JCMS JOURNAL OF COMMON MARKET STUDIES
UACES
JCMS 2024 pp. 1–12 DOI: 10.1111/jcms.13681

Examination of the Critical Infrastructure Resilience Directive From the Maritime Point of View

MARCOS JULIEN ALEXOPOULOS, ARTO NIEMI, BARTOSZ SKOBIEJ and FRANK SILL TORRES
German Aerospace Center, Institute for the Protection of Maritime Infrastructures, Bremerhaven, Germany

This article evaluates the implementation challenges of the Critical Entities Resilience (CER) Directive in comparison with the Network and Information Security (NIS) Directive and the Floods Directive (FD) within the European Union (EU). CER, which aims to enhance the resilience of critical entities, including critical maritime infrastructure, allows for considerable interpretative flexibility by Member States in defining critical entities and security measures. This flexibility could lead to heterogeneous impacts, introducing inconsistencies that hinder the functioning of the single market, and thereby resilience uniformity across the EU. In contrast, the FD's structured approach with clear objectives and detailed reporting requirements has led to a more consistent and effective implementation. This paper argues that the lack of specificity in the CER Directive may undermine its effectiveness. It suggests that adopting a more structured approach similar to the FD could improve the implementation consistency and resilience of critical entities across the EU.

Keywords: Critical Entities Resilience (CER) Directive; European Union (EU); Floods Directive (FD); maritime infrastructure; Network and Information; Security (NIS) Directive; resilience

Introduction

Critical maritime infrastructure (CMI) comprises ports, shipping lanes, undersea cables, pipelines and offshore facilities, which are essential for trade, energy security and defence (Bueger and Liebetrau, 2023; Center for Strategic and International Studies (CSIS), 2023; Department of Defense, 1999; OECD, 2024; World Bank Blogs, 2024). CMI faces various threats, including natural hazards[1] and deliberate attacks[2]. For example, climate change may increase the frequency and intensity of natural hazards[3] and strain the global food supply, which may increase reliance on food exports Allen et al., 2018; Masson-Delmotte et al., 2021. The vulnerability of critical assets, defined as a function of susceptibility and exposure (Blaikie et al., 1994; United Nations Office for Disaster Risk Reduction (UNDRR), 2019), will increase with the growth of maritime installations (European Commission, 2023a; Patterson and Bridgelall, 2020). The European Union (EU) has addressed these challenges by introducing directives to enhance the resilience of critical infrastructure. The directive on identification and designation of European Critical Infrastructures (ECIs) (2008/114/EC) was the first one to address this topic.

[1]Blake et al., 2013; Claremont Colleges Scholarship Repository, 2021; de Moel et al., 2013; Federal Emergency Management Agency, 2017; Fritz et al., 2011; Kajitani et al., 2013; Knabb et al., 2005; Mori et al., 2011; National Centers for Environmental Information (NCEI) and NOAA, 2023; National Oceanic and Atmospheric Administration (NOAA), 2023; United States Geological Survey (USGS), 2023
[2]Bloomberg, 2021; Bueger and Liebetrau, 2023; Reuters, 2021; Statista, 2022; The Barents Observer, 2022; The Guardian, 2023; The New York Times, 2021
[3]Allen et al., 2018; Masson-Delmotte et al., 2021

It has now been repealed by the Critical Entities Resilience (CER) Directive (EU) 2022/2557 (European Parliament and Council of the European Union, 2022b). In parallel, the Network and Information Security (NIS1) Directive (2016/1148) marked a first step towards improving cybersecurity across the EU (European Parliament and Council of the European Union, 2016). Yet its implementation faced deficiencies (European Commission, 2020; Porcedda, 2018; Timmers, 2019), and as a response, the NIS2 Directive (2016/1148) was established to strengthen the EU's cybersecurity framework (European Parliament and Council of the European Union, 2022a).

For the implementation of the CER Directive, we see similar challenges that were present during the implementation of the NIS Directive. These challenges arise from the lack of a standardized resilience assessment framework and potential variations in criticality criteria across Member States. A varied implementation of the CER Directive by different Member States may lead to disparities that obstruct the operation of the single market, thus undermining the consistency of resilience measures across the EU. The new CER Directive has already been assessed by previous works (Niemi and Sill Torres, 2022; Pursiainen and Kytömaa, 2022). This article compares these directives to the EU's Floods Directive (2007/60/EC) (FD), aimed to reduce flood risks (European Parliament and Council of the European Union, 2024; Mysiak et al., 2013; Heintz et al., 2012). Whilst it faced some limitations, such as data uncertainties and uneven implementation across Member States (Bodoque et al., 2023; Dimitriadis et al., 2017; Priest et al., 2016; Nones, 2016; Yannopoulos et al., 2015), the FD has evolved to emphasize climate change adaptation and stakeholder engagement (European Commission, 2021a; Douka, 2020).

This paper is organized as follows. Section 2 further introduces the relevant EU directives, whilst Section 3 assesses differences in implementing the NIS1 and FD. Section 4 examines the potential pitfalls in implementing the CER Directive by drawing parallels to the challenges faced by the NIS Directive and proposing measures to ensure its effective implementation in the context of CMIs. Our assessment highlights the FD's more focused scope, enhanced coherence and detailed reporting requirements as advantages over the current EU infrastructure resilience directives. Finally, Section 5 concludes this work.

I. Background on Relevant Directives

Resilience Frameworks and EU Infrastructure Resilience Directives

The Hyogo Framework for Action (HFA) (2005) was the first blueprint for disaster risk reduction (DRR) at the country level, aiming to reduce disaster losses by 2015 (United Nations International Strategy for Disaster Reduction, 2005). It delineates five priority areas for action and offers guidance for achieving disaster resilience within sustainable development. The Sendai Framework for Disaster Risk Reduction 2015–2030 builds upon the HFA, shifting from reducing disaster losses to proactive disaster risk management (United Nations Office for Disaster Risk Reduction, 2015). It expands the scope of DRR to include natural and man-made hazards by introducing measurable global targets and priorities for action (United Nations Office for Disaster Risk Reduction, 2024).

The predecessor of CER, and now obsolete Directive 2008/114/EC, established the procedure for identifying and designating ECIs (European Parliament and Council of the European Union, 2022b). It prioritized the threat of terrorism whilst considering other

man-made and natural disasters. It mandated a two-tiered approach for identifying ECIs using cross-cutting and sector-specific criteria, required Operator Security Plans (OSPs) for designated ECIs and called for the designation of Security Liaison Officers.

Amongst resilience frameworks Directive 2016/1148 (European Parliament and Council of the European Union, 2016), NIS1 marked a first step towards enhancing the cybersecurity posture across the EU. It introduced legal measures to boost the overall level of cybersecurity and fostered a culture of security amongst critical stakeholders. However, the Directive 2016/1148 assessment, as presented in Annex 5 of the Impact Assessment Report (European Commission, 2020), and the successive Directive 2022/2555 (NIS2) (European Parliament and Council of the European Union, 2022a) have highlighted certain deficiencies.

The NIS Directive had several key deficiencies, most notably inconsistent implementation across Member States and inadequate addressing of current and emerging cybersecurity challenges. Other issues included divergent security and incident reporting, limited scope in terms of covered sectors and companies and lack of alignment with international standards (Porcedda, 2018; Timmers, 2019).

To address the shortcomings of the NIS Directive, NIS2 was established to strengthen the EU's cybersecurity framework. Its primary focus is on harmonizing reporting and notification requirements and introducing stricter sanctions for non-compliance. NIS2 also updates definitions and scope and ensures consistency with other regulatory frameworks for enhanced coherence.

The FD

The FD was introduced to reduce flood risks to human health, the environment and economic activity (European Parliament and Council of the European Union, 2024). It allowed Member States to upgrade their flood risk practices through a three-step process (Mysiak et al., 2013; Heintz et al., 2012). This included a preliminary flood risk assessment by 2011 (Chapter II, Articles 4 and 5), identifying areas with significant flood risks. Flood hazard and risk maps for at-risk areas were required by 2013 (Chapter III, Article 6). Flood risk management plans, co-ordinated at the river basin district level, were due by 2015, defining objectives and measures for prevention, protection and preparedness. These plans are subject to public participation and six-yearly updates.

The FD evolved to emphasize climate change adaptation (Douka, 2020; European Commission, 2021a) and stakeholder engagement, leading to more participatory approaches (European Commission, 2021a). Efforts have improved public participation and flood awareness (European Commission, 2021a). The FD is increasingly implemented in co-ordination with other EU directives, particularly the WFD, ensuring policy synergies. There has also been a shift towards sustainable flood management, including nature-based solutions (European Commission, 2021a).

The FD has provided a context and framework for flood risk assessments, where estimates remain realistic (Papaioannou et al., 2018). Its specific target objectives and concrete milestones have enhanced both governance and technical issues, further contributing to the paradigm shift from flood protection to flood risk management (Adamson, 2018). This shift represents a change in the overall policy and objectives, helping to define the problem more clearly. The FD has thus played a role in challenging organizational

structures by introducing performance-based regulations (Hartmann and Albrecht, 2014). Whilst Rauter et al. (2019) question whether it introduced genuinely new disaster plans or significantly changed the responsibilities and structure of specific organizations in an Austrian city, they acknowledge that it has altered the behaviour of different stakeholders and institutions, which in turn led to improved co-ordination between various bodies (Rauter et al., 2019).

II. Differences in the Implementation of NIS1 and FD

The European Commission (EC) has developed the fitness check assessment to measure the success of the directive's implementation. Some of the core components include effectiveness, efficiency and coherence. The FD has a more tangible scope for effectiveness than NIS1. When the objectives outlined in Article 1 for FD and NIS1 are compared, the FD's clear objectives allow for more targeted implementation measures, contributing to its effectiveness. In contrast, NIS1 aims at achieving a high standard level of network and information security across the EU. The more abstract nature of cybersecurity and the rapidly evolving threat landscape make it harder to define concrete implementation steps, potentially impacting its effectiveness. Admittedly, the FD also benefits from enhanced coherence due to the pre-existing WFD, adopted in 2000, which had already established a framework for community action in the water policy (European Parliament and Council of the European Union, 2000). This coherence allowed Member States to build upon existing structures, experience and a 'common language' when implementing the FD.

On the other hand, NIS1 was the first piece of EU-wide legislation on cybersecurity when it was adopted in 2016, which led to a lower baseline regarding harmonized capabilities and incident response procedures across Member States. The fitness check highlights specific issues that affected the efficiency and coherence of implementing the NIS Directive, such as significant differences in how Member States identified operators of essential services. This led to a fragmented approach where the same type of entity could be subject to different regulatory regimes across Member States, therefore impacting the Directive's coherence. The FD implementation has achieved a slightly more consistent approach, with Member States following harmonized methodologies for preliminary flood risk assessments and identifying areas of potential significant flood risk. The FD's detailed reporting requirements, with concrete milestones like preparing flood hazard and risk maps and establishing flood risk management plans, also contributed to its effective implementation. NIS1 lacked similarly specific reporting obligations in its initial iteration, which probably affected its success.

III. Overview of CER Implementation in the Context of CMIs

CER, the successor of Directive 2008/114/EC, establishes a framework to enhance the resilience of critical entities, including those in the maritime sector, that provide essential services across the EU. CER encompasses CMI under various sectors, including energy, transport and digital infrastructure. It requires Member States to identify all critical entities within their jurisdictional territories based on criteria, such as the provision of essential services and the potential disruptive effects of incidents (Article 6). CMIs must implement appropriate security and organizational measures based on risk assessments, Article

13(1), addressing prevention, physical protection, response and recovery. They must also have a resilience plan or equivalent documents describing these measures, Article 13(2). Despite the clear objectives, there remains flexibility for Member States in bolstering resilience. Each Member State must develop a comprehensive strategy (Article 4), like conducting risk assessments, which the EC describes as a systematic process involving the identification and analysis of potential threats, vulnerabilities and hazards, and evaluating potential consequences, Article 2(7).

However, several issues arise in the implementation of CER. Firstly, it lacks a standardized framework to measure and assess resilience, making it challenging to establish consistent benchmarks and evaluate the effectiveness of the measures implemented by critical entities. This will eventually need to be addressed, as was the case for ISO 31000:2009, which attempted to resolve vocabulary ambiguities in risk management (Purdy, 2010). Secondly, whilst CER provides an annex listing sectors and categories of critical entities, the criteria for determining criticality may vary across Member States.

For instance, Germany considers offshore wind farms (OWFs) critical once they exceed a capacity threshold of approximately 100 MW, which may differ in other countries (Federal Ministry of the Interior and Community, 2021).

Article 5 requires Member States to conduct risk assessments following previous regulations, such as (EU) 2017/1938 and (EU) 2019/941, aligning with CER's holistic approach to resilience. Regardless, a pan-European policy is needed to ensure standardized practices. The current flexibility that individual countries have during implementation (Niemi and Sill Torres, 2022) detracts from the holistic approach to resilience. However, the CER Directive mandates the Commission to give non-binding guidelines for Member States. For example, the ISO 31000 standard on risk management (ISO, 2018) or ISO 22301 business continuity management (ISO, 2019) could act as a basis for such guidelines.

In the case of OWFs, the criteria and standards for mitigation measures, such as surveillance radars set up as insurance requirements, are often based on cost considerations rather than agreed-upon protocols, potentially compromising the security of the asset of interest. CER might face pitfalls similar to those of the NIS Directive. Leaving the responsibility of creating an inventory of relevant potential threats specific to each sector solely to Member States may result in a narrow focus on what is considered critical and potentially overlooks specific incidents that could have far-reaching consequences. A top-down approach (Parsons et al., 2016), guided by a comprehensive threat inventory, could aid in identifying and addressing potential risks that may not be immediately apparent to individual Member States.

More specific guidance on the minimum technical and organizational measures expected for different types of critical infrastructure could be provided. This might involve specifying requirements for physical hardening, access control and surveillance for maritime assets (Bueger et al., 2022; Gabriel et al., 2022), such as setting a threshold for minimum radar coverage of OWFs. Similar standards could then be established for securing ports, patrolling key shipping routes or protecting undersea cables.

Dealing with CMIs becomes increasingly complex. In this context, 'complex' refers to a system that is more than the sum of its individual parts. The rules of interaction between components may change over time and may not be well understood. These rules can be fluid, and the interaction between the individual parts may be obscure. Complex systems often lack a central organizing principle and respond and interact with their environment.

Additionally, there is usually inadequate information about the state of the influencing variables. Therefore, the overall behaviour of such systems cannot be simplified by examining its individual building blocks. This is in contrast to the initial EU objectives for co-ordinate resilience strategies (Joseph and Juncos, 2019). According tothe United Nations Convention on the Law of the Sea (UNCLOS) (Tanaka, 2019), entities are situated in different zones, which gives countries differing legal rights and responsibilities. It is a particular feature that many CMIs cut across these zones, and this lack of clarity becomes relevant (Halog et al., 2024). For example, OWFs are set to expand into the Exclusive Economic Zone (EEZ) of the North and Mediterranean Seas to meet renewable energy targets (European Commission, 2021b; 2023b). Within the CER Directive, the existing strategies for safeguarding critical infrastructure are sector specific, and separate policies and regulatory agencies govern each. This fragmentation of responsibilities challenges coherence and integrated planning across various sectors under a unified critical infrastructure umbrella.

The practical implementation of co-operation between Member States, as emphasized in Article 11, may be hindered by the different organizational structures and responsibilities of competent authorities across Member States, as the systems introduced within the directive are open for interpretation (Pursiainen and Kytömaa, 2022). Furthermore, at the European scale, there are no standardized protocols for disaster mitigation and protection measures, leaving the surveillance of critical entities up to the responsible stakeholders and their willingness to invest in it. It should also be mentioned that diverse regulations across the single market create uneven competitive conditions (Pelkmans, 2012). This fosters a 'race to the bottom', as Member States hesitate to enforce stringent regulations that may introduce an economic disadvantage. This is also applicable in the security industry (Scheerlinck et al., 2017). For example, in the security of ports, a country might opt for minimal security investments to lower operational costs, facilitating investors' prioritization of quick entry and exit strategies.

Human capacity, which refers to the skills, knowledge and abilities of individuals involved, is an integral component of maritime security (Okafor-Yarwood et al., 2024), and its variation prevents consistent capabilities across Europe. This may hinder the implementation of consistent mitigation measures and affect disaster recovery. For example, surveillance capacity influences insurance policy, and costs fluctuate based on the protection measures in place.

The aforementioned leaves significant space for interpretation amongst Member States. Implementation challenges of EU directives in administrative bodies are primarily due to resource shortages, including a lack of skills at the municipal level and insufficient capacity in organizations overseeing environmental regulation (European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL), 2024). Enforcement mechanisms are also criticized for being ineffective, with lenient sanctions and fines for non-compliance (Jones Day, 2024). The complexity of EU policy formulation, reliance on Member States for implementation and conflicting legislation further exacerbate these issues (Adam et al., 2021; Hurka and Steinebach, 2020; Hurka et al., 2022; Zingraff-Hamed et al., 2020). Directives provide a framework and regulatory objectives for Member States to incorporate into national laws, but this transposition process can alter implementation, leading to compliance difficulties. For instance, in Sweden, economic priorities have hindered the effective implementation of the Water Framework Directive (WFD) (Söderberg, 2016).

Insufficient exchange of information and co-ordination amongst various sectors or departments is a significant issue that can lead to misaligned goals and inefficient resource utilization. It can also result in poor policy integration, barriers to stakeholder engagement, delayed or ineffective decision-making and knowledge gaps (Tsani et al., 2020).

Concluding Remarks

Implementing CER will likely invite challenges due to the complex and diverse landscape of critical infrastructure governance across EU countries. The directive's effectiveness will depend on how well it can navigate the varying organizational structures, responsibilities and stakeholders involved in ensuring the resilience of critical entities at the subnational level. The cross-border nature of CMI adds another layer of complexity to the implementation process. With critical infrastructure spanning multiple Member States and extending beyond the EU's borders, CER must foster enhanced co-operation and co-ordination amongst relevant authorities and stakeholders across different jurisdictions.

We acknowledge the life cycle of the EU directives, which typically involves several years of evaluation and revision. Still, the challenges faced in implementing the CER Directive bear similarities to those encountered during the rollout of the NIS1, because every critical entity faces different regulatory regimes across the EU. To effectively enhance the resilience of critical entities, CER could benefit by following the FD template. Concrete policy milestones, frameworks and guidance addressing the specific needs and characteristics of different sectors and entity categories would provide each Member State with palpable steps. Despite the foreseen problems arising with the application of CER, it propels the enhancement of CMI resilience towards the right direction.

Acknowledgements

The authors would like to thank the reviewers for their insights, which helped shape the final version of the manuscript.

Open Access funding enabled and organized by Projekt DEAL.

Correspondence:
Marcos Julien Alexopoulos, German Aerospace Center, Institute for the Protection of Maritime Infrastructures, Fischkai 1, 27572 Bremerhaven, Germany.
email: marcos.alexopoulos@dlr.de

References

Adam, C., Hurka, S., Knill, C. and Steinebach, Y. (2021) 'On Democratic Intelligence and Failure: The Vice and Virtue of Incrementalism Under Political Fragmentation and Policy Accumulation'. *Governance*, Vol. 35, pp. 525–543. https://doi.org/10.1111/gove.12595

Adamson, M. (2018) 'Flood Risk Management in Europe: The EU 'Floods' Directive and a Case Study of Ireland'. *International Journal of River Basin Management*, Vol. 16, No. 3, pp. 261–272. https://doi.org/10.5194/nhess-13-2883-2013

Allen, M. R., Dube, O. P., Solecki, W., et al. (2018) *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change* (IPCC).

Blaikie, P., Cannon, T., Davis, I. and Wisner, B. (1994) *At Risk: Natural Hazards, People's Vulnerability and Disasters* (Routledge).
Blake, E. S., Kimberlain, T. B., Berg, R. J., Cangialosi, J. P. and Beven II, J. L. (2013) 'Tropical Cyclone Report: Hurricane Sandy'. https://www.nhc.noaa.gov/data/tcr/AL122005_Katrina.pdf
Bloomberg (2021) 'Colonial Hackers Stole Data Thursday Ahead of Shutdown'. Available from: https://www.bloomberg.com/news/articles/2021-05-09/colonial-hackers-stole-data-thursday-ahead-of-pipeline-shutdown
Bodoque, J. M., Esteban-Munoz, A. and Ballesteros-Canovas, J. A. (2023) 'Overlooking Probabilistic Mapping Renders Urban Flood Risk Management Inequitable'. *Communications Earth & Environment*, Vol. 4, 279. https://doi.org/10.1038/s43247-023-00940-0
Bueger, C. and Liebetrau, T. (2023) 'Critical Maritime Infrastructure Protection: What's the Trouble?' *Marine Policy*, Vol. 155, No. 1, 105772. https://doi.org/10.1016/j.marpol.2023.105772
Bueger, C., Liebetrau, T. and Franken, J. (2022) 'Security Threats to Undersea Communications Cables and Infrastructure—Consequences for the EU'. In-Depth Analysis, European Parliament, Accessed: 2024-04-23, https://www.europarl.europa.eu/RegData/etudes/IDAN/2022/702557/EXPO_IDA(2022)702557_EN.pdf
Center for Strategic and International Studies (CSIS) (2023) 'NATO's Role in Protecting Critical Undersea Infrastructure'. Available from: https://www.csis.org/analysis/natos-role-protecting-critical-undersea-infrastructure
Chen, S. and Gong, B. (2021) 'Response and Adaptation of Agriculture to Climate Change: Evidence From China'. *Journal of Development Economics*, Vol. 148, 102557. https://doi.org/10.1016/j.jdeveco.2021.102557
Claremont Colleges Scholarship Repository (2021) 'A Study of the 2004 Indonesian Tsunami: The Effects on GDP'. Available from: https://scholarship.claremont.edu/cgi/viewcontent.cgi?article=2844&context=scripps_theses
de Moel, H., Botzen, W. and Aerts, J. (2013) 'Economic and Direct Losses From Hurricane Sandy'. *Annals of the New York Academy of Sciences*, Vol. 1294, pp. 81–104.
Department of Defense (1999) 'The Department of Defense Critical Infrastructure Protection (CIP) Plan'. Available from: https://irp.fas.org/offdocs/pdd/DOD-CIP-Plan.htm
Dimitriadis, P., Tegos, A., Petsiou, A., et al. (2017) 'Flood Directive Implementation in Greece: Experiences and Future Improvements'. In *Proceedings of the 10th World Congress on Water Resources and Environment "Panta Rhei"*, (European Water Resources Association).
Douka, A. (2020) 'Adaptation Measures to Climate Change Within the European Floods Directive (2007/60/EC)'. *Environmental Sciences Proceedings*, Vol. 2, 38. https://www.mdpi.com/2673-4931/2/1/38
European Commission (2020) 'Proposal for a Directive of the European Parliament and of the Council on Measures for a High Common Level of Cybersecurity Across the Union, Repealing Directive (EU) 2016/1148'. Online Accessed: 2024-03-27, https://eur-lex.europa.eu/resource.html?uri=cellar:d51e4bbb-3fa8-11eb-b27b-01aa75ed71a1.0001.02/DOC_2&format=PDF
European Commission (2021a) 'Current Practice in Flood Risk Management in the European Union: September 2021'. Available from: https://op.europa.eu/en/publication-detail/-/publication/21d8c5c2-2199-11ec-bd8e-01aa75ed71a1/language-en/format-PDF/source-232431484
European Commission (2021b) 'European Green Deal: Commission Proposes Transformation of EU Economy and Society to Meet Climate Ambitions'. Accessed: 2024-02-20, https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3541
European Commission (2023a) 'Commission Sets Out Immediate Actions to Support the European Wind Power Industry'. Online Accessed: 2024-03-19, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5185

European Commission (2023b) 'Commission Sets Out Immediate Actions to Support the European Wind Power Industry'. Accessed: 2024-02-20, https://ec.europa.eu/commission/presscorner/detail/en/ip

European Parliament and Council of the European Union (2000) 'Directive 2000/60/EC Establishing a Framework for Community Action in the Field of Water Policy'.

European Parliament and Council of the European Union (2016) 'Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 Concerning Measures for a High Common Level of Security of Network and Information Systems Across the Union'. Online Accessed: 2024-03-27, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016L1148

European Parliament and Council of the European Union (2022a) 'Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on Measures for a High Common Level of Cybersecurity Across the Union, Amending Regulation (EU) no 910/2014 and Directive (EU) 2018/1972, and Repealing Directive (EU) 2016/1148 (NIS 2 Directive)'. Online Accessed: 2024-03-27, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022L2555

European Parliament and Council of the European Union (2022b) 'Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the Resilience of Critical Entities and Repealing Council Directive 2008/114/EC'. Online Accessed: 2023-03-04, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2557

European Parliament and Council of the European Union (2024) 'Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the Assessment and Management of Flood Risks'. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32007L0060

European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) (2024) 'Challenges in the Practical Implementation of EU Environmental Law: Study of the IMPEL Network - March 2015'. Available from: https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/temas/medio-ambiente-industrial/implementation-challenge-report-summary-23-march-2015_tcm30-426821.pdf

Federal Emergency Management Agency (2017) 'Mitigation Assessment Team Report: Hurricane Irma in Florida'. Available from: https://www.fema.gov/sites/default/files/2020-07/mat-report_hurricane-irma_florida.pdf

Federal Ministry of the Interior and Community (2021) 'Zweite Verordnung zur Änderung der BSI-Kritisverordnung'. In *Bundesgesetzblat teil i* (Bundesanzeiger Verlag), pp. 4163–4187.

Fritz, H. M., Synolakis, C. E., Catalán, P. A., et al. (2011) 'Field Survey of the 27 February 2010 Chile Tsunami'. *Pure and Applied Geophysics*, Vol. 168, pp. 1989–2010. https://doi.org/10.1007/s00024-011-0283-5

Fuglie, K. (2021) 'Climate Change Upsets Agriculture'. *Nature Climate Change*, Vol. 11, pp. 294–295. https://doi.org/10.1038/s41558-021-01017-6

Gabriel, A., Tecklenburg, B. and Sill Torres, F. (2022) 'Threat and Risk Scenarios for Offshore Wind Farms and an Approach to Their Assessment'. In *19th International Conference on Information Systems for Crisis Response and Management*, pp. 162–173.

Halog, J., Margat, P. and Stadermann, M. (2024) 'Submarine Infrastructures and the International Legal Framework'. *Transactions on Maritime Science*, Vol. 13, No. 1. https://doi.org/10.7225/toms.v13.n01.w16

Hartmann, T. and Albrecht, J. (2014) 'From Flood Protection to Flood Risk Management: Condition-Based and Performance-Based Regulations in German Water Law'. *Journal of Environmental Law*, Vol. 26, No. 2, pp. 243–268. https://doi.org/10.1093/jel/eqt032

Heintz, M. D., Hagemeier-Klose, M. and Wagner, K. (2012) 'Towards a Risk Governance Culture in Flood Policy Findings From the Implementation of the "Floods Directive" in Germany'. *Water*, Vol. 4, No. 1, pp. 135–156. https://doi.org/10.3390/w4010135

Hurka, S., Haag, M. and Kaplaner, C. (2022) 'Policy Complexity in the European Union, 1993-Today: Introducing the EUPLEX Dataset'. *Journal of European Public Policy*, Vol. 29, No. 9, pp. 1512–1527. https://doi.org/10.1080/13501763.2021.1938174

Hurka, S. and Steinebach, Y. (2020) 'Legal Instrument Choice in the European Union'. *Journal of Common Market Studies*, Vol. 59, No. 2, pp. 278–296. https://doi.org/10.1111/jcms.13068.

ISO (2018) 'Risk Management - Guidelines'. (*ISO 31000*): International Organization for Standardization.

ISO (2019) 'Security and Resilience - Business Continuity Management Systems - Requirements'. (*ISO 22301*): International Organization for Standardization.

Jones Day (2024) 'EU Proposes Criminalizing Sanctions Breaches'. Available from: https://www.jonesday.com/en/insights/2022/12/eu-proposes-criminalizing-sanctions-breaches

Joseph, J. and Juncos, A. E. (2019) 'Resilience as an Emergent European Project? The EU's Place in the Resilience Turn'. *Journal of Common Market Studies*, Vol. 57, No. 5, pp. 995–1011. https://doi.org/10.1111/jcms.12881

Kajitani, Y., Chang, S. E. and Tatano, H. (2013) 'Economic Impacts of the 2011 Tohoku-Oki Earthquake and Tsunami'. *Earthquake Spectra*, Vol. 29, No. 1_suppl, pp. 457–478. https://doi.org/10.1193/1.4000108

Knabb, R. D., Rhome, J. R. and Brown, D. P. (2005) 'Tropical Cyclone Report: Hurricane Katrina'. Available from: https://www.nhc.noaa.gov/data/tcr/AL122005_Katrina.pdf

Masson-Delmotte, V., Zhai, P., Pirani, A., et al. (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC).

Mori, N., Takahashi, T., Yasuda, T. and Yanagisawa, H. (2011) 'The 2011 Tohoku Earthquake Tsunami Joint Survey Group'. *Coastal Engineering Journal*, Vol. 54, No. 1, pp. 1250001–1–1250001–27. https://doi.org/10.1142/S0578563412500015

Mysiak, J., Testella, F., Bonaiuto, M., Carrus, G., De Dominicis, S., Ganucci Cancellieri, U., Firus, K. and Grifoni, P. (2013) 'Flood Risk Management in Italy: Challenges and Opportunities for the Implementation of the EU Floods Directive (2007/60/EC)'. *Natural Hazards and Earth System Sciences*, Vol. 13, pp. 2883–2890. https://doi.org/10.5194/nhess-13-2883-2013

National Centers for Environmental Information (NCEI) and NOAA (2023) '2011 Tohoku tsunami event information'. Available from: https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-more-info/5413

National Oceanic and Atmospheric Administration (NOAA) (2023) '2010 Chile tsunami'. Available from: https://nctr.pmel.noaa.gov/chile20100227/

Niemi, A. and Sill Torres, F. (2022) 'Evaluation of the Proposed European Commission Directive on Critical Entities Resilience and Its Potential to Consolidate the Resilience terminology'. In *Proceedings of the 32nd European Safety and Reliability Conference (ESREL 2022)*. https://doi.org/10.3850/978-981-18-5183-4_S21-02-213-cd

Nones, M. (2016) 'Implementation of the Floods Directive in Selected EU Member States'. *Water and Environment Journal*, Vol. 30, pp. 228–239. https://doi.org/10.5751/ES-08913-210450.

OECD (2024) 'Ocean Shipping and Shipbuilding'. Available from: https://www.oecd.org/ocean/topics/ocean-shipping/

Okafor-Yarwood, I., Eastwood, O., Chikowore, N. and de Oliveira Paes, L. (2024) 'Technology and Maritime Security in Africa: Opportunities and Challenges in Gulf of Guinea'. *Marine Policy*, Vol. 160, 105976. https://doi.org/10.1016/j.marpol.2023.105976

Papaioannou, G., Efstratiadis, A., Vasiliades, L., Loukas, A., Papalexiou, S. M., Koukouvinos, A., Tsoukalas, I. and Kossieris, P. (2018) 'An Operational Method for Flood Directive

Implementation in Ungauged Urban Areas'. *Hydrology*, Vol. 5, No. 2, 24. https://doi.org/10.3390/hydrology5020024
Parsons, M., Glavac, S. M., Hastings, P. A., et al. (2016) 'Top-Down Assessment of Disaster Resilience: A Conceptual Framework Using Coping and Adaptive Capacities'. *International Journal of Disaster Risk Reduction*, Vol. 19, pp. 1–11. https://api.semanticscholar.org/CorpusID:168330379
Patterson, D. A. and Bridgelall, R. (2020) 'Attack Risk Modelling for the San Diego Maritime Facilities'. *Marine Policy*, Vol. 121, 104210. https://doi.org/10.1016/j.marpol.2020.104210
Pelkmans, J. (2012) 'The Economics of Single Market Regulation'. (*25*). Bruges: College of Europe Available at College of Europe Research Repository.
Porcedda, M. G. (2018) 'Patching the Patchwork: Appraising the EU Regulatory Framework on Cyber Security Breaches'. *Computer Law & Security Review*, Vol. 34, No. 5, pp. 1077–1098.
Priest, S. J., Suykens, C., Van Rijswick, H. F., et al. (2016) 'The European Union Approach to Flood Risk Management and Improving Societal Resilience: Lessons From the Implementation of the Floods Directive in Six European Countries'. *Ecology and Society*, Vol. 21, No. 4, 50. https://doi.org/10.5751/ES-08913-210450
Purdy, G. (2010) 'Iso 31000:2009-Setting a New Standard for Risk Management'. *Risk Analysis: An Official Publication of the Society for Risk Analysis*, Vol. 30, pp. 881–886. https://doi.org/10.1111/j.1539-6924.2010.01442.x
Pursiainen, C. H. and Kytömaa, E. (2022) 'From European Critical Infrastructure Protection to the Resilience of European Critical Entities: What Does It Mean?' *Sustainable and Resilient infrastructure*, Vol. 8, pp. 85–101. https://doi.org/10.1080/23789689.2022.2128562
Rauter, M., Thaler, T., Attems, M.-S. and Fuchs, S. (2019) 'Obligation or Innovation: Can the EU Floods Directive Be Seen as a Tipping Point Towards More Resilient Flood Risk Management? A Case Study From Vorarlberg, Austria'. *Journal of Environmental Management*, Vol. 11, No. 19, pp. 5505. https://doi.org/10.1016/j.jenvman.2019.109748
Reuters (2021) 'One Password Allowed Hackers to Disrupt Colonial Pipeline, CEO Tells'. Available from: https://www.reuters.com/business/colonial-pipeline-ceo-tells-senate-cyber-defenses-were-compromised-ahead-hack-2021-06-08
Scheerlinck, G., Buts, C., Reniers, G. and Cools, M. (2017) 'Law in Action in the Private Security Industry: The Impact of Regulation on Competition'. *European Competition and Regulatory Law Review*, Vol. 1, No. 2, pp. 96–114. https://doi.org/10.21552/core/2017/2/4
Söderberg, C. (2016) 'Complex Governance Structures and Incoherent Policies: Implementing the EU Water Framework Directive in Sweden'. *Journal of Environmental Management*, Vol. 183, pp. 90–97. https://doi.org/10.1016/j.jenvman.2016.08.040, Accessed: 2024-04-07.
Statista (2022) 'Industrial Ransomware Targeted Industry Sectors Worldwide 2022'. Available from: https://www.statista.com/statistics/1368824/industries-targeted-industrial-ransomware-attacks-by-number-of-attacks/
Tanaka, Y. (2019) *The International Law of the Sea* (3rd edition). (Cambridge: Cambridge University Press).
The Barents Observer (2022) '"Human Activity" Behind Svalbard Cable Disruption'. Available from: https://thebarentsobserver.com/en/security/2022/02/unknown-human-activity-behind-svalbard-cable-disruption
The Guardian (2023) 'Undersea Pipeline Damage Appears to be Deliberate, Says Finland'. Available from: https://www.theguardian.com/world/2023/oct/10/undersea-pipeline-damage-appears-to-be-deliberate-says-finland
The New York Times (2021) 'Cyberattack Forces a Shutdown of a Top U.S. Pipeline'. Available from: https://www.nytimes.com/2021/05/08/us/politics/cyberattack-colonial-pipeline.html
Timmers, P. (2019) 'Cybersecurity: The EU's Approach'. In *The Routledge Handbook of EU Security Law and Policy* (Routledge), pp. 283–298.

Tsani, S., Koundouri, P. and Akinsete, E. (2020) 'Resource Management and Sustainable Development: A Review of the European Water Policies in Accordance With the United Nations sustainable development goals'. *Environmental Science & Policy*, Vol. 114, pp. 570–579. https://doi.org.yncjkj.com/10.1016/j.envsci.2020.09.008, Accessed: 2024-04-07.

United Nations International Strategy for Disaster Reduction (2005) 'Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters'. Available from: https://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf

United Nations Office for Disaster Risk Reduction (UNDRR) (2019) 'Global Assessment Report on Disaster Risk Reduction (GAR2019)'. Geneva, Switzerland. Available from: https://gar.undrr.org/report-2019

United Nations Office for Disaster Risk Reduction (2015) 'Sendai Framework for Disaster Risk Reduction 2015-2030'. Available from: https://www.undrr.org/implementing-sendai-framework/what-sendai-framework

United Nations Office for Disaster Risk Reduction (2024) 'Words Into Action Guideline: Man-Made/Technological Hazards'. Available from: https://www.undrr.org/publication/words-action-guideline-man-made/technological-hazards

United States Geological Survey (USGS) (2023) 'Magnitude 8.8 - Offshore Maule, Chile'. Available from: https://earthquake.usgs.gov/earthquakes/eventpage/official20100227063411530_30

World Bank Blogs (2024) 'Why Ports Matter for the Global Economy'. Available from: https://blogs.worldbank.org/transport/why-ports-matter-global-economy

Xiang, T., Malik, T. H., Hou, J. W. and Ma, J. (2022) 'The Impact of Climate Change on Agricultural Total Factor Productivity: A Cross-Country Panel Data Analysis, 1961-2013'. *Agriculture*, Vol. 12, No. 12, 2123. https://www.mdpi.com/2077-0472/12/12/2123

Yannopoulos, S., Eleftheriadou, E., Mpouri, S., et al. (2015) 'Implementing the Requirements of the European Flood Directive: The Case of Ungauged and Poorly Gauged Watersheds'. *Environmental Processes*, Vol. 2(Suppl 1, pp. 90–97. https://doi.org.yncjkj.com/10.1016/j.jenvman.2016.08.040

Zingraff-Hamed, A., Schröter, B., Schaub, S., et al. (2020) 'Perception of Bottlenecks in the Implementation of the European Water Framework Directive'. *Water Alternatives*, Vol. 13, No. 3, pp. 458–483. https://doi.org.yncjkj.com/10.1016/j.envsci.2020.09.008