power transmission substations and broadcasting and cellular phone infrastructure in the urban surroundings. To incorporate this kind of CI as UCI we can also define the urban area in terms of the influence reach of the city (Da Silva et al 2012). UCI could be therefore defined as CI on which a city has direct influence. Indirect influence could hint at outside dependencies.

If we slightly alter the CI definition from the EC Directive we get: 'An asset, system or part thereof located in an urban area which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in an urban area as a result of the failure to maintain those functions'. This alteration makes the importance of boundaries clear, as the impacts inside an urban area can originate from the inside and the outside. The problem is that modern cities often do not have clear borders. Between the city and the surrounding rural areas is a transitional zone, where built-up areas are mixed with rural areas (EEA, 2015b).

This implies the need for a more systemic approach to the urban area and UCI. This report is not the place to discuss system theoretic fundamentals, and the manifold definitions and interpretation of the term system, so this is considered at a very general level. A system can be seen as 'a regularly interacting or interdependent group of items forming a unified whole' (Merriam Webster 2015). Part of an urban system is UCI. The UCI can therefore be seen as a subsystem of the urban system. The UCI has subsystems itself, i.e. power system, sewer system etc., so we have a system of systems. To add another layer of complexity, the UCIS is also the subsystem of the national CIS and the sub-sub system of the European CIS. The systemic view enables us to analyse the dependencies of an UCIS in a more structured way. The analysis of complex and dynamic systems need a theoretical foundation. There are different disciplines who are concerned with urban systems: geographers, economists, sociologists, town planners. All of them have aimed to substitute the physical concept of an urban area with a more systemic concept (Archibugi, 1998). Even so, it is important to bear in mind that practitioners may not be accustomed to such abstract concepts and prefer the territorial delimitation of a build-up area or administrative borders.

In the literature no clear definition of the term urban system could be found. Many see urban systems as systems of urban areas or cities (Bretagnolle et al., 2009; Abdel-Rahman and Anas, 2004). One influential theory is the central place theory by Walter Christaller (Christaller, 1933; Christaller 1966), but this theory and is criticised often as ‘unrealistic’ because of some heroic assumptions. For others urban systems represent the complex and interdependent social-ecological, technical and economical components inside an urban area (see Figure 7 the urban system). The study of these social-ecological systems is prevalent in the climate change adaptation literature. Social-ecological systems developed as an approach to explore integrated, interdisciplinary frameworks that do not consider ecological systems in isolation from social systems as they interact with one another; they are ‘coupled’ (Berkes and Folke, 2000; Binder et al., 2013; Collins et al., 2010; Grimm et al., 2008; Gunderson and Holling, 2002; Newell et al., 2005; Pickett et al., 2001; Pickett et al., 2011; Turner et al., 2003; Walker et al., 2004; Young et al., 2006).

At a very broad level, analyses of social-ecological systems draw upon complexity theory and urban systems theory. Similarly, ecosystems are also composed of interacting subsystems; thus they are ‘hierarchical’. Each subsystem has its own processes and there is evidence of co-evolution, learning and adaptation across systems and scales. This means that social-ecological systems may be characterised as nonlinear and stochastic. Feedback loops, threshold behaviour, tipping points, and cascading effects are important concepts to understand social-ecological systems as they are for critical infrastructure systems.

Here too, issues with different scales and spatial levels are crucial. Watersheds are contained within ecosystems and buildings make up streets within cities (Forman, 2014, p. 12). At an organisational level, there are different institutions and social agents at regional, national and international scales (Berkes et al., 2003, p. 6). The interactions between social and ecological systems vary according to scale (spatial, political, and temporal) (Cash et al., 2006). Gunderson and Holling’s (2002) ‘panarchy’ theory posits that the structure of the overall system depends on the interactions between processes operating at different scales which are each undergoing an ‘adaptive cycle’. The adaptive cycle highlights how processes such as ‘revolt’ (which causes abrupt change and cascading effects) and ‘remember’ (which emphasises a slower process of accumulated learning) lead to systemic changes. In practice there is often a mismatch between the processes that happen at different scales (Berkes, 2002; Borgstrom et al., 2006; Cash et al., 2006; Peters et al., 2004; Young, 2002).

In sum, social-ecological systems are (See McHale et al., 2015, pp. 5213-5214).

- complex (cities and regions have a number of social, economic and ecological dynamics – they are ‘spatially heterogeneous’);
- connected (dynamic social networks, flows of capital, energy, information and so on);
- diffuse (porous boundaries and overlapping administrative remits); and
- diverse (structurally and functionally differentiated and, consequently, with a variety of different applicable models)

2.2.1 Section summary

In this section we have shown the importance but also the difficulties of defining urban borders. The simple concept of urban vs. rural comes somewhat short. In the scientific literature more complex systemic approaches were developed. But we have to keep in mind, that the more traditional physical/administrative view on urban borders are dominant for the practitioners in the cities.

2.3. European Critical Infrastructure and Critical Infrastructure Protection

The protection of its European and national CI is of utmost importance to the EU and its Member States (MS). Consequently, the European Commission has issued the Directive 114/2008/EC to foster the implementation of critical infrastructure protection (CIP) measures in all MS to protect the European critical infrastructure (ECI) that span multiple MS. ECI is defined as: 'Critical infrastructure located in Member States the disruption or destruction of which would have a significant impact on at least two Member States. The significance of the impact shall be assessed in terms of cross-cutting criteria. This includes effects resulting from cross-sector dependencies on other types of infrastructure' (EU Directive 114/2008/EC). This definition highlights the increasingly complex interlinkages of CI in the EU, for example power generation and transmission or the European gas pipeline network. Why could that be important to cities? Cities are dependent from functioning CI, both inside and outside of the city limits. CI are interwoven into the fabric of the city. Cities often own CI that are again interlinked to other CI, and CI play important roles in cities' emergency plans and adaptation plans. We conclude that every European city has a vital need of understanding CI interlinkages and the consequences of these interlinkages for their functioning as a system and their viability in general.

Example: CIP in Germany

Germany has started preparing for CIP in the early 2000s by drafting a plan for implementing the protection of the national Critical Infrastructure (in German: KRITIS (Kritische Infrastrukturen)). In 2005, this plan – UP KRITIS (Umsetzungsplan KRITIS / Implementation plan for KRITIS) has been officially released. The German Federal Ministry of the Interior (Bundesministerium des Inneren (BMI)) has organised UP KRITIS as a PPP (Public-Private Partnership) that comprises CI utility operators, national agencies, ministries, and industry associations. This measure is accompanied by specific regulation per CI sector. The CIP regulation is being integrated into revised sector specific laws, like the IT Sicherheitsgesetz (IT Security Law). References: Bundesministerium des Innern 2009, 2005a, 2005b.

The Directive has pushed the EU and the MS to address the CIP topic. Most MS use similar definitions as the EU for defining their national CI and CI Sectors (see Annex I and II), and progress in CIP has been made. Some MS have passed national CIP plans or established agencies responsible for CIP. The EU has also established the European Public-Private Partnership for Resilience (EP3R).

Nevertheless, the CEPS report ‘Protecting Critical Infrastructure in the EU’ [CEPS] identified a number of critical issues, including:

- The EU preparedness for [large-scale] CI disruptions is far from being mature;
- National policies and EP3R at the EU-level increasingly focus on the cyber threats to CI which is not compliant with the all hazards approach of the Directive;
- The understanding of CI dependencies and cascading failure and subsequent societal impact is still limited and needs to be improved;
- There is a lack of common taxonomies, ontologies, metrics, and risk management framework for CIP-related risk and threats are barriers that need to be overcome.

To address these issues, the CEPS Task Force (2011) made recommendations, including:

- ‘The key pillars [of a [European] CIP policy] are then the development of standards and best practices, education and training, R&D and information-sharing, and modelling and EU wide simulation capabilities’ (CEPS, 2011, p. 89).
- ‘In the ex-ante phase of CIP policy, infrastructure risk assessment plays a key role, and should be subject to further research and standardisation (CEPS, 2011, p. 48).’
- The EU must empower a single agency to deal with CIP and CIIP [Critical Information based Infrastructures Protection] issues adopting an all-hazards approach’ (CEPS, 2011, p. 89).

There are many different organizations involved in CIP who have different viewpoints and interests. Besides the EC and the national governments of the MS, there are the supra-regional and local infrastructure operators that are the most prominent stakeholders of CIP, for example electricity suppliers, water suppliers and telecommunication providers. They are responsible for the functioning of the CI. But other groups are also important for CIP. Governmental agencies and local public administration are concerned with the safety of CI. Crisis managers and emergency forces and technical responses are called in the case of failure. Last but not least are the customers of the infrastructure services, as they are directly affected by CI failures.

But what exactly is the substance of CIP? The very first and essential step consists of understanding the complex system of systems that infrastructures in Europe comprise. After Zio and Kröger (2009), general steps are (see Figure 9) system analysis, quantification of system vulnerability indicators, identification of critical elements and application to system improvements.

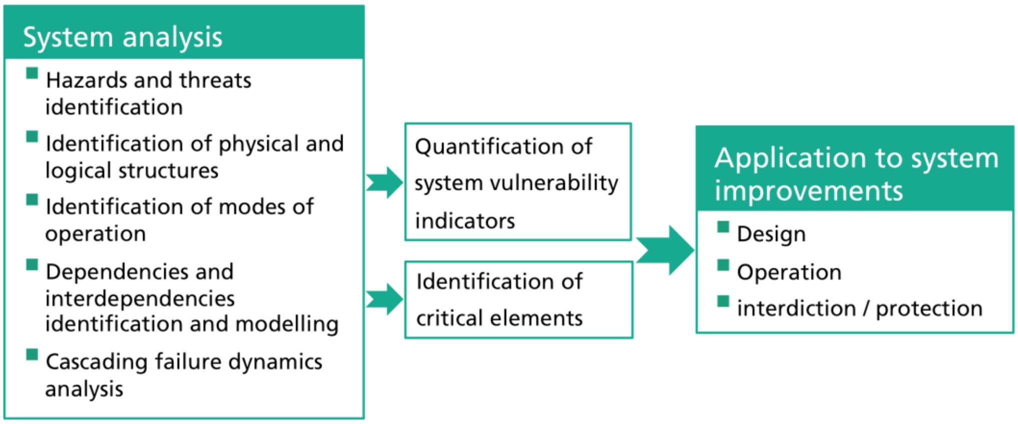

Figure 9: Basic steps in CI vulnerability assessment

Similar to investigations in CC, vulnerability assessment is a key element of analysis. The main purpose of the system analysis is the identification and quantification of vulnerability indicators and the identification of critical elements within a CI. Zio and Kröger (2009) describe the elements of vulnerability of technical system, which also apply to infrastructure systems, as follows: 'Three elements of vulnerability of technical systems:

- Degree of **loss**, and **damages** due to the impact of a hazard;
- Degree of **exposure to the hazard**, i.e., the likelihood of being exposed to hazards of a certain degree, and the susceptibility of an element at risk to suffer loss and damages; and
- Degree of **capacity of resilience**, i.e., the ability of a system to anticipate, cope with or absorb, resist, and recover from the impact of a hazard or disaster (social).' (Zio and Kröger, 2009, pp. 1–2).

It should be noted here that some parts of system analysis have to be performed for individual CI by CI sector experts. Specifically, the identification of physical and logical structures and modes of operation:

- Require domain specific knowledge and data
- May be subject to privacy issues
- May cause security issues

Based on the results of the system analysis phase, system improvements are being developed. These can consist of improved design of technical systems, improvements in operations for achieving a higher security level, or even regulation. A typical challenge in deciding which vulnerabilities to fix are potential events with a low probability but extreme consequences (like the tsunami causing the Fukushima nuclear disaster in Japan 2011).

2.3.1 Section summary

This section gave an overview about critical infrastructure protection in general and critical infrastructure protection on a European level. One important notion is that the cities are embedded in a larger European CIP context. For our analysis we have to take this into account.

2.4. Current approaches for modelling dependencies and cascading effects

A specific focus of system analysis of CI has been the analysis of the interlinkages or dependencies of CI. This has also been a research topic for years. To summarise the main general findings, we can state that:

- Almost all CI are dependent on electrical power and ICT
- Other dependencies are not so obvious: The volcanic ash cloud of the Eyjafjallajökull, for example, had impacts on the health system. Eurotransplant aeroplanes could not transport donated organs, and some highly specialised medical experts on vacation or business trips could not get back on time to scheduled operations in their hospitals
- CI dependencies form chains and may cross borders
- Failures may propagate from one CI to other dependent CI and so on (so-called cascading effects or domino effect)
- Mutual dependencies are called interdependencies
- Dependencies may be static, dynamic, physical, logical or geographical:

– Static dependencies do not change over time, like the dependency of a railway signal from power supply

– Dynamic dependencies are dependencies that change over time or emerge due to certain conditions. For example, a mobile antenna mast that has a backup power supply may become dependent from Diesel supply in case of a longer power outage

– A geographical dependency can arise by colocation of elements of different CI. For example, if an electricity transformer case in a street burns down, a telecommunication box sitting side-by-side to it may also be affected.

– A physical dependency between two CI exists if one CI is directly dependent on the material output of the other CI. For example, a hospital is physically dependent from drinking water supply.

– An example of a logical dependency is the dependency of CI operating companies from the financial market, from legislation, or from economic developments. For example, several political decisions in Germany hit power companies very hard, like unbundling, subsidising of renewable energies and the exit from nuclear energy production. In California, a large CI utility was pushed into bankruptcy by a financial crisis in late 2000 (Rinaldi et al., 2001).

- Geographical dependencies may rise from co-location of cables and pipes of different CI
- Dynamic dependencies may evolve depending on a CI's mode of operation: An antenna of the mobile telecommunication net may become dependent on Diesel supply when its back up power supply steps in

Early research on CI dependencies and interdependencies typically dealt with dependencies between CI sectors, topological properties of dependency networks and possible applications of the gained insights (Rinaldi 2001, Bagheri and Gorbani, 2007, Bloomfield et al., 2009, Casalicchio et al., 2007, Dudenhoeffer et al., 2006, Laprie et al., 2007). Real dependencies between CI are not publicly known, and also mostly unknown to CI operators. Until recently, this knowledge did not play a role in CI operators' businesses, since their services were provided under certain service level agreements (SLA) that were considered sufficient for handling business-to-business (B2B) operations.

Recently, however, several new developments have taken place during European research projects. The following text discusses three examples that are relevant for the RESIN project.

- The Dutch research organisation TNO, for example, has set up a database of CI failures in Europe. Web crawlers populated the database with information extracted from public news sites, looking for a specific set of keywords in eight different languages. In 2010, Luiijf et al (2010) evaluated their insights from the database. They found that almost one third of all reported failures were cascading failures, but that the cascades typically fade out after two or three stages (
- Figure 10).

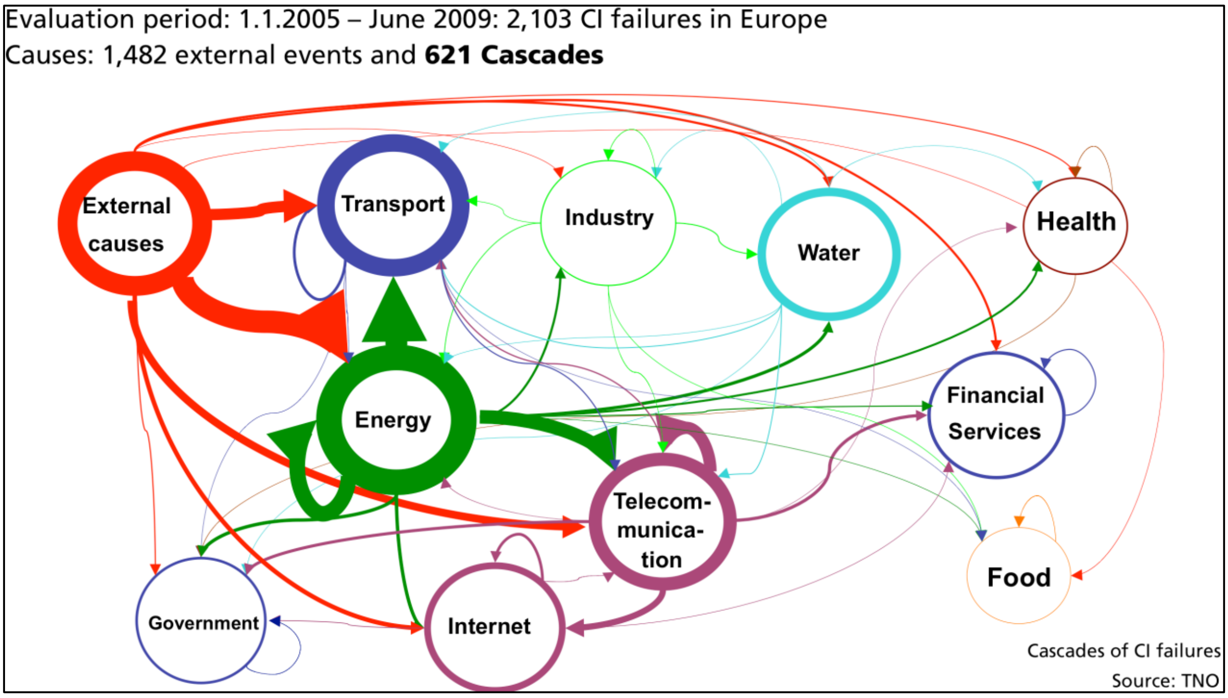

Figure 10: CI sector dependencies in Europe (Luiijf et al., 2010)

- The EU project CIrcle invited CI operators to analyse their CIs' dependencies and documented this in a graphic way. This was a prerequisite for studying cascading effects in two case studies related to flooding in the Netherlands. The advantage of the CIrcle approach is that the CI operators need to disclose just a very limited amount of information.

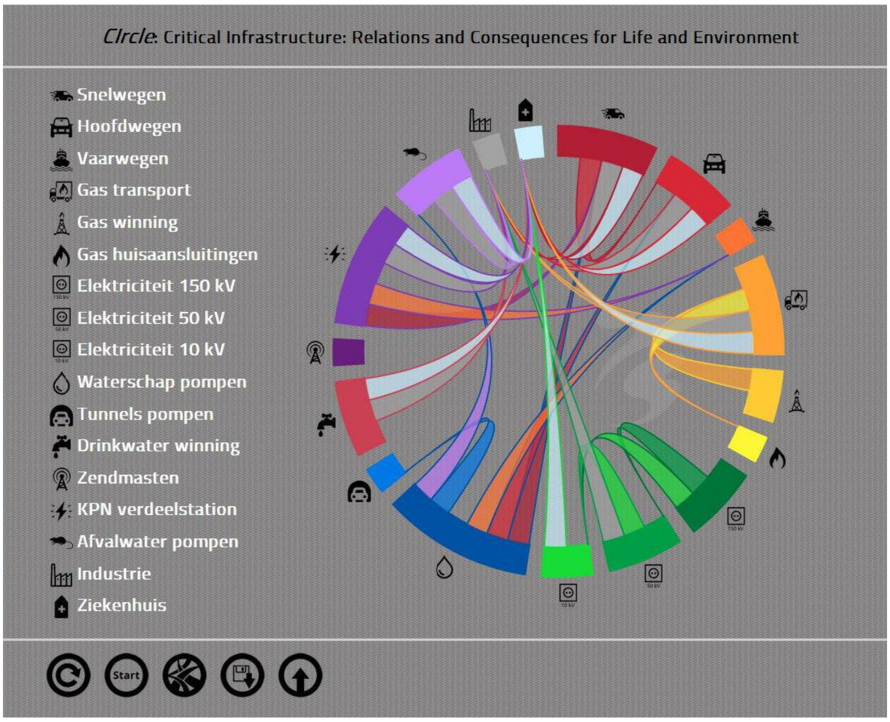

Figure 11: CI dependencies in the Netherlands (Source: EU project Circle)

- A partner within the EU project CIPRNet collaborated with several CI operators on identifying the real dependencies between their infrastructure elements. This new knowledge has an added value for all involved utilities, since it enables them to better prepare for and react more effectively on cascading effects during disturbances of their services.

Finally, we would name some of the essential limitations and obstacles for investigating, modelling and assessing the vulnerability of UCIS.

2.4.1 Data provision

A prerequisite for modelling UCIS is the acquisition of data on UCIS. Useful assessment results can only be achieved if the underlying data are correct. There are several sources of open data, like OpenStreetMap projects, that are now available. Some data can be acquired commercially. However, up-to-date detailed CI data are typically owned by the CI operator and confidential. Only in rare cases do CI operators disclose their data to researchers. In such cases, a responsible treatment of these data and a high level of security are inalienable. Typically, this is safeguarded by contracts and NDAs.

2.4.2 Establishing a trustful collaboration with CI operators and other stakeholders

Obtaining data and knowledge from CI operators and other stakeholders is only possible if there is a trustful collaboration. Such trust may emerge from collaboration in joint projects. But this is only possible if researchers understand the stakeholders and their needs and respect the limitations imposed by requirements of confidentiality and responsible treatment of data and information. Security assessment of dissemination material, securing data bases, and limiting access to the stakeholders' assets are a necessity.

2.4.3 Determining the right level of detail, domain knowledge and general limitations of modelling

It is impossible to model a CI in all detail. Therefore, simplifications are necessary. The art of modelling starts with selecting the right level of detail. Models should be detailed enough to produce non-trivial useful results, but the level of detail should not cause severe performance problems for computer-based evaluations or simulations. Since the simplifications impose limitations on the usage of the results, the assumptions made during the modelling process and the resulting limitations of the model, expressed, for instance, as uncertainties, would need to be made explicit. The Intergovernmental Panel on Climate Change (IPCC) reports contain detailed discussions of how uncertainties can be communicated to stakeholders.

The modelling of UCIS requires not only data, but also domain knowledge, such as knowledge of the electricity grid or knowledge of blue and green infrastructure. That is, for a comprehensive modelling of UCIS, one would need experts from all involved domains. One of the recommendations of this report is that:

- RESIN should create an inventory of expertise that is represented in the consortium
- Based upon this inventory, RESIN should identify missing expertise
- RESIN should try to acquire missing expertise via the liaisons of the RESIN partner cities

One of the general limitations of modelling is that the domain data can never be completely up-to-date, since an urban system is continually changing. It takes time to update a database, and during that time other changes happen. Wim Huiskamp of TNO stated the difficulty of the modelling and simulation task like this: 'Tomorrow's operations are simulated today with yesterday's data'. George E.P. Box underlines this by saying that: 'essentially, all models are wrong, but some are useful' (Box and Norman, 1987, p. 424). A justifiable question then is: What is the point of modelling?

In our view the point of modelling is the following. The world as it is and will be is incredibly complex. Even focusing on a 'small' part of the world like an urban system does not reduce complexity sufficiently for the task of a comprehensive vulnerability assessment without any support. This complexity cannot be mastered by thorough thinking alone. Modelling, sometimes combined with simulation and analysis, may help in reducing the complexity of some of the subtasks in vulnerability assessment. Also, the models serve as a documentation of the identified dependencies and relations of the Urban Systems and its constituents.

2.4.4 Communicating the results of system analysis

Given that data have been acquired and modelling succeeded, the actual investigation can take place, like system analysis of UCIS. While researchers are used to deal with probabilities and uncertainties, stakeholders like CI operators or local administration typically do not have a sufficient level of understand the repercussions of probabilities on their decision-taking. Therefore, any presentation of results should be designed carefully and take human factors into account. It is essential that options for decision-taking can be understood, and that the basis of an assessment and the limitations of the assessment results are communicated clearly.

2.4.5 Section summary

This section gave an overview on the analysis and modelling of dependency between critical infrastructure systems, sectors and elements. It shows the extent of cascading failures and the need and methods to analyse possible ways of failure propagation. But it showed also that detailed CI data is often not readily available and the difficulties to collect those data.

2.5. Critical Infrastructure Protection and Climate Change Adaption

Activities for CIP and Climate Change Adaptation (CCA) seem to run in a rather uncoordinated fashion. CIP activities in Europe typically follow an ‘all hazards’ approach. That is, hazards caused by CC are just one of many hazards to consider. Also, some threats to CI are more immediate (e.g. terrorist acts like cyber-attacks (EC, 2006) than CC related hazards and thus gain more attention. However, we think that coordination of both lines of activities could be beneficial. In Figure 12, we have tried to characterise both lines of activities. As far as the differences between both activities are concerned, this first coarse characterisation highlights different:

- time scales (decades of CCA vs months or years in CIP);
- stakeholders (mostly public authorities in CCA vs public authorities and CI operators in CIP);
- states of regulation (early stages in CCA vs more advanced regulation in CIP).

A rather new development in CIP is the investigation of methods for analysing the potential consequences (fatalities, service availability, environmental and economic consequences) of loss or degradation of CI services.

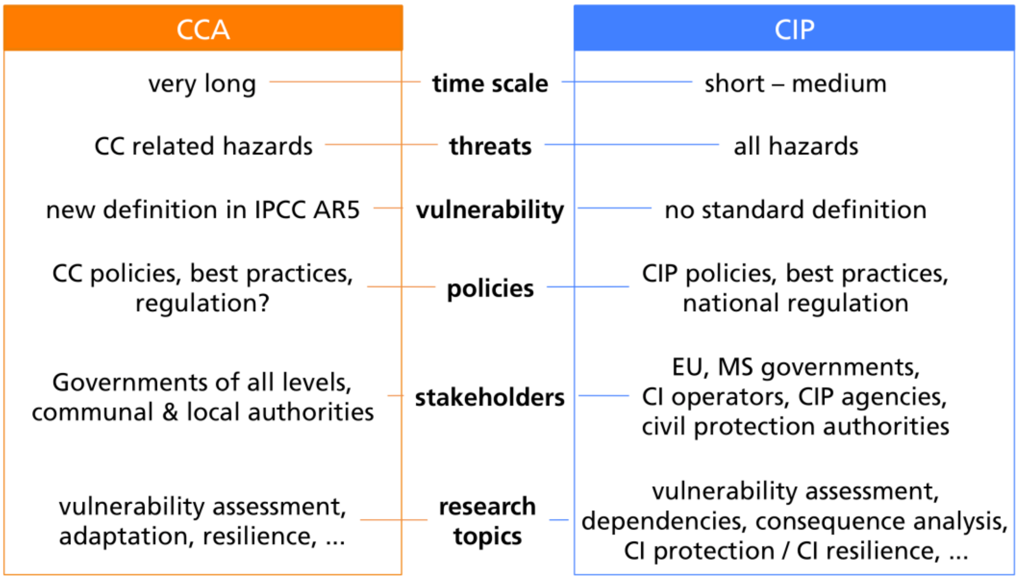

Figure 12: A coarse characterization of activities in CCA and CIP

A harmonization of vulnerability assessment both for CIP and as a basis for adaptation to CC seems feasible. Both areas could benefit from each other. The CC research community has advanced knowledge in modelling CC related hazards, which could be shared with the CIP community. The CIP community has advanced knowledge in modelling CI and could contribute to UCIS modelling. In both areas, vulnerability assessment is being performed as a basis for taking action towards better protection or enhanced resilience. Here, it is important to understand the underlying definitions for being able to identify potential synergies.

3. Project issues and connections

In this section a number of conceptual and practical issues are outlined. We be begin in 4.1 with the most important issues which **should** be explored further in the RESIN project. This is followed by 4.2 with some ideas and approaches who **could** be interesting.

3.1. Most important issues for the RESIN project

We need to 'harmonize' or 'integrate' the approaches from CIP, CCA and social-ecological systems to have a conceptual base for the identification of urban critical infrastructure. A coherent terminology is needed in the project. The glossary in this report is a first step in this direction, but further discussion is needed. Specifically, vulnerability assessment is an activity both for CCA and CIP, but though same terms are being used, they have a different meaning (like 'exposure'). A harmonisation seems possible, though. Underlying definitions and procedures for vulnerability assessment should be inspected carefully as a basis for any harmonisation proposal (see Connelly et al., 2015).

A really important topic is the conceptualization of urban areas. The report has shown the difficulties of defining clear borders between urban and rural, and the conceptual problems of allocating CI to an urban area as UCI. This issue is highly relevant for the whole RESIN project: the conceptual framework and the city typology (WP1), the vulnerability analysis (WP2), the identification of adaptation options (WP3), the city cases (WP4), standardization (WP5) and the decision support (WP6). As the urban areas are very location specific UCI has to be defined and identified for every city case. We should discuss the conceptualization of UCI with the RESIN cities with the help of ICLEI.

As working definition for UCI(S) we propose the slightly altered CI definition of the EC Directive: 'An asset, system or part thereof located in an urban area which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in an urban area as a result of the failure to maintain those functions'.

Adaptation measures, like introducing and reinforcing blue and green infrastructure (B&GI) may lead to a situation in which the availability of B&GI may become a critical issue. Thus, B&GI may be considered CI sometime in the future, and there is limited evidence that some organizations are already categorizing B&GI in this way. This issue has to be discussed further between WP 1, WP2 and WP3.

We need to quickly identify which data we would need for our investigations, our modelling and assessment activities (WP2). Thereafter, we would need to collaborate with the RESIN cities in order to identify the domain experts that we would need to involve (WP4). We would also need to identify possible data sets and data sources that the RESIN cities need to be acquire for the modelling, assessment and decision-support tasks within RESIN (WP2 and WP6).

3.2. Ideas and approaches that RESIN could adopt

RESIN can build on the knowledge and assets in investigating UCI acquired by several partners (including Fraunhofer, TNO, EIVP, ITTI).

Regarding the identification of UCI dependencies, an approach like that of the CIrcle project could be helpful, since the limited amount of information required makes it more likely that stakeholders would be willing to disclose that.

We recommend that RESIN also takes a look at the consequence analysis approaches developed in other projects by RESIN partners (CIPRNet).

4. Conclusions

The way that urban areas/cities are defined has significant implications for understanding climate change risks and adaptation responses. Some degree of standardisation and precision over how a city and its CI is defined would support climate change risk assessment and adaptation planning in European cities. For every city case we need to define their specific urban area and their UCIS. We have to give guidelines and tool support how to do this. The shown European and national definitions are helpful for the identification. But we have to bear in mind that practitioners (our stakeholders in the cities) might not be accustomed to abstract concepts of urban systems and prefer the territorial delimitation of a built-up area or administrative borders.

A very important step in modelling UCIS for our city cases will be the identification of dependencies between infrastructure elements, since impacts of, say, extreme weather events may cause cascading effects along dependencies. Dependencies within and between CI have been investigated in several research projects, so that RESIN can built upon existing knowledge of dependency modelling within the consortium. However, UCIS consist of more than the technical infrastructure (CI). Dependencies between CI, blue and green infrastructure and built infrastructure is a rather new area of investigation. This bears not only potential for new original research results in RESIN, but may also prove essential for comprehensive vulnerability assessment approaches in CCA related research.

Key resources for the RESIN project have been identified below:

Name	Address
CIPedia©:	http://www.cipedia.eu
CIPRNet bibliography of CIP literature:	https://www.ciprnet.eu/bibliography.html
Critical infrastructure protection blog:	https://criticalinfrastructureprotection.wordpress.com/category/epcip/
EU vademecum for civil protection:	http://ec.europa.eu/echo/files/civil_protection/vademecum/menu/2.html
EU DG Energy: CIP	http://ec.europa.eu/energy/en/topics/infrastructure/protection-critical-infrastructure
European Environmental Agency	http://www.eea.europa.eu/soer-2015/europe/urban-systems

5. Working Glossary of Key Terms

The working glossary is based on cipedia.de and the CIPRNet project glossary. For non-CIP terms various sources are utilised. The glossary is not exhaustive. Also, we would want to point out that some of the key terms would require new and agreed definitions for the work in RESIN. For instance, the definition of 'vulnerability' in this list is provisional.

Term	Definition	Source
Blue and green infrastructure	A blue infrastructure is a natural water infrastructure. A green infrastructure is a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water. Blue and green infrastructure	European Commission (2013): Green Infrastructure. Building a green infrastructure for Europe.
Cascading effect	Sequence of events in which each individual event is the cause of the following event; all the events can be traced back to one and the same initial event.	http://www.kritis.bund.de/SharedDocs/Downloads/Kritis/EN/Baseline%20Protection%20Concept.pdf Protection of Critical Infrastructures – Baseline Protection Concept: Recommendation for Companies, BMI.
CI (EC)	An asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions.	Council Directive 2008/114/EC
CI (ISO)	Organizations and facilities that are essential for the functioning of society and the economy as a whole.	ISO/IEC TR 27019:2013
CII (Critical Information Infrastructure)	Critical information infrastructures ('CII') should be understood as referring to those interconnected information systems and networks, the disruption or destruction of which would have serious impact on the health, safety, security, or economic well-being of citizens, or on the effective functioning of government or the economy.	OECD Recommendation of the Council on the Protection of Critical Information Infrastructures C(2008)35

Term	Definition	Source
CI dependency	CI dependency is the relationship between two (critical infrastructure) products or services in which one product or service is required for the generation of the other product or service.	
CI element	Part of a CI. Can have sub-elements	
CI interdependency	The mutual dependency of products or services.	ACIP consortium, Analysis and Assessment for Critical Infrastructure Protection (ACIP) final report, EU/DG Information Society and Media, Brussels, Belgium, 2003
CI sector	Economic sectors considered critical (see Annex II).	
CIP	All activities aimed at ensuring the functionality, continuity and integrity of critical infrastructures in order to deter, mitigate and neutralise a threat, risk or vulnerability.	Council Directive 2008/114/EC
Consequence	The term ‘consequence’ is not well-defined in the literature and confusion arises when compared to the terms ‘impact’, ‘harm’ or ‘effect’. For CIPRNet we defined that a consequence is the outcome of an impact. This is in line with the ISO definition ‘The outcome of an event affecting objectives.’	ISO/IEC 27000:2014 and ISO 31000:2009
Cyber Security	Cyber-security commonly refers to the safeguards and actions that can be used to protect the cyber domain, both in the civilian and military fields, from those threats that are associated with or that may harm its interdependent networks and information infrastructure. Cyber-security strives to preserve the availability and integrity of the networks and infrastructure and the confidentiality of the information contained therein	Joint Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Cybersecurity Strategy of the European Union: An Open, Safe and Secure Cyberspace, 07/02/2013
Damage	Damage classification is the evaluation and recording of damage to structures, facilities, or objects according to three (or more) categories.	Internationally agreed glossary of basic terms related to Disaster Management, UN Department of Humanitarian Affairs, 1992

Term	Definition	Source
Disruption	Incident, whether anticipated (e.g. hurricane) or unanticipated (e.g. a blackout or earthquake) which disrupts the normal course of operations at an organization location.	ISO/PAS 22399:2007 Societal security - Guideline for incident preparedness and operational continuity management.
European CI	Critical infrastructure located in Member States the disruption or destruction of which would have a significant impact on at least two Member States. The significance of the impact shall be assessed in terms of cross-cutting criteria. This includes effects resulting from cross-sector dependencies on other types of infrastructure.	Council Directive 2008/114/EC
Grey infrastructure	Familiar urban infrastructure such as roads, sewer systems and storm drains is known as 'grey infrastructure'. Such conventional infrastructure often uses engineered solutions typically designed for a single function.	Houses of Parliament (2013): Urban Green Infrastructure. Hg. v. Parliamentary Office of Science & Technology (Postnote, 448).
Impact	The term 'impact' is not well-defined in the literature and confusion arises when compared to the terms 'consequence', 'harm' or 'effect'. For CIPRNet we defined that impact is the direct outcome of an event.	
Incident	Event that might be, or could lead to, an operational interruption, disruption, loss, emergency or crisis.	ISO/PAS 22399:2007
Infrastructure	Infrastructure refers to all public and private facilities which are considered to be necessary for adequate public services and economic development. In most cases, the infrastructure is divided into technical infrastructure (e.g. transport and communications facilities, energy and water supply or wastewater disposal) and social infrastructure (e.g. schools, hospitals, shopping or cultural facilities).	http://www.kritis.bund.de/SubSites/Kritis/DE/Servicefunktionen/Glossar/Functions/glossar.html (translated)
Inoperability	The degree of function loss of an object.	

Term	Definition	Source
Recovery	The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors	2009 UNISDR Terminology on Disaster Risk Reduction
Reliability	Property of consistent intended behaviour and results.	ISO/IEC 27000:2014
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.	2009 UNISDR Terminology on Disaster Risk Reduction, United Nations International Strategy for Disaster Reduction (UNISDR), Geneva, Switzerland, May 2009.
Risk	The probability of adverse effects caused by a hazardous phenomenon or substance in an organism, a population, or an ecological system.	European Commission's CBRN Glossary, 2012
Social infrastructure (institutional)	The social infrastructure includes the humans, organizations and governments that make decisions and form our economy as well as our institutions and policies.	Chappin, Emile J.L.; van der Lei, Telli (2014): Adaptation of interconnected infrastructures to climate change: A socio-technical systems perspective. In: Utilities Policy 31, S. 10–17.
Social infrastructure (physical)	Schools, hospitals, shopping or cultural facilities	Unpublished working glossary of UP KRITIS and BSI, 2014
Urban / Urban Area	In simple words: not rural. Definition of Weeks (2010): ‚Urban ‘is a function of (1) sheer population size, (2) space (land area), (3) the ratio of population to space (density or concentration), and (4) economic and social organization.’	Weeks 2010, p.34.
Urban critical infrastructure	An asset, system or part thereof located in an urban area which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in an urban area as a result of the failure to maintain those functions	Slightly altered definition from Council Directive 2008/114/EC
Urban critical infrastructure system	Urban critical infrastructure from a systemic viewpoint. It is part of the urban system and simultaneously part of the	

Term	Definition	Source
	national critical infrastructure system.	
Urban system	System of urban areas (Urban settlements from a systemic viewpoint)	
Vulnerability	Weakness of an asset or control that can be exploited by one or more threats.	ISO/IEC 27000:2014

6. References

6.1. List of relevant projects

FP7 DESURBS
Designing safer urban spaces
www.desurbs.net

FP7 HARMONISE
Holistic Approach to Resilience and Systematic Actions to make Large Scale UrbaN Built Infrastructure Secure
http://harmonise.eu

FP7 SPIRIT
Safety and Protection of built Infrastructure to Resist Integral Threats
http://www.infrastructure-protection.org

FP7 RIBS
Resilient infrastructure and building security
www.ribs-project.eu

FP7 VITRUV
Vulnerability Identification Tools for Resilience Enhancements of Urban Environments
http://www.vitruv-project.eu

FP7 SESAME
Securing the European electricity Supply Against Malicious and accidental thrEats
https://www.sesame-project.eu

EURAM
Generating a European risk assessment methodology for critical infrastructures

FP7 PREDICT
PREparing for the Domino effect In Crisis siTuations
http://www.predict-project.eu

FP7 CIPRNet
Critical infrastructure protection and resilience research network
http://www.ciprnet.eu

FP7 RAIN
RAIN will quantify the complex interactions between weather events and land based infrastructure systems.
http://rain-project.eu/about/

FP07 WEATHER
Weather Extremes: Impacts on Transport Systems and Hazards for European Regions
http://www.weather-project.eu/weather/index.php

FP07 RASOR
Rapid Analysis And Spatialization Of Risk
http://www.rasor-project.eu/

INTERREG IVC GRaBS
Green and Blue Space Adaptation for Urban Areas and Eco Towns
http://www.grabs-eu.org/assessment.php

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Annex I - Examples of CI Definitions in European Member States

France: 'Vital infrastructure is any establishment, facility or structure for which the damage, unavailability or destruction as a result of a malicious action, a sabotage or terrorism action could directly or indirectly: if its activity is difficultly substitutable or replaceable, severely burden the war potential or economic potential, the national security or the survivability of the nation, or to seriously affect the population's health or life.'3

Germany defines CI as 'organizational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in sustained supply shortages, significant disruptions of public safety and security, or other dramatic consequences'.4

Netherlands: 'Critical infrastructures (Dutch: Vitale Infrastructuur) refers to products, services and the accompanying processes that, in the event of disruption or failure, could cause major social disturbance.'5

Poland: 'A critical infrastructure shall be understood as systems and mutually bound functional objects contained therein, including constructions, facilities, installations and services of key importance for the security of the state and its citizens, as well as serving to ensure efficient functioning of public administration authorities, institutions and enterprises.'6

In **Slovakia** Critical infrastructure is made up of individual sectors and elements. 'CI is designed according to the sectoral criteria and cross-cutting criteria … in particular, the engineering construction of the CI, the service in the public interest and the information system in the sector critical infrastructure whose disruption or destruction would have a serious adverse effect criteria according to the sectoral and cross-cutting criteria for the implementation of economic and social functions of the Slovak Republic, and thereby the quality of life of the inhabitants from the point of view of protection of their life, health, safety, property and the environment (Act No. 45/2011)' (Dvořák/Sventeková 2013).

Spain: 'The strategic infrastructures (that is, those that supply essential services) the functioning of which is necessary and does not allow alternative solutions, reason why their disruption or destruction would have serious impact on essential services.'7

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[3] Instruction Generale Interministerielle Relative a la Securite des Activites d'Importance vitale N°6600/SGDSN/PSE/PSN du 7 janvier 2014, Premier Ministre, Secretariat General de la Defense et de la Securite Nationale, Direction Protection et Sécurité de l'Etat N° NOR: PRMD1400503J

[4] National Strategy for Critical Infrastructure Protection(CIP Strategy), BMI 17 June 2009

[5] Bijlage bij Kamerstuk 26643 nr. 75 Rapportage Bescherming Vitale Infrastructuur

[6] Polish Government Centre for Security: http://rcb.gov.pl/eng/?page_id=210

[7] http://www.cnpic.es/en/Preguntas_Frecuentes/Que_es_una_Infraestructura_Critica/index.html

UK: ‘those facilities, systems, sites and networks necessary for the functioning of the country and the delivery of the essential services upon which daily life in the UK depends.’8

8 http://www.cpni.gov.uk/about/cni/

Annex II – Examples of CI Sectors in European Member States

Germany:

Energy	Electricity
	Gas
	Oil
ITK	Telecommunications
	Information technology
Transport & Traffic	Air transport
	Maritime transport
	Inland waterways transport
	Rail transport
	Road transport
	Logistics
Health	Medical services
	Pharmaceuticals and vaccines
	Laboratories
Water	Public water supply
	Public sewage disposal
Food	Food industry
	Food trade
Finance and insurance industry	Banks
	Stock exchanges
	Insurance companies
	Financial service providers
Government and public administration	Government and public administration
	Parliament
	Judicial bodies
	Emergency/rescue services including civil protection
Media and culture	Broadcasting (television and radio), print and electronic media
	Cultural property
	Structures of symbolic meaning

- Federal Ministry of the Interior: National Strategy for the Protection of Critical Infrastructures (*KRITIS-Strategie*)
- http://www.bmi.bund.de/SharedDocs/Downloads/DE/Themen/Sicherheit/SicherheitAllgemein/kritis.html (17.06.2009)

France:

Civil activities of the State	Ministry of Home Affairs
Judicial activities	Ministry for Justice
Military activities of the State	Ministry of Defence
Power	Ministry for Agriculture
Electronic communication, audio visual and information	Ministry for Electronic communications
Energy	Ministry for Energy
Space and Research	Ministry of Research
Finance	Ministry of the Economy and Finance
Water management	Ministry for Ecology
Industry	Ministry for Industry
Health	Ministry of Health
Transport	Ministry of Transport

This is a non-official translation in English and the Ministry in charge may change name at each nomination of a new government.

- Arrêté du 3 juillet 2008 portant modification de l'arrêté du 2 juin 2006 fixant la liste des secteurs d'activités d'importance vitale et désignant les ministres coordonnateurs desdits secteurs. JOURNAL OFFICIEL DE LA REPUBLIQUE FRANCAISE N°0156 du 5 juillet 2008, NOR : PRMD0813724A. [http://www.legifrance.gouv.fr/jopdf/common/jo_pdf.jsp?numJO=0&dateJO=20060604&numTexte=1&pageDebut=08502&pageFin=08502
- Arrêté du 2 juin 2006 fixant la liste des secteurs d'activités d'importance vitale et désignant les ministres coordonnateurs desdits secteurs. JOURNAL OFFICIEL DE LA REPUBLIQUE FRANCAISE N°0129 du 4 juin 2006, NOR : PRMX0609332A]

Poland:

Banking and financial systems
Health protection systems
Communication and computer systems
Transport systems
Rescue systems
Systems ensuring functioning of the public administration
Food and water provision systems
Energy and fuel provision systems
Systems that deal with the production, use, storage of chemical and radioactive substances, and also dangerous substance pipelines.

Source: CIPEDIA

Netherlands:

Critical Processes	Category	Product, service or location	Sector	Responsible Ministry
Nation-wide power transmission and distribution	A	Power	Energy	Economic Affairs
Regional power distribution	B			
Gas production & nation-wide gas transport and distribution	A	Gas		
Regional gas distribution	B			
ICT - internet access and data transport, voice, satellite, time & navigation	*t.b.d.*		ICT/Telecom	Economic Affairs
Drinking water	A	Drinking water	Drinking water	Infrastructure and the Environment
Stemming and managing water quantity	A	(part of) primary water works, (part of) regional water works	Water	Infrastructure and the Environment
Air traffic control and Flight & air craft handling	B	Mainport Schiphol	Transport	Infrastructure and the Environment
Shipping	B	Mainport Rotterdam		
Large scale production, processing and/or storage of (petro)chemical substances	B	(petro)chemical industry	Chemical	Infrastructure and the Environment
Storage, production and processing of nuclear materials	A	Nuclear industry	Nuclear	Infrastructure and the Environment
Retail payments	B	Payment infrastructure	Financial	Finances
Massive electronic payments (giraal betalingsverkeer)	B			
Inter bank transactions	B			
Stock transactions	B			
Emergency Services communication (1-1-2 and C2000)	B	Public order and Safety	Public order and Safety (OOV)	Security and Justice
Deployment of Police	B			
Availability of integer base information set about persons, organisations, information exchange between base data sets and availability of data systems in operation for critical processes of multiple government agencies	B	Digital government *(under review)*	Public Administration	The Interior and Kingdom Relations

Source: https://www.nctv.nl/actueel/nieuws/kabinet-versterkt-crisisbeheersing.aspx?cp=126&cs=59950 Voortgangsbrief nationale veiligheid 9 april 2015

UK:

Communications
Emergency services
Energy
Financial services
Food
Government
Health
Transport
Water

http://www.cpni.gov.uk/about/cni/

Spain:

Administration
Chemical Industry
Energy
Financial and Tax System
Food Supply Chain
Health
Information and Communication Technologies (ICT)
Nuclear Industry
Research Laboratories
Space
Transport
Water

http://www.cnpic.es/en/Preguntas_Frecuentes/Que_es_una_Infraestructura_Critica/index.html

Slovakia:

Not publicly available.