EU-CIRCLE

A pan-European framework for strengthening Critical Infrastructure resilience to climate change

D8.12 Future activities towards standardisation

Contractual Delivery Date: 26/10/2018	Actual Delivery Date: 26/10/2018
Type: Document	Version: V1.0
Dissemination Level [Public] Deliverable	
Statement :	

This is a report about future activities towards standardisation that are relevant for enhancing the resilience of Critical Infrastructure to natural hazards related to climate change. It describes the two main domains that need standardisation activities, i.e. the ICT domain (data interoperability and big data), as well as a guidance/guidelines to including climate change adaptation to existing and future standards for improved risk management.

EU-CIRCLE is a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653824. Please see http://www.eu-circle.eu/http://www.eu-circle.eu/for more information.

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Document Log			
Issue	Date	Comment	Author / Organization
V0.0	07/09/18	Initial ToC prepared by UNEXE	AC/LVL (UNEXE)
V0.1	25/09/18	Initial version	LVL
V0.2	23/10/2018	Additions	LVL
		List here the changes and their rational for each release	

Executive Summary

This document presents and details future activities towards standardisation, that are relevant for EU-CIRCLE, i.e., for enhancing the resilience of Critical Infrastructure to natural hazards and extreme events.

To the best of our knowledge, there is no single standard or group of standards[1], which covers all the aspects in the holistic Resilience Framework Assessment developed in EU-CIRCLE. Related standards and standardisation initiatives, for which ongoing and future standardisation activities are related to EU-CIRCLE fall under two main categories:

(a) ICT and related technologies standards;

(b) Climate change adaptation measures in related standards for Risk Management in products (design, constructions, infrastructures).

The Deliverable provides the ongoing and future actions and activities on standardisation for these two groups. The related ICT standards consist mainly on issues related to data interoperability and big data. The water domain, which is very important for CI resilience to a series of natural hazards and extreme events (e.g. flooding) lags behind other sectors in standardisation. Consequently specific future activities are required, which have been detailed.

With regards to adaptation measures to climate change, the document provides a guidance on the steps to be taken for adapting/developing related standards for risk management.

In conclusion, there are several gaps and needs in standardisation, which need specific actions to enhance the resilience of Critical Infrastructure to natural hazards, related to Climate Change.

[1] The term "standards" is used in this document in a generic way for all such deliverables from both recognised standards organisations and from standardisation fora and consortia Whenever required in this document the terms are specified in a more detailed way drawing on the definitions given in the Regulation on European standardisation (1025/2012/EU).

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List of domain specific abbreviations

AIOTI	Alliance for the Internet of Things Innovation
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
EN	European Standard
ETSI	European Telecommunications Standards Institute
DCAT	Data Catalogue Vocabulary
DIN	Deutsches Institut für Normung (German Institute for Standardisation)
IPCC	Intergovernmental Panel on Climate Change
CI	Critical Infrastructure
ICT	Information and communication technologies
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardisation
ITU-T	International Telecommunication Union -Telecommunication Standardisation Sector.
LCA	Life cycle assessment
LCT	Life-cycle thinking
OGC®	Open Geospatial Consortium
PSA	Professional Standards Authority for Health and Social Care (UK)
SAREF	Smart Appliances REFerence (SAREF) ontologies
W3C	Web of Thing Working Group

1 Introduction

1.1 Deliverable subject matter

EU-CIRCLE is an interdisciplinary project consisting of several models, types of applications, case studies and sets of data. Moreover it has developed a holistic approach to resilience for Critical Infrastructures (CI) for natural hazards under climate change, taking into account cascading effects. The methodology has been applied to specific Case Studies, related chiefly to fire and flooding (various types) disasters.

Currently no standardised methodology or approach exists for this type of problems. Additionally estimating resilience for CI involves several aspects (e.g. data exchange, ICT issues, climate change models, hazard and risk modelling and risk assessment) for several sectors and types of CI, i.e. energy, water, telecommunication, transportation, health, commerce etc.

Some interface standards do exist (e.g. OpenMI- http://www.openmi.org, OGC, CF metadata) from organisations for standards (e.g. ETSI, SAREF) but also from other projects. They do not cover every aspect of EU-CIRLE, and they are not sufficient for the holistic and interdisciplinary approach adopted in EU-CIRCLE. In particular there are two domains/groups of future activities related to EU-CIRCLE

This Deliverable (a) lists the major categories of related existing standards and standardisation approaches for which ongoing and future activities are relevant, (b) proposes the standardisation adaptation requirements for disaster resilience problems related to climate change, and guidance based on recommendations by the EU, so as to draw them to the attention of appropriate standards organisations (e.g. CEN etc).

1.2 Link to other deliverables

This task is linked to Deliverable 2.4 (climate and climate change metadata) and the Deliverables from WP4, chiefly D4.3 (Resilience Framework) and D4.8 (Resilience Metadata). It is also linked to the CIRP platform (WP5) and SIMICI (WP7) for the ICT related issues.

1.3 Structure of the deliverable

The deliverable is structured as follows: Chapter 1 is the Introduction, followed by a short description of the resilience framerork in EU-CIRCLE, and its lins to groups of standards and gaps in standardisation (Chapter 2). Chapter 3 described the gaps and activities in ICT related standrads, followed by guidelines on iincluding climate change adaptation to risk management standards (Chapter 4). The deliverable ends with Conclusions (Chapter 5).

2 Categories and types of standards, for which future activities are relevant to EU-CIRCLE.

EU-CIRCLE developed and introduced a holistic framework approach for enhancing CI resilience to natural hazards and extereme events under climate change, linking risk management, resilience and modelling, involving ICT and related technologies. The themes of the five Case Studies where this approach was applied and validated involved damages from flooding, wind (combined with flooding) and forest fires.

This framework approach (detailed in D 4.3) links risk management and modelling to enhance the resilience of CI, as shown in Figure 1.

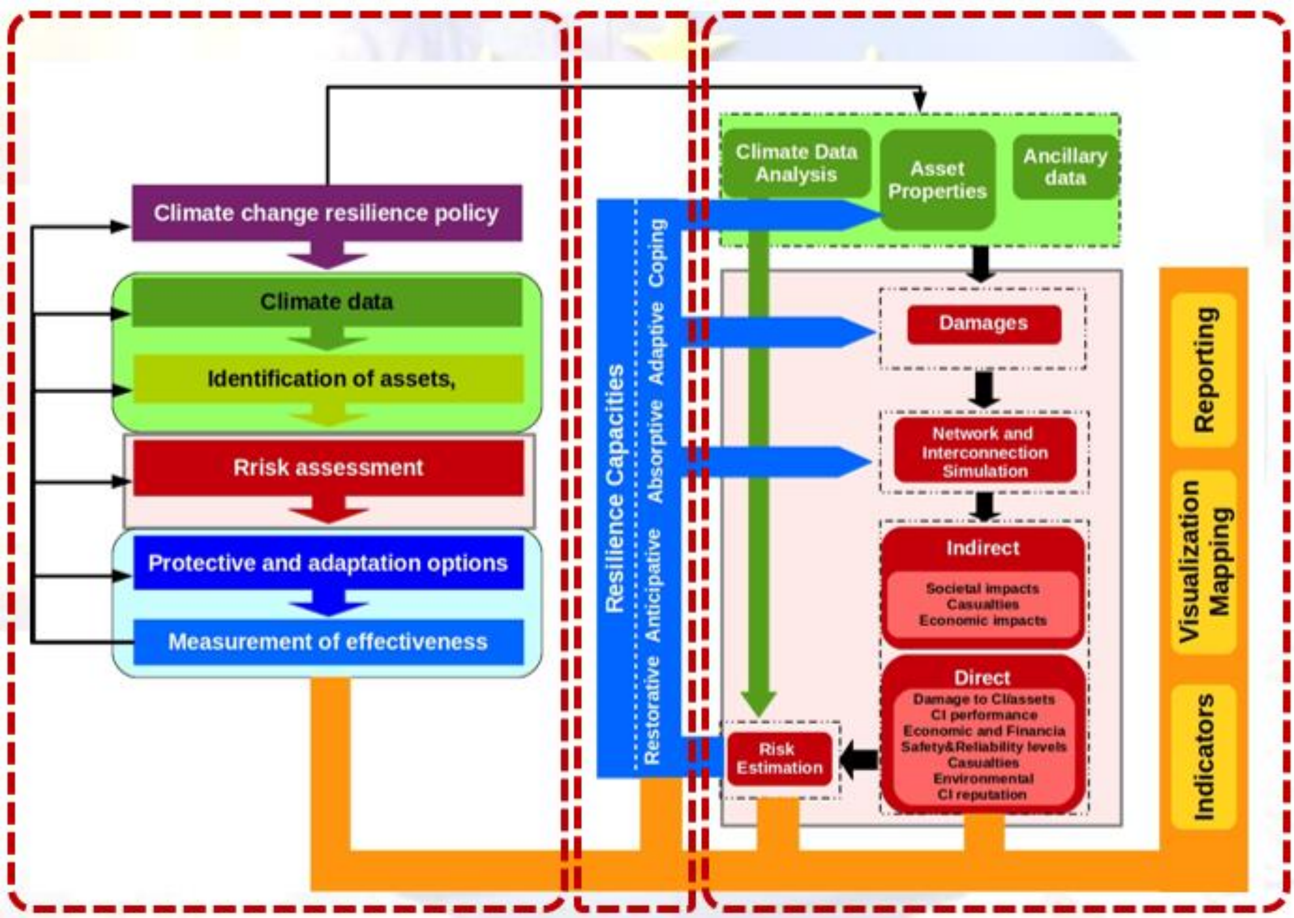

Figure 1: Linking risk management and modelling to enhance resilience under climate change

This figure shows that climate and climate change data and analysis, as well as simulation (ICT technologies) play an important role for a specific type of risk management suitable for CI resilience under climate change.

To the best of our knowledge, there is no single standard or group of standards[2], which covers all these aspects or resilience to climate change in general. Related standards and standardisation

[2] The term "standards" is used in this document in a generic way for all such deliverables from both recognised standards organisations and from standardisation fora and consortia Whenever required in this document the terms are specified in a more detailed way drawing on the definitions given in the Regulation on European standardisation (1025/2012/EU).

initiatives, for which ongoing and future standardisation activities are related to EU-CIRCLE fall under two main categories:

(a) ICT and related technologies standards;

(b) Climate change adaptation measures in related standards for Risk Management in products (design, constructions, infrastructures).

In the following sections this document provides an overview and analysis of the situation related to these two groups of standards/initiatives, the gaps and the recommendations from the project.

There are several standardisation bodies worldwide. Some (e.g. ISO) are relevant at a global scale, others (e.g. CEN) are relevant at European scale, while standardisation bodies exist in most countries producing standards at national level. Since EU-CIRCLE is a EU funded project, the document focuses mainly on European standards and standardisation activities, as well as recommendations, because they are the relevant ones.

3 ICT related standards and standardisation ongoing and future activities

3.1 ICT role for EU-CIRCLE

Risk Assessment for EU-CIRCLE is relying heavily on modelling and digital technologies for data exchange, data processing and analysis. CI impact assessment involves series of different types of data, which need to be interlinked and analysed, as shown in Figure 2 for flood assessment.

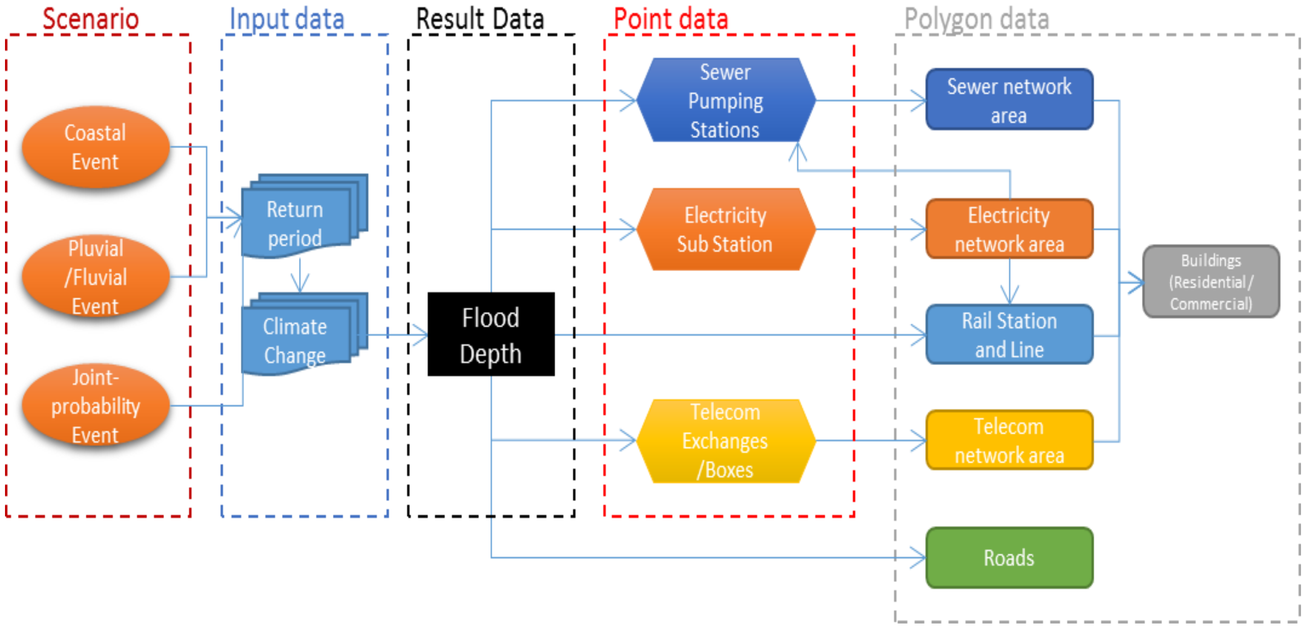

Figure 2 Data Flow and Data exchange in EU-CIRCLE for impact assessment

This Figure shows that data exchange and interoperability plays a very important role for impact assessment to CI. There are also various types of data involved from different sources: Climate data, geo-location data, modelling data, as input or output to the different steps.

Consequently data interoperability and exchange is of prime importance.

3.2 Data interoperability standardisation: EU initiatives and priorities

Data interoperability and standardisation is a crucial domain for the Digital Single Market Strategy for Europe[3]. The digitisation of the global economy and society affects all sectors. It is at the heart of the EU's political agenda and is necessary for European competitiveness. Having common ICT standards is one of the measures needed to ensure that European industries are at the forefront of developing and exploiting ICT technologies: they ensure interoperability and guarantee that such technologies work smoothly and reliably together.

In the last decades, many of the most commonly used ICT technical specifications are produced by forums and consortiums that have become leading ICT standards development bodies. The Commission financially supports the work of the 3 European standardisation organisations:

ETSI – the European Telecommunications Standards Institute

[3] COM/2015/0192 final, A Digital Single Market Strategy for Europe

CEN – the European Committee for Standardisation

CENELEC – the European Committee for Electrotechnical Standardisation

EU-funded research and innovation projects also make their results available to the standardisation work of several standards-setting organisations. So far EU-CIRCLE has already contributed in this domain, as detailed in Section 3.3.

It is a domain where several standards already exist:

For Geo-spatial data echange and protocols, as well as related software development, most of the standards are being derived by OGC® . A full list can be found at this address : http://www.opengeospatial.org/standards . Software developers use these documents to build open interfaces and encodings into their products and services and they have been used in the development of CIRP (WP5) as an open interface platform.

Another group of ICT standards is related to ETSI/CEN/CENELEC. Most of these standards refer to telecommunications and related matters. With regards to interoperability and data exchange a full list can be found here: https://www.etsi.org/standards-search#Interoperability

ICT, data exchange and interoperability is also a domain where several activities are taking place. With the Communication on ICT Standardisation Priorities the EC proposes to focus standard-setting resources and communities on five priority areas: 5G, Internet of Things, cloud computing, cybersecurity and data technologies because they are essential for wider EU competitiveness. Action in these areas can accelerate digitisation and have an immediate impact on competitiveness in domains such as eHealth, intelligent transport systems and connected/automated vehicles, smart homes and cities, and advanced manufacturing. Out of these priorities data technologies and cloud computing (CIRP in EU-CIRCLE is cloud based) are essential for enhancing the resilience of CI to natural hazards related to climate change.

The issue of ***cross-sectorial flow of data*** is of particular importance for EU-CIRCLE, as in the assessment of cascading effects, related to resilience of CI, there is the need of data collection and interoperability from various sectors and utilities: climate and weather forecast data, water sector data (water utilities), energy and transport sector data, health services data. As demonstrated in the Case Studies it is impossible to carry out simulation scenarios successfully without data and cooperation from all these sectors. This is a major issue, because of interoperability issues, but also because there are no policies promoting the cooperation of all these sectors.

In fact there are substantial differences in the capacity for interoperability between the sectors: telecommunications, energy and transport are far more advances in terms of ICT standardisation, whereas the water sector lags behind, when in comes to interoperability and standards, as detailed in the following section (3.3).

The Communication encourages the take up of the right ICT standards as one of the deliverables of the Digital Single Market Strategy adopted in 2015. However, priority setting alone does not suffice. Success depends on a high-level commitment to standardisation from a broad stakeholder base. This includes industry, standard-setting organisations and the research community.

Based on this, the EC has established the the European Multi-stakeholders Platform, the ICT Rolling Plan on ICT Standardisation and the Annual Union Work Programme for European Standardisation as delivery mechanisms for standards and standardisation deliverables. The

European Multi Stakeholder Platform on ICT Standardisation[4] has been set up to advise the Commission on matters relating to the implementation of ICT standardisation policy, including priority-setting in support of legislation and policies, and the identification of specifications developed by global ICT standards development organisations.

Members of the platform include representatives of EU and EFTA countries, European and international standard developing bodies, organisations active in Europe in the field of ICT standardisation development, and organisations representing industry, SMEs, consumers and societal stakeholders.

The Platform also advises on the elaboration and implementation of the annual **Rolling Plan on ICT standardisation**[5] , which analyses and updates all the issues and priorities related to standardisation and sets up priorities. It allows for increased convergence of standardisation makers' efforts towards European policy goals. The Rolling Plan focuses on those actions that can support the EU policies but does not seek comprehensiveness as regards to the work programmes of the various standardisation bodies; it simply urges for specific actions and identifies gaps and needs. The Rolling Plan further details the requirements for ICT standardisation, articulates them in the form of actions and provides a follow-up mechanism for the actions.

The Rolling Plan 2018 identifies 170 actions organised around four thematic areas: key enablers, societal challenges, innovation for the single market and sustainable growth. Not all of these priorities are directly relevant for the increased resilience of CI infrastructures (although all the actions that improve standards in telecommunication are indirectly relevant-but beyond the scope of this document).

Based on the 2018 Rolling Plan, a relevant crucial key enabler is **public sector information, open data and big data,** i.e. free flow of data, access and transfer in relation to machine generated data, liability and safety in the context of emerging technologies, portability of non-personal data, *interoperability and standards*. Under the Horizon 2020 ICT Work Programme 2016-2017 on topic ICT-14 / Big Data PPP, several actions have started on data integration and experimentation (including cross-sectorial and cross-lingual issues). The Communication on ICT Standardisation priorities identifies big data as priority domain and proposes some actions to contribute to global standardisation in the field of data. These are of primary importance for the enhancing the resilience of CI, as already mentioned. Any standardisation activity related to big data is of relevance for the CI resilience, since resilience assessment lies on data collection and processing from various sources and sensors.

Standardisation at different levels (such as metadata schemata, data representation formats and licensing conditions of open data) is essential to enable broad data integration, data exchange and interoperability with the overall goal of fostering innovation based on data. This refers to all types of (multilingual) data, including both structured and unstructured data, and data from different domains as diverse as geospatial data, statistical data, weather data, public sector information (PSI) and research data.

Studies conducted for the European Commission showed that businesses and citizens were facing difficulties in finding and re-using public sector information, a fact that was also noticed in EU-CIRCLE, when collecting data for the Case Studies. The Communication on Open data states that

[4] https://ec.europa.eu/digital-single-market/european-multi-stakeholder-platform-ict-standardisation
[5] https://ec.europa.eu/growth/content/2018-rolling-plan-ict-standardisation-released_en

"the availability of the information in a machine-readable format and a thin layer of commonly agreed metadata could facilitate data cross-reference and interoperability and therefore considerably enhance its value for reuse".

A common standard for the referencing of open data in the European open data portals would be useful. A candidate for a common standard in this area is the data catalog vocabulary (DCAT)[6]

The Communication on ICT Standardisation Priorities for the Digital Single Market proposes priority actions in the domain of Big Data. Actions mentioned herein below reflect some of them.

- **ACTION 1** Invite the CEN to support and assist the DCAT-AP standardisation process. DCAT-AP is based on the data catalogue vocabulary (DCAT). It contains specifications for metadata records to meet the specific application needs of data portals in Europe while providing semantic interoperability with other applications on the basis of reuse of established controlled vocabularies (e.g. EuroVoc) and mappings to existing metadata vocabularies (e.g. SDMX, INSPIRE metadata, Dublin Core, etc.). DCAT-AP and its extensions have been developed by multi-sectorial expert groups. Experts from international standardisation organisations participated in the group together with open data portal owners to ensure the interoperability of the resulting specification and to assist in its standardisation. These mappings have provided already a DCAT-AP extension to cover geospatial datasets, called GEO/DCAT-AP. The specification was developed under the coordination of the JRC team working on the implementation of the INSPIRE Directive[CC(2] . Another extension to describe statistical datasets, called STAT/DCAT-AP, was published end 2016. This work has been coordinated by EUROSTAT and the Publications Office.
- **ACTION 2** Promote standardisation in/via the open data infrastructure, especially the European Data Portal[CNECT3] being deployed in 2015-2020 as part of the digital service infrastructure under the Connecting Europe Facility programme,
- **ACTION 3** Support of standardisation activities at different levels: H2020 R&D&I activities; support for internationalisation of standardisation, in particular for the DCAT-AP specifications developed in the ISA programme, and for specifications developed under the Future Internet public-private-partnership, such as FIWARE NGSI and FIWARE CKAN[7].
- **ACTION 4** Bring the European data community together, including through the H2020 Big Data Value public-private partnership, to identify missing standards and design options for a big data reference architecture, taking into account existing international approaches .
- **ACTION 5** Encourage the CEN to coordinate with the relevant W3C groups on preventing incompatible changes and on the conditions for availability of the standard(s), to standardise the DCAT-AP.

The list of the main ongoing activities related to standardisation for big data and interoperability are shown in Table 1:

Table 1: Big Data and standardisation ongoing activities

[6] http://www.europeandataportal.eu/en/content/edp-and-fiware-launch-new-partnership
[7] www.fiware.org

Standardisation Body	Short Description and web links
ITU-T	It published a roadmap for big data standardisation in ITU-T under the name of Y.3600-series Supplement 40 "**Big Data Standardisation Roadmap**" that includes the standardisation landscape, identification/ prioritization of technical areas and possible standardisation activities. http://www.iso.org/iso/iso_technical_committee%3Fcommid%3D45020://itu.int/itu-t/workprog/wp_search.aspx?sg=13 The **Focus Group on Data Processing and Management** to support IoT and Smart Cities & Communities was set up in 2017. This Focus Group is expected to develop a standardisationroadmap for data management, taking into consideration the activities currently undertaken by the various standards developing organizations (SDOs) and forums. http://www.iso.org/iso/iso_technical_committee%3Fcommid%3D45020s://itu.int/en/ITU-T/focusgroups/dpm
OGC®	The Open Geospatial Consortium (OGC) defines and maintains **standards for location-based, spatio-temporal data and services.** The work includes, for instance, schema allowing description of spatio-temporal sensor, image, simulation, and statistics data (such as "datacubes"), a modular suite of standards for Web services allowing ingestion, extraction, fusion, and (with the web coverage processing service (WCPS) component standard) analytics of massive spatio-temporal data like satellite and climate archives. OGC also contributes to the INSPIRE project. http://www.iso.org/iso/iso_technical_ committee%3Fcommid%3D45020://www.opengeospatial.org
IEEE	**Pre-standardisation** activities on Big Data and open data: http://www.iso.org/iso/iso_technical_committee%3Fcommid%3D45020://standards.ieee.org/develop/msp/open-big-data.pdf
CEN/CENELEC	CEN/WS (Workshop) ISAEN "Unique Identifier for Personal Data Usage Control in Big Data" seeks to operationalize the bourgeoning policy initiatives related to big data, in particular in relation to personal data management and the protection of individuals' fundamental rights. http://www.iso.org/iso/iso_technical_committee%3Fcommid%3D45020s://www.cen.eu/news/workshops/
INSPIRE	**INSPIRE Directive**. Reference EU architecture for data sets sharing between EU countries. http://inspire.ec.europa.eu
W3C	DCAT vocabulary (done in the linked government data W3C working group) http://www.iso.org/iso/iso_technical_committee%3Fcommid%3D45020://www.w3.org/TR/vocab-dcat/ **Dataset Exchange Working Group** to revise DCAT, provide a test suite for content negotiation by application profile and to develop additional relevant vocabularies in response to community demand http://www.iso.org/iso/iso_technical_

	committee%3Fcommid%3D45020s://www.w3.org/2017/dxwg

3.3 The Water Sector: special issues and gaps. Ongoing and future activities in the domain of interoperability and standardisation

Water infrastructure is one of the most important CI domains for the resilience to narural hazards related to climate change. Moreover several adaptation measures are related to works and constructions for the water sector (e.g. sewer and drainage systems, flood protection). Additionally water supply and distribution systems are the most vulnerable and critical CI in times of extreme events. However the water domain is the most problematic, when it comes to ICT standards and standardisation at a European and global level.

The water sector needs to implement a range of measures to ensure being at the forefront of developing and exploiting digitalization, automation, sustainable production and processing technologies to serve the integrated water markets of the future. Following this major goal, the Action Plan for a Digital Single Market of Water services[8], was developed and adopted by the EC in 2018. This Plan was developed with the cooperation of the ICT4WATER cluster[9], a cluster of 35 EU funded projects[10].

The water domain is characterized by a low level of maturity concerning the standardisation of ICT solutions, their business processes and the related implementation in the legislative framework. This is due to the fragmentation of the sector, no holistic vision being set out and a lack of integration and standardisation of the technology. The development of system standards is essential for smart water solutions that should ensure interoperability of solutions, i.e. adaptability of solutions to new user requirements and technological change as well as avoidance of entry barriers or vendor lock-in through promoting common meta-data structures and interoperable (open) interfaces instead of proprietary ones

The Action Plan proposes actions relating to technology, market, business, awareness and possible regulation in the area of ICT supporting the water domain and its interactions. It enhances emerging Digital Water issues (current and future trends) in terms of services, data management, interoperability, intelligence, cybersecurity and standardisation, including synergies between the proposed solutions and with other related sectors (e.g. circular economy, water reuse, transport, energy, agriculture and smart cities), also considering social aspects (operators, consumers, legal issues, water value awareness).

With regards to standardisation for the “ICT and Water” sector, the Plan defines the following complementary actions (activities) on standardisation:

- **ACTION 1**: Guidelines for the definition of Smart Water Grids, powered by IoT technologies and standards, which contributes to decentralised bi-directional water and information flow.
- **ACTION 2**: Guidelines and collaborative work among key actors (associations, alliances, SDOs, etc.) for the definition of Water Big Data standardisation frameworks, which contributes to

[8] https://ec.europa.eu/futurium/en/system/files/ged/ict4wateractionplan2018.pdf
[9] www.ict4water.eu
[10] UNEXE, a partner in EU-CIRCLE, is a founding member and in the leading group of the ICT4WATER cluster

implementing smart water practices. Making special emphasis on key aspects of a big data platform such as integration, analytics, visualisation, development, workload optimisation, security and governance.

- **ACTION 3**: Selection and integration of the best technologies in each class among all the range of suitable standards and ontologies ensuring the interoperability at data and communication level.
- **ACTION 4**: Definition of open models and open data through interoperable platforms.
- **ACTION 5**: Provision of a long term regulatory strategy and advice relevant stakeholders about the adoption of smart technologies
- **ACTION 6**: Incentives for the adoption of Open Data standards, in order to be able to provide information in a transparent and up to date manner

The ongoing water related standards initiatives, related to the ICT for water sector are:

Table 2: Ongoing initiatives and activities related to standardisation for the water sector

Standardisation Body	Short Description and web links
CEN/CENELEC/ ETSI	**Functional reference architecture for communications in smart systems.** A European standard comprising a software and hardware open architecture for smart sensors and meters that supports secure bidirectional communication upstream and downstream through standardised interfaces and data exchange formats and allows advanced information and management and control systems for consumers and service suppliers ftp://ftp.cen.eu/cen/Sectors/List/Measurement/Smartmeters/CENCLCETSI_TR50572.pdf
OGC®	**HY_FEATURES**. Reference model defining real-world water-objects and the way they relate to each other according to hydro-science domain defined by semantics and network topology. http://www.opengeospatial.org/projects/groups/hydrofeatswg
ETSI	**SAREF Investigation for Water** (DTR/SmartM2M-103547) Determining the requirements for an initial semantic model for the Water domain based on a limited set of use cases and from available existing data models https://goo.gl/324EyW
OGC®	**WaterML2.0**. Standard information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems, through the use of existing OGC standards. http://www.opengeospatial.org/projects/groups/waterml2.0swg
INSPIRE	**INSPIRE Directive**. Reference EU architecture for data sets sharing between EU countries. http://inspire.ec.europa.eu
ISO/IEC	**Generic Sensor networks Application Interfaces** (ISO/IEC 30128). International Standard that depicts operational requirements for generic

	sensor network applications, description of sensor network capabilities, and mandatory and optional interfaces between the applications.
ITU-T	Ubiquitous sensor network middleware, applications, identification (**F.744** standard). Service description and requirements for ubiquitous sensor network middleware.
PSA	**WITS Standard Protocol.** Standard method dedicated to water industry telemetry control and monitoring. This standard protocol makes interoperable equipment from different manufacturers by using features of the DNP3 protocol to satisfy water industry specific functional requirements. http://www.witsprotocol.org
AIOTI	**High Level Reference Architecture.** Reference ICT architecture and semantic data model based on the ISO/IEC/IEEE 42010 standard for representing IoT entities and services. This reference architecture is transversal to a number of domains including water. https://aioti.eu/wp-content/uploads/2017/06/AIOTI-HLA-R3-June-2017.pdf
W3C	**Web of Thing Working Group.** RDF and Linked Data vocabularies to reduce the fragmentation generated in the IoT devices. Moreover, this group is also focused on providing best practices and corresponding APIs to enable semantic interoperability within the Smart City. **Iot-Schema.org[11].** Extension of schema.org data model towards modelling IoT entities with focus on energy, transport and water infrastructures.

In the digital economy, interoperability means ensuring effective and meaningful data exchange between digital components like devices, tools, networks or data repositories. For the water sector, it represents connecting better along the whole water value chain or between industry and services sectors. It results in more efficient connections across systems, between domains/sectors and between services and stakeholders. Standardisation has an essential role to play in increasing interoperability of new technologies within the Digital Single Market. It can help steer the development of new technologies such as 5G wireless communications, digitization digitisation of manufacturing (Industry 4.0), data driven services, cloud services, cybersecurity, e-health, e-transport and digital water, which must be an important component too. The EU Rolling Plan for ICT StandardisationStandardisation, detailed in the previous section, is an essential instrument in this regard. However, an increased effort is needed to ensure that standardisationstandardisation outputs keeps pace with changes in technologies. Currently, industry stakeholders decide 'bottom-up' in which areas to develop standards and this is increasingly taking place outside of Europe, undermining our long-term competitiveness. We need to define missing technological standards that are essential for supporting the digitization digitisation of our industrial and services sectors (e.g. Internet of Things, cybersecurity, big Big data and cloud Cloud computing) and mandating standardisationstandardisation bodies for fast delivery.

Availability of standards is often not sufficient to ensure interoperability, if existing standards are not integrated by suppliers in their solutions. Public procurement plays an important role in promoting standards and the water sector needs to create catalogues of ICT-standards and

[11] https://iot.schema.org/

interoperability specifications to guide public procurers and accelerate standards adoption on water markets. Integrating these catalogues into European catalogues would avoid market fragmentation at EU level.

The Digital Water Action Plan sets out specific activities and priorities and a timeline to implemente them, in order to endure the transition to the Digital Society and the Smart City of the Futires for the Water sector. The following activities are directly relevant to the gaps in standardisation and interoperability for the Water domain. Consequently they are also directly relevant for increasing the resilience of the Water CI, but also the resilience of CI overall, since flooding and subsequent cascading effects, which have an impact to all the CI (transport, energy, telecommuniations) usually depend on the reliable and resilient operation of the water infrastructure.

It should be pointed out that the Plan contains multiple activities. Here only the activities related to standardisation are included.

Also the outcomes from EU-CIRCLE have been trasmitted to the group that developed the Action Plan[12] and have been included in a specific activity DS.2, as shown below.

Table 3: Planned activities related to standardisation in the Action Plan for Digital Water Services (2018)

No.		**Action**	**Activities**	**Timetable**	**Implementation Instruments**
			A. INTEROPERABILITY & STANDARDISATION (I&S)		
1	**I&S.1**	To develop an European Catalogue of ICT4Water standards including: Adoption of Priority and Feasibility of integration [13] **INMEDIATE ACTION**	**Activity 1:** Develop guidelines for the adoption of ICT standards and emerging digital technologies in the water sector. **Activity 2:** Propose good Practices on the implementation of water information exchange standards, and their right portfolio, considering a cross-sectorial interoperability approach. **Activity 3:** Develop interoperability recommendations and specifications in due consideration of the Communication on ICT Standardisation Priorities for the Digital Single Market[14]. **Activity 4:** Provide guidelines for the inclusion of ICT Standards in public procurements. **Activity 5:**	2018	• Procurement < 15.000€

[12] UNEXE was a member of the group that prepared the Action Plan
[13] European Interoperability Framework (EIF) is part of the Communication (COM(2017)134), https://ec.europa.eu/isa2/eif_en
[14] COM(2016) 176 final, ICT Standardisation Priorities for the Digital Single Market

			Link water standards with the Rolling Plan for ICT Standardisation [15] **Activity 6:** Promote standardisation and interoperability through the deployment and application of standards[16].		
2	**I&S.2**	Development of information exchange water standards[17] including common languages to properly contextualise the business processes in the water domain (E.g. SAREF[18], HyFeatures[19], etc.)	**Activity 1:** Identify and develop interface standards essential for the integration of systems. **Activity 2:** Develop specifications for interoperability and data sharing across services (water, energy, assets, etc.) and their infrastructures. **Activity 3:** Promote and accelerate the development on standards and ontologies on data (Related to the ACTIONS)	2019- 2023	• Promote in the framework of standardisation bodies • Digital water interoperability award • Dedicated research and innovation actions • Cross European Data-water Association / ICT4Water cluster working group
			B. DATA SHARING (DS)		
3	**DS.1**	Develop recommendations ensuring interoperability and data sharing across services, making special emphasis on the free flow of non-personal data[20]	**Activity 1:** Define, develop, improve, operationalise, maintain and promote interoperable services and tools, standards and specifications following existing directives and initiatives: WFD, INSPIRE, GEOSS … **Activity 2:** Contribute to existing repositories by Improving collection, access and retrieval of coherent water related data. For instance, European Environmental Agency data and maps[21]; WISE[22] portal (Water Information System for Europe is the European information gateway to water issues). **Activity 3:** Engagement with other interconnected domains (e.g.	2018- Onwards	• Cross European Data-Water-Standardisation Associations working group • H2020 and following Funding Schemas • Current funded activities • European, National, Reginal Funding schemas • European-wide water data-sharing regulations

[15] http://ec.europa.eu/growth/content/2017-rolling-plan-ict-standardisation-released-0_en
[16] M/441 EN STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI IN THE FIELD OF MEASURING INSTRUMENTS FOR THE DEVELOPMENT OF AN OPEN ARCHITECTURE FOR UTILITY METERS INVOLVING COMMUNICATION PROTOCOLS ENABLING INTEROPERABILITY
[17] M/441 EN STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI IN THE FIELD OF MEASURING INSTRUMENTS FOR THE DEVELOPMENT OF AN OPEN ARCHITECTURE FOR UTILITY METERS INVOLVING COMMUNICATION PROTOCOLS ENABLING INTEROPERABILITY
[18] https://sites.google.com/site/smartappliancesproject/ontologies/reference-ontology
[19] http://external.opengis.org/twiki_public/HydrologyDWG/ModelRelationships
[20] COM 2017 (495) final, on a framework for the free flow of non-personal data in the European Union
[21] https://www.eea.europa.eu/data-and-maps
[22] http://water.europa.eu/

			climatology, agriculture, geography, etc.) for multidisciplinary systems with interoperable solutions. To integrate existing European public platforms (e.g. by JRC) and services (e.g. Copernicus by ESA)		
4	**DS.2**	Development of cross-domain data sharing mechanisms (Water-Energy-Communications-Agriculture-Transport-Climate)	**Activity 1:** Develop and provide cross-domain alignment open interfaces and establishing Open Data (or meta data) policies to facilitate the data flow between different systems and domains.	2021-2025	• Dedicated Research and Innovation actions

4 Guidance for standardisation for resilience assessment and adaptation measures related to climate change

4.1 Introduction

There exist several standards for risk management, chiefly related to business and industrial production processes, or investments, at a global scale. The most reknown and comprehensive group are the family of standards ISO 31000. However none of the existing standards takes into account adaptation measures, related to climate change, which is the most important consideration for improving the resilience of CI. The existing standards all refer to operations under non climate change conditions, for each type of CI.

However, design decisions that do not take account of climate based risks throughout the whole life of any CI may result in constructions (e.g. sea walls) that are not fit for purpose, either because they ignore the changing conditions, or because the materials used are not suitable e.g. for the expected changes in temperature. Therefore standards related to resilience that ignore the effects of climate change may be failing at their main objective of ensuring fitness for purpose, further embedding vulnerability into the infrastructure and economy.

In addition, weather already affects all stages of the life cycle of products (see the definition of products in the next section). For example, raw material acquisition can be affected if materials are sourced from regions that are especially vulnerable to weather disasters; water intensive production processes can be compromised during times of drought; and severe weather events regularly cause supply chain disruption or disputed functionalities. These impacts range from slight to significant; they can be short-term or long-term; they can occur at global, regional or local level and they can be different on each stage of a standardisation subject's life-cycle.

In some cases, these risks are being underestimated and not adequately dealt with. Therefore, even in the absence of climate change considerations, there is a benefit to improving resilience to the current climate. Provisions in product and design standards can help organizations and communities to be more prepared for the impacts of severe weather events and to adapt to climatic change, including the resulting hazards.

Climate change adaptation is a field which is constantly evolving. It should therefore be noted that these guidelines are based on the best available knowledge and on the recommendations of CEN[23]. The dynamic nature of climate change strengthens the need to be considered in the standard development or revision process at a very early stage.

In order to develop design standards for structures related to adaptation to climate change, one should:

- emphasize that taking into account aspects of climate change is a complex process that requires to look beyond the common boundaries of a special standardisation subject;
- identify and understand basic principles that need to be considered when thinking about adaptation to climate change and
- integrate climate change adaptation provisions in standards.

[23] CEN-CLC Guide 32:2016

These guidelines propose a step-by-step approach, based on the principle of life-cycle thinking, for inclusion of climate change issues, as follows:

Step 1: WHY: Impacts of climate change can affect the materials or design of structures (including CI) and their resilience should be enhanced

Step 2: WHAT: Integration of effects of climate change should be included in the design

Step 3: HOW: By using a decision tree, where sources of information, modelling considerations, provisions for climate change adaptation are to be taken into consideration for the design, the materials and the constructions.

Step 4: OUTCOME: Standards that are fit for purpose in a changing climate

4.2 Terms and definitions

This document follows the term terms and definitions given in CEN Guide 4 and the following apply. In many cases (e.g. in the definition of "products" they use special terms, which are not encountered in other parts and deliverables, because they are based on the definitions and recommendations of CEN/CENELEC for developing and/or adapting standards. Consequently this glossary has been added here, in order to clarify the special meaning for standardisation recommendations.

Climate: average and variability of weather at a given location over a period of time, normally 30 years. The definition of climate is based on the IPCC definition.

Climate change: change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer, as per the IPCC definition. Both natural processes and human activity can cause climate change.

Climate change adaptation: process of adjustment to actual or expected climate change and its effects. The definition of climate change adaptation is based on the IPCC definition.

Climate change factor: multiple that describes the difference between the current and the future climate or their effects

Climate-influenced product: multiple that describes the difference between the current and the future climate or their effects; a product whose fitness for purpose may be affected if climate change is ignored

Climate information: information relating to the current, future or past climate or its effects

Climate projections: time-dependent information about the future climate, modelled on the basis of plausible assumptions about future greenhouse gas emissions and climatological relationships. The definition of climate projections is based on the IPCC definition.

Climate resilience product: product whose main aim is to reduce vulnerability to climate hazards, such as flood barriers, sea walls etc.

Flexibility: extent to which a design decision can be altered as more information becomes available

Hazard: circumstance or situation where life, health, property, infrastructure, livelihoods, service provision or environmental resources are threatened.

Infrastructure/critical infrastructure: set of interacting or interdependent structural elements (system) that provide basic physical and organizational structures needed for the functional operation of society, enterprise or the services and facilities necessary for an economy. These vital functions are generally ensured by products, systems and processes that are often subject of standards. As examples of functional operation of society and economy following demands can be called: basic supply (e.g. production, storage and distribution of water, food, energy and products), habitation, communication, finance, health including emergency service and public administration including civil protection and public security. Critical infrastructure is an infrastructure which is considered vital or indispensable to society, and whose failure or disruption would have a large impact, e.g., emergency services, communications, electricity substations, water supply and treatment works, transport infrastructure, reservoirs.

Life cycle assessment (LCA): compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle[24]

Life-cycle thinking (LCT) : consideration of all relevant environmental aspects (of a product) during the entire (product) life-cycle[25]

Product: A good, service, infrastructure, construction or test. The definition from CEN has been broadened for the purposes of this report.

Resilience: capacity of a social, ecological or economic system to cope with hazardous events or disturbance, responding or reorganizing in ways that maintain its essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation. The definition of resilience is based on the IPCC definition.

Sensitivity: degree to which a system is affected, either adversely or beneficially, by climate variability or change. The definition of sensitivity is based on the IPCC definition.

Severe weather: weather event or combination of events that has significant effects or consequences. These events include heat waves, droughts, heavy precipitations, floods and storms that affect both society and the economy. In addition severe weather is rare and occurs at a certain place at a certain time.

Thresholds: level of magnitude of a climate variable (e.g. temperature) at which an effect or impact occurs

Vulnerability: propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to

[24] IEC Guide 109:2003, 3.10
[25] IEC Guide 109:2003, 3.10

harm and lack of capacity to cope and adapt. IPCC definition, 5th Assessment report.

Weather: physical state of the atmosphere at a particular time or in an even short period of time at a specific location. The weather is characterized using quantifiable parameters. These parameters are fundamental variables of the weather (weather elements) such as temperature, humidity, air pressure, wind direction and wind speed, cloud cover, precipitation, and visibility.

4.3 Approach for integrating climate change adaptation provisions in standards

This section contains basic principles and approaches that should be considered by standard writers and provides guidance for integrating climate change adaptation provisions in standards.

In drafting provisions, standards should consider relevant aspects and impacts of climate change at all stages of the product-, service- or testing-lifecycle, following the step approach described in the previous section. In addition, standards should advocate a risk based approach to taking account of climate impacts on fitness for purpose.

When drawing standards for resilience and adaptation to climate change, reference should be made to the *life cycle of a product*. Life cycle assessment is not an appropriate approach for adaptation. However, life cycle thinking can help to make sure all relevant aspects of a product are considered.

a) Good and infrastructure standards:

For the purposes of this document the following stages of a good or infrastructure life cycle are defined (based on CEN Guide 4):

1) acquisition;

2) production;

3) use;

4) end-of-life.

b) Testing standards:

CEN-CENELEC Guide 33, Guide for addressing environmental issues in testing standards, explains that testing can take place in different stages of a products life cycle and defines the following life-cycle stages of testing:

1) sampling;

2) sample preparation;

3) testing;

4) reuse, recycle, recover.

With normative testing of products their required properties and their suitability for the intended use should be checked, proven and possibly classified. These tests usually simplify the real operating conditions in form of the laboratory simulation. In this case, both the maximum load to be expected, as well as a number of combinations of possible impacts, can be applied. On this basis, products and systems with respect to their suitability for the application, for example suitability for one or more climatic zones can be tested and classified, if necessary.

To adapt the testing standards to climate change, and consequently to the resilience to climate change impacts, it should be therefore examined, starting from the scientific climate projection, whether:

— the climatic conditions of the tests are to be adjusted, if necessary, for example for road surface, which can optionally be subjected to a much higher temperature in summer,

— the test methods for climatic simulation, if necessary, should be adapted due to higher frequent changes of extreme conditions, e. g. climatic chamber for reproduction of the aging process of protective coatings, and

— new normative test methods are to be developed for products and systems that can contribute to improving resilience, such as mobile flood protection systems, for which there is currently no standards on tests exist.

Each stage of testing might be influenced by climate change.

c) Service standards:

For the purposes of this document the following stages of services life cycle are defined (based on

CEN Guide 15):

1) acquisition;

2) promotion;

3) service provision;

4) end of service provision.

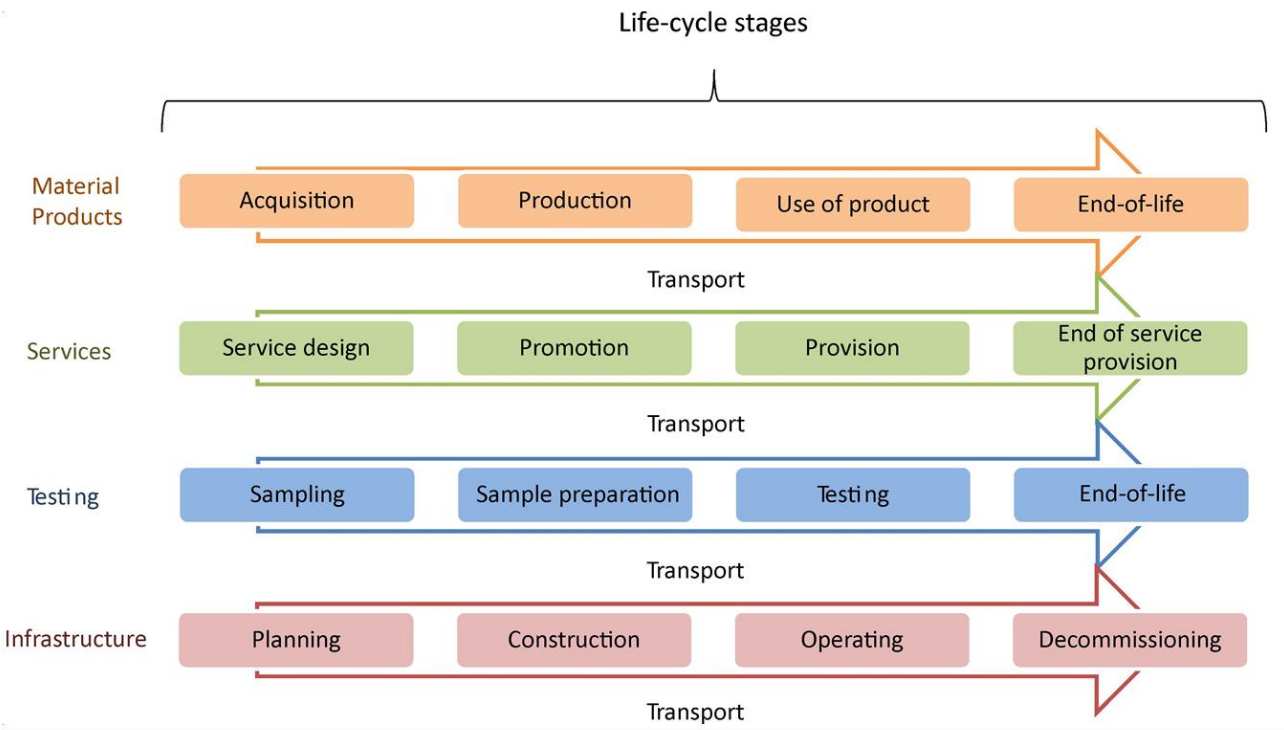

Figure 3: Life cycle stages

Climate drivers
Annual / seasonal / monthly average (air) temperature Extreme (air) temperature (frequency and magnitude) Annual / seasonal / monthly average precipitation Extreme precipitation (frequency and magnitude) Average wind speed Maximum wind speed Humidity Solar radiation

Secondary effects/ climate related drivers
Sea level rise (SLR) (plus local land movements) Sea/ water temperatures Water availability Storm (tracks and intensity) including storm surge Flood Ocean pH Dust storms Coastal erosion Soil erosion Soil salinity Wild fire Air quality Ground instability/ landslides/ avalanche Urban heat island effect Growing season length Icy conditions/ ground frost Thawing of permafrost

Impacts
Physical damage Loss of access Behaviour change Health effects Social change

Consequences	Life cycle stages			
	1	2	3	4
Changes to prices and availability of inputs	X	X		
Disruption to supply of raw materials	X	X		
Changes in demand		X		
Changes in user requirements			X	
Effects on quality/ performance			X	
Effects on chemical or mechanical processes			X	X
Transport disruption	X	X	X	X

Figure 4: Climate drivers, impacts and consequences for life-cycle changes

4.4 Use of a risk based approach

It is now “unequivocal” that the climate system is warming and extremely likely that human activity is the dominant cause, in accordance with IPCC 5th Assessment Report. However, plenty of uncertainty remains in terms of the rate and geographical distribution of this change and the effects it will have.

Adapting to climate change involves making decisions in the face of uncertainty. There are uncertainties relating to the rate and geographical distribution of changes in climate variables and there are modelling uncertainties. Most importantly, however, there are uncertainties relating to how climate change will translate into impacts on materials, processes and systems and what the consequences of these impacts will be for society. The use of a risk-based approach to adaptation allows for uncertainties to be acknowledged and embraced in the decision making process and for climate risks to be considered alongside and on an equal footing to other risks that are routinely managed. Here risk is determined in general by the probability of damage occurring as a realization of the hazard and the expected extent of damage as the consequences in case of a realization of the hazard. This definition differs from ISO 31000 (Family of standards for Risk Management in general, mainly for businesses and industrial processes) in wording and is nevertheless consistent with the ISO definition. Here, the uncertainty can be determined as the probability of a damage occurring and the effects of uncertainty (or hazard) on objectives as the consequences.

For risk-based analysis, it is necessary to identify and evaluate all relevant risks. For the risk assessment both the probability and the expected extent of impacts should be quantified as far as possible. Currently, the probability of the possible impacts of climate change, e. g. severe weather events, is mostly based on computational modelling. Therefore, it shall be examined in the context of risk management, which extent of impacts in case of a risk realization is still acceptable for the affected communities and businesses. This can inform the necessary measures for the adaptation. It can also be used to evaluate a range of adaptation options. Individuals and organizations have different objectives and attitudes to risk (how much risk they are prepared to accept) so in many cases it is not appropriate to standardize the outcome of a risk assessment, especially in an organization. However, at the level of the product, the main objective should be seen as fitness for purpose and standards writers may in some cases see merit in standardizing the level and type of adaptation required using a risk based approach.

4.5 Taking into account climate change and severe weather events

Climate change threatens the different regions of Europe in different ways, although all regions will experience climate change through a mix of gradual changes (such as increasing temperature or changes to biodiversity) and rapid ones (such as flooding). Moreover, some severe weather events have increased, with more frequent heat waves, forest fires and droughts in southern and central Europe. Heavier precipitation and flooding is projected in northern and north-eastern Europe, with an increased risk of coastal flooding and erosion. Northern Europe could also experience higher and heavier snow-loads and more fluctuations around zero degrees causing freeze thaw weathering. A rise in such events is likely to increase the magnitude of disasters, leading to significant economic losses, public health problems and deaths

Impacts vary across the EU depending on climate, geographic and socioeconomic conditions. All the countries in the EU are exposed to climate change (see Figure 2 below). However, some regions are more at risk than others. The Mediterranean basin, mountain areas, densely populated floodplains, coastal zones, outermost regions and the Arctic are particularly vulnerable. Additionally, three quarters of the population of Europe live in urban areas, which are often ill-equipped for adaptation and are exposed to heatwaves, flooding or rising sea levels.

Standards writers are quite used to taking into account weather risks, when drafting provisions. The impacts of severe weather events include flood or storm damage, health effects and disruption to energy supply, transport or supply chains. Here, they are encouraged to also take into consideration the impacts of a changing climate, i.e. those that arise from an increasing frequency and intensity of weather events or from trends in monthly or seasonal averages. The impacts of such trends include a reduction in water available for production and use stage processes and an increase in ground instability affecting buildings or infrastructure assets. Exposure to both severe weather and the impacts of climate change depends heavily on geographical factors, for example, urban areas are particularly exposed to temperature rise and sea level rise and its associated impacts are more of a concern for coastal zones, islands, areas already below sea level or offshore locations.

a) Changes to long-term averages:

The impacts of changes to long-term averages include effects on water and other ecosystems and food production. The impacts of severe weather events include flood or storm damage, health effects and disruption to energy supply, transport or supply chains. These changes shall be considered for standards that imply long term consequences. For products, if there are any long term consequences of design decisions, these are almost always going to occur in the use and end of life phases of products that have long life times.

b) Severe weather events:

In addition to average changes in climate severe weather events are expected to become more common.

Risks based on severe weather events are relevant throughout the whole life cycle. Such risks can be underestimated due to:

1) weather events being seen as something familiar and unavoidable;

2) over the last few years the frequency of severe weather events has increased, while the risk perception has stayed the same.

Due to climate change, future climate risks will be different from those in the present or recent past. Therefore, when considering the use and end of life stages of products with long life times, future climate risks that draw on climate projections need to be considered.

For the other life cycle stages (and for whole life cycle if the product life time and planning horizon is short), only the current climate risk is relevant. However, current climate risks can be underestimated due to:

— weather events and the effects of climate being seen as something familiar and unavoidable;

— the perception of risk not keeping up with the effect that climate change has already had on the level of risk.

A variety of adaptation measures are available to organizations, ranging from technological solutions and management responses to strategic changes. For example, flood walls, backup systems for business data, remote working, emergency plans or diversified supply chains.

Product standards, however, can only include measures that involve a change to the design of the product itself. The next section describes this in more detail.

Design decisions for products and production processes are an important way of dealing with climate change related issues in all stages of a life cycle. In particular, the exposure or operating conditions for products and systems may change substantially (e.g. the maximum temperature in summer for the design of asphalt pavement or for the cooling load). In addition, new products and systems may be needed or increasingly required to control new hazards, e.g. against heavy rain[26].

Ways in which product standards could contribute to adaptation include:

— taking into account extreme end use conditions within appropriate calculations, changing material composition or structure to adapt to the expected changes in operating conditions, testing in relation to changed end use conditions or new hazards (interfaces to testing standards); and

— increasing maintenance to achieve the planned life of products and in spite of the changed end use conditions (interfaces to service standards).

For example, iInitial discussions about the adaptation of the standards to climate change in Germany (DIN) have concluded that it is necessary that:

a) the standards writers know, understand and can assess the implications of climate change
b) climate scientists know which climate data with which accuracy are needed for standardisation.

For this reason, DIN is considering developing a standard for climate data with the involvement of climate scientists, weather experts and standards writers.

In most cases, products are interacting components of whole systems that provides a function to society or the economy. For example within a railway system, track is designed to interact with the earthwork it sits upon, the rail is designed to match the vehicle wheel, the earthwork is designed to support the track and electrification masts, the wheel and its suspension are designed to match the rail characteristics, etc. Drainage can affect earthwork stability and track geometry which in turn can impact upon the efficiency of electricity power current collection and rail/ wheel grip. Standard writers should therefore identify whether their standardisation subject interfaces with any climate influenced products and take steps to make sure that their standard does not constrain adaptation at these interfaces. This may include consideration of supply chain and other processes internal to the organization.

In addition, new components will have to interface with existing components and there will be a range of different lifetimes between individual components. Any timescales for the consideration of climate change within standards will need to take into account the interface of components with different ages and lifetimes.

[26] The EU approach to the circular economy considers design as a life cycle stage. However, for the purposes of this document design sits outside the life cycle as the means by which impacts across the whole life are managed.

4.6 Guidance for integrating climate change adaptation provisions in the product standard

This section describes how to integrate provisions regarding effects of climate change. It covers each life cycle stage and provides examples of climate change impacts and climate change adaptation provisions and the related decision trees.

Tables 1 to 6 give examples of recommendations for each stage of the life cycle that should be reflected while integrating provisions on climate change adaptation. Depending on the nature of the relevant climate impact and the scope of the standard, standard writers should decide if such provisions need to be included in a standard as requirement, recommendation or statement. The attention of standards writers is drawn on possible counterproductive effects in case adaptation measures result in more GHG emissions than before the revision of concerned standards. Such a warning should also be included in the decision trees (for both new and existing standards).ion

Climate change related impacts on the acquisition of raw materials include:

— supplier disruption due to weather event, in particular where suppliers are in vulnerable locations, such as near rivers, on flood plains or in areas of water scarcity;

— raw material production affected by climate change, in particular for agricultural products where climate is a key input or raw materials whose production requires high volumes of water.

Table 4 gives recommendations for adaptation provisions related to acquisition of raw materials.

Table 4: Acquisition stage related examples

Examples of provisions in standards	Choices, limitations or win-wins
	Any change in raw materials: - can affect quality, emissions, energy use at any life cycle stage; - can affect the costs of making the product and taking it to market; - could have implications for resource scarcity or end-of-life options. NOTE These apply to all of the following examples.
Give preference to materials that can be sourced from more than one place.	A choice between social objectives and resilience occurs where the production/ export of the material with only one source is essential to support livelihoods.
For agricultural products, consider different ingredients or new climate resilient varieties.	The limit to this is where the more vulnerable ingredients or varieties are vital for sustaining a poor rural community. Changing raw material qualities and increased costs for raw material due to poorer harvests.
Design for flexibility so that adjustments can be made later on as more information becomes available.	Reorganization measures for existing products, processes and buildings, especially for historical buildings, can´t be carried out without any limitations.
Give preference to materials without climate sensitive production processes.	
Give preference to materials, the extraction of which will not increase the vulnerability of the area of origin.	
Provide suitable information for the producer e.g. information about boundary conditions.	

Climate change related impacts on production processes include:

— impacts on staff comfort or health and safety due to severe weather and its impacts;

— impacts on climate, weather or temperature sensitive production processes, such as those reliant on cooling, water use, energy supply, using long-lived assets;

— impacts on outdoor activities that are weather dependant.

Decisions related to manufacturing processes are normally made in the short term e.g. purchasing or leasing of machinery, planning of production processes, recruitment of staff and training, in which case only the current climate should be considered. An exception might be the procurement of machinery that is expected to last a long time. For adaptation of products and production to climate change as a possible subject of standardisation it is also helpful that the processes for the design of products and production are systematically and continually examined. Therewith the adaptation in time should be ensured.

Table 5 gives recommendations for adaptation provisions related to production.

Table 5: Production stage related examples

Examples of provisions in standards	Choices, limitations or win-wins
Encourage use of water efficient process equipment.	There may be choices to make between water efficiency and energy efficiency, quality or costs as well as with sensitivity to temperature or other weather variables.
Avoid designs that require weather or temperature sensitive production processes or equipment.	There may be choices to be made between temperature/ weather sensitivity and water or energy efficiency, quality or costs.
Choose materials that can be easily stockpiled i.e. those that do not degrade quickly and can be easily stacked.	
Design aids and recommendations, such as maps including information about driving rain zones, should be updated with projected climate information for appropriate future time periods, where this is available.	The limit to this is where the right kind of future climate information is not available.

Climate change related impacts on service provision include:

— impacts on staff or customer comfort or health and safety due to excessively high temperatures or inclement weather;

— impacts on staff or customer travel due to severe weather or flooding;

— impacts on climate, weather or temperature sensitive equipment or consumables, such as those reliant on cooling, water use or energy supply;

— impacts on outdoor activities that are weather dependant.

These impacts can lead to either a disruption, where service provision ceases entirely or to a change in the quality of the service provided. Decisions related to service provision are normally made in the short term e.g. purchasing or leasing of machinery, planning of production processes, recruitment of staff and training, in which case only the current climate should be considered. However, if resources, such as equipment or premises require longer planning horizons, the future climate conditions should be taken into account.

Table 6 gives recommendations for climate change adaptation provisions related service provision.

Table 6: Service provision related examples

Examples of provisions in standards	Choices, limitations or win-wins
Ensure buildings can function and provide thermal comfort in a changing climate.	There may be choices to be made between water efficiency and energy efficiency, quality or costs.
Put in place remote working arrangements.	There may be choices to be made between quality or costs e.g. of providing associated information and communications equipment.
Put in place flexible working arrangements.	There may be choices to be made between quality.
Use business continuity plans and procedures to minimize the impact of a disruption when it occurs including plans for recovery.	
Give preference to equipment that is not weather sensitive.	There may be choices to be made between quality or costs.
Design aids and recommendations, such as maps including information about driving rain zones, should be updated with projected climate information for appropriate future time periods, where this is available.	The limit to this is where the right kind of future climate information is not available..
Include different design approaches depending on the geographical factors of area of use and provide relevant supporting information e.g. maps.	

The impacts of climate change on the use stage include:

— impacts on the effectiveness of a product that is climate or weather sensitive;

— impacts of climate change on users lead to changing requirements of products, especially for users in vulnerable locations or those with vulnerable supply chains;

— impacts on maintenance requirements.

In order to protect the fitness for purpose of the product throughout the whole of its life it is necessary to first have a clear understanding of the expected life time. Where this is longer than about 10 years, design decisions should take into account how the climate will change over this time frame. For products with shorter lifetimes, climate change may not be looked at as having potential impact unless e.g. the end of life of the product, service or process has long term effects and is climate sensitive (as in case of landfilling).

Table 7 gives recommendations for climate change adaptation provisions related to the use stage.

Table 7: Recommendations for climate change adaptation provisions related to the use stage

Examples of provisions in standards	Choices, limitations or win-wins
Choose materials that are more robust, heat resistant, porous, waterproof (depending on the context).	Any change in raw materials or design: - can affect quality, emissions, energy use at any life cycle stage; - can affect the costs of making the product and taking it to market; - could have implications for resource scarcity or end-of-life options; - will have implications for the functioning and vulnerability of the whole system.
Choose materials that are more robust, heat resistant, porous, waterproof (depending on the context).	
Design for resilience/ resistance e.g. changed dimensions.	
Design for durability including improved reparability and maintainability.	
Optimize the lifetime.	This will have implications for resource efficiency.
Design for portability so it can be moved and kept safe from weather hazards, e.g. smaller, lighter, movable, easily assembled/ disassembled, can be controlled remotely, own power source, etc.	
Inclusion of information for users e.g. operating instruction that take into account climate change related impacts.	Uncertainties with respect to climate change and knowledge gaps.
Include different design approaches depending on the geographical factors of area of use and provide relevant supporting information, e.g. maps.	

Climate change related impacts on a product at the end of its life include:

— some disposal or reprocessing activities may be weather or temperature sensitive;

— reusability can be affected by increased weather related wear and tear;

— product in the waste stage can no longer be landfilled, incinerated or become harmful to health and environment.

Table 8 gives recommendations for climate change adaptation provisions related to the end of life operations.

Table 8: End-of-Life stage related examples

Examples of provisions in standards	Choices, limitations or win-wins
Development of a systematic evaluation procedure for cases of damage.	No known limitations or decision conflicts/No example provided.
Assess that products at end of life will not be negatively affected by climate change in their reuse, recycling, recovery, disposal or decommissioning and look for new/alternative end-of-life options if necessary.	

Transportation needs to be considered at all stages of the life cycle.

Climate change related impacts to products during transportation (including transport of raw materials, product to market or product at the end of its life) include:

- weather events cause disruption to transport infrastructure leading to delays, in particular if travelling over long distances or through affected regions:
- transport infrastructure can be damaged by severe weather events or thawing of permafrost;
- loss of access e.g. due to flooding;
- product is damaged or degraded during transport due to temperature or humidity.

Table 9 gives recommendations for climate change adaptation provisions related to transportation.

Table 9: Transportation stage related examples

Examples of provisions in standards	Choices, limitations or win-wins
Traffic planning (not through vulnerable regions).	Longer delivery routes may lead to delay and higher costs.
Consider the location of raw material production (see acquisition).	
Choose the most resilient way of transport.	Choose the optimum between resilience and reduction of GHG emissions.
Choose new/ alternative ways of packaging.	Balance between waste and GHG emissions.

The actions to be taken for developing or adapting standards to resilience to climate change are dependent on decision trees,as follows:

The decision trees are used to determine the relevance of the actions. If the answer to any of the following seven questions is yes then climate change adaptation considerations are relevant to the development of the specific standardisation document(s).

— Does the production or service delivery depend on the supply of water (high volumes or specific quality), energy, agricultural or forestry products?

— Is the climate or water a key input into the production process?

— Does production or service provision involve any outdoor activities (including emergency responses)?

— Are there any climate, weather or temperature or humidity sensitive production processes, such as those reliant on cooling, water use or energy supply?

— Is the standard for a test method that is sensitive to temperature or humidity?

— Is the effectiveness of the product be affected by the weather or climate?

— Does the weather or climate influence what properties are required of the product?

— Are disposals or reprocessing activities likely to be weather or temperature sensitive?

If the answer to the above questions is no, but the answer to any of the following four questions is yes then climate change adaptation considerations may be relevant to the development of the standardisation document. The reasons for the decision need to be explicitly documented.

— Does the product rely on the supply of specific raw materials or inputs from a specific region?

— Is production or service provision likely to rely on staff occupying premises where of health, safety and comfort could be compromised by weather?

— Is the design lifetime of the product more than 10 years including its reuse? Is reusability important?

— Does the standard deal with transportation or its transport involved in any stage of the life-cycle?

If the answer to all of the above questions is no, then the climate change adaptation considerations are not relevant to the development of the standardisation document(s).If the answer is yes to any of the above questions then decision trees are needed to be used, to determine whether or not climate change adaptation is relevant.

The steps to be made and the needs are outlined in the decision trees that follow.

The first decision tree refers to the main issue, i.e. whether a new standard is to be developed or notr.

The decision trees contain letters in red that refer to the check tables that follow.

Figure 3: Preliminary decision

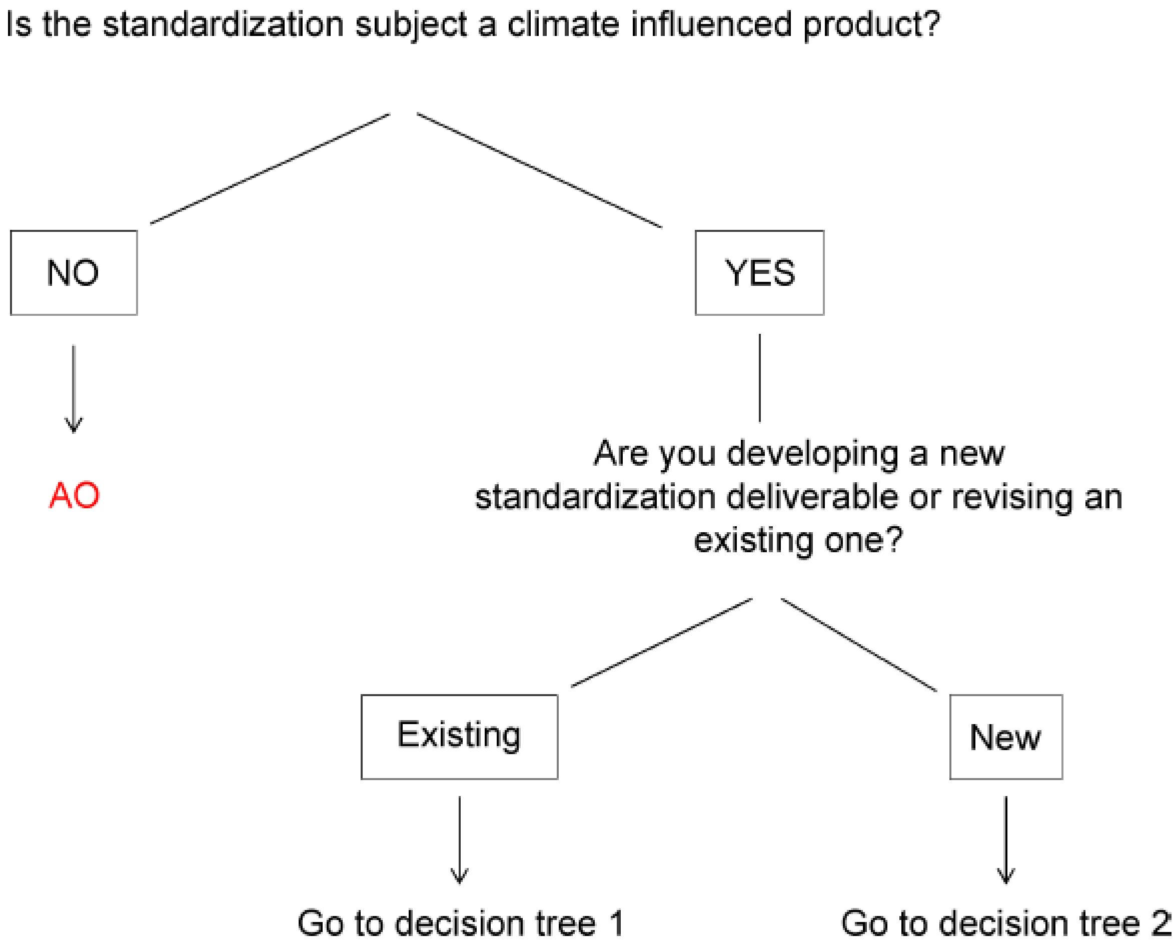

Figure 5: Flowchart of preliminary decision

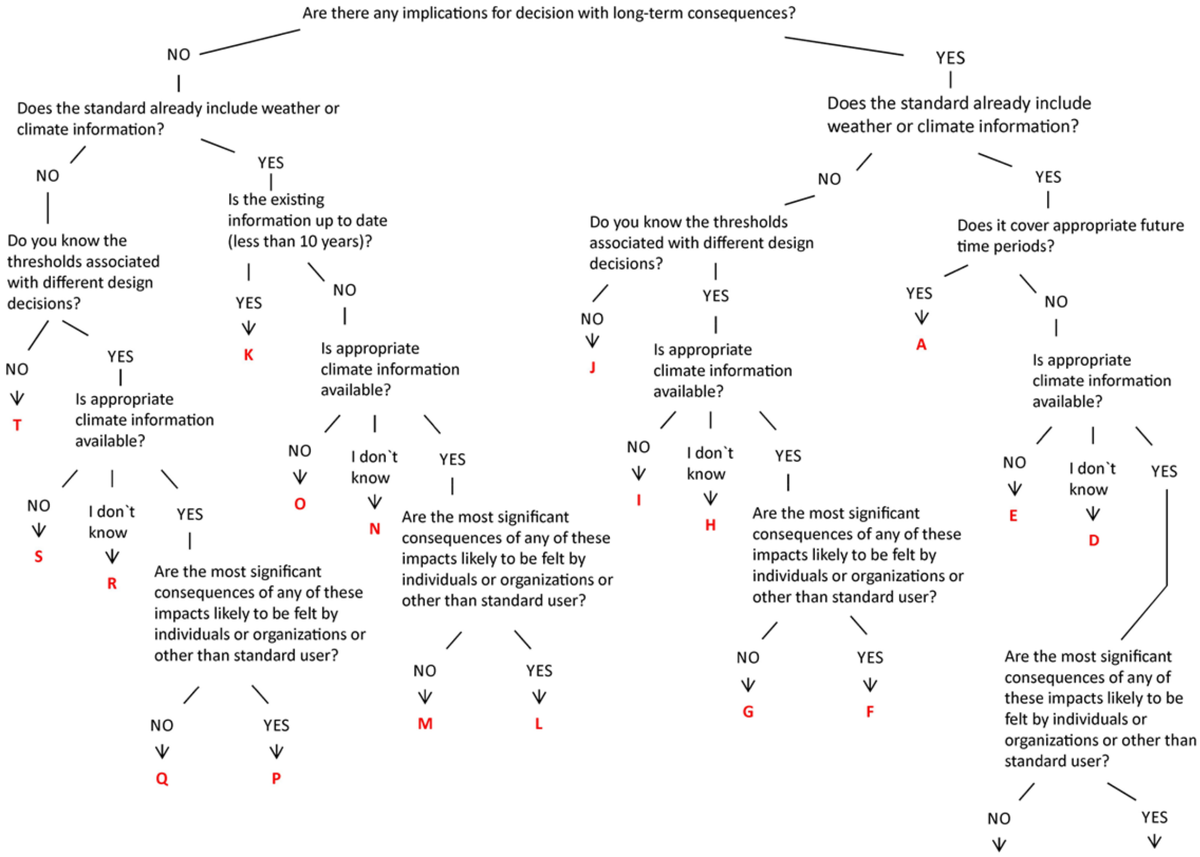

Figure 6: Decision tree 1 - review existing standardisation deliverables

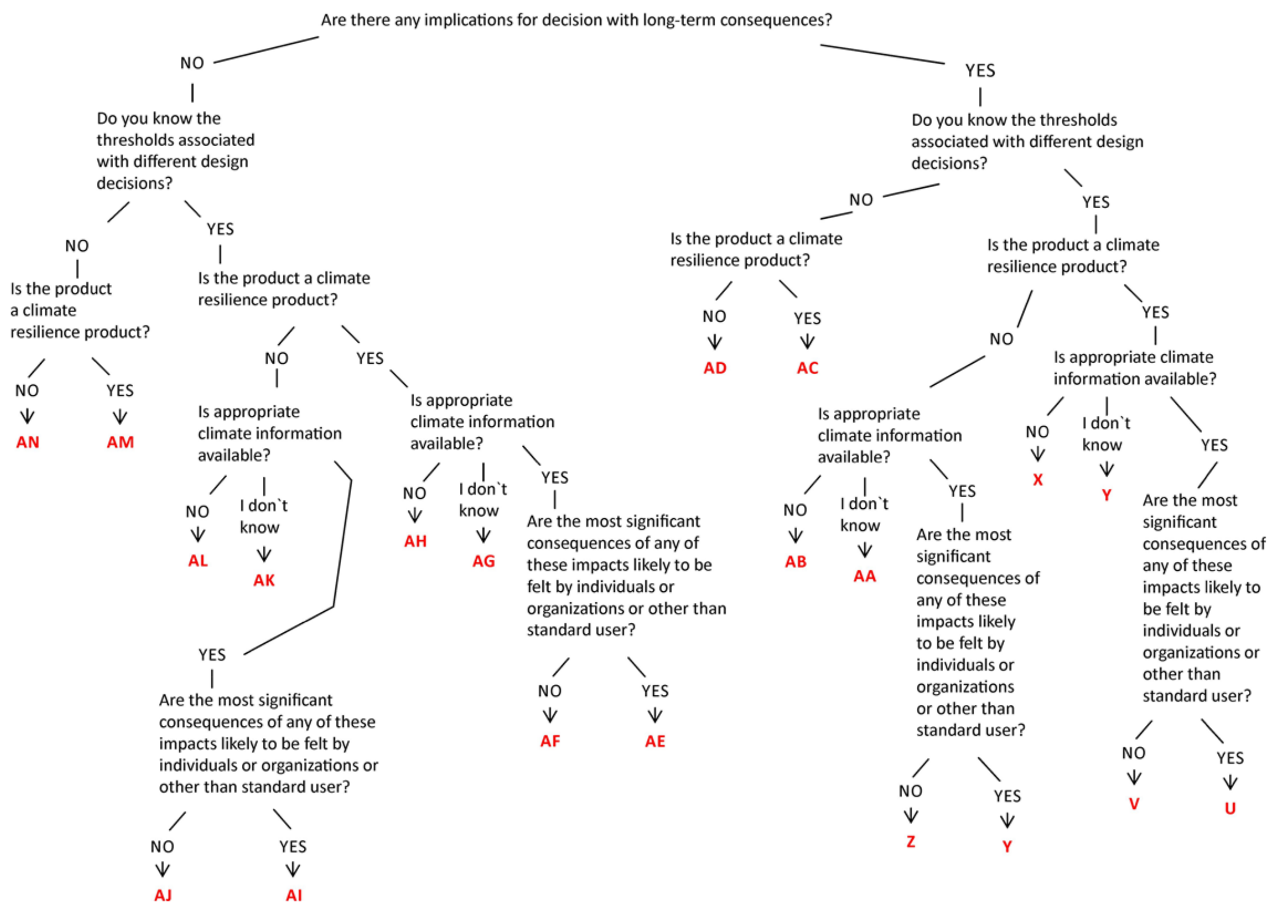

Figure 7: Decision tree 2 - drafting new standardisation deliverables

Once the decision tree has been developed and the route defined, the recommended checklists (red capital letters in the figures) are given in the following Tables.

The checklists refer to three categories for actions for the standard writer:

(a) Research needs

(b) Information in standards

(c) Provisions in standards

They provide guidance on the steps that are needed to develop/adapt standards, taking into account climate change and adaptation to climate change.

Table 10: Checklist for research needs

Research	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
Identify a range of adaptation options that could be incorporated in product design																																									
Identify which climate variables are relevant to the climate related impacts including the time period over which they need to be measured and averaged. Check available information sources to see if relevant information is available. Then start decision tree again.																																									
Identify any thresholds that are described or implied in existing climate information																																									
Consider carrying out or commissioning research to identify thresholds																																									
Identify the projected change in relevant climate variables, including the range of uncertainty throughout the design lifetime and end-of-life																																									
Consider commissioning research to generate climate information for all appropriate time periods and locations																																									
Research to identify an appropriate climate change factor																																									
Check whether existing information covers everything that you need																																									

Table 11: Checklist for Information in standards

Information in standards	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
Include appropriate future climate information (or a signpost to these) within the standard, replacing any existing climate information where necessary																																									
Replace old climate information with up to date climate information																																									
Consider the use of a climate change factor to update the existing climate information to take account of climate change																																									
Give extra consideration to the intended lifetime of product and consider inclusion of climate information from multiple time periods																																									
Include guidance on how to use future climate information (or a signpost to this) within the standard																																									
Climate related impacts on the acquisition and production stages may occur in other regions of the world not currently considered. Make sure climate information takes this into account																																									

Table 12: Checklist for provisions in standards

Provisions in standards	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
Define what level of risk or what level of impact the product needs to be resilient to		■				■						■				■					■				■						■				■						
Consider no regrets options i.e. those that yield benefits even in the absence of climate change and where the costs are relatively low	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	
Consider adaptive measures: i.e. options that make provision now for future adaptation	■	■	■		■	■	■		■	■											■	■		■	■	■		■	■	■											
Consider designing for exceedance i.e. Design for 'X', check sensitivity of product/ component against 'X+'	■	■	■		■	■	■								■						■	■			■	■															
Consider 'designing for degraded performance': Check what happens if the product/ component performs at below design capacity	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	
Consider how provisions can encourage increased resilience to indirect impacts from weather and climate e.g. through flood, drought or disruption from weather events	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	■		■	■	■		■	■	■	■	■		■	■	■		■	■	■	■
Consider the requirement for labelling that indicates thresholds relevant for use and end of life phase impacts		■				■						■				■					■	■		■	■				■		■	■		■	■				■		

5 Conclusions

This document presented and described future activities towards standardisation, that are relevant for EU-CIRCLE, i.e., for enhancing the resilience of Critical Infrastructure to natural hazards and extreme events.

To the best of our knowledge, there is no single standard or group of standards[27], which covers all the aspects in the holistic Resilience Framework Assessment developed in EU-CIRCLE. Related standards and standardisation initiatives, for which ongoing and future standardisation activities are related to EU-CIRCLE fall under two main categories:

(a) ICT and related technologies standards;

(b) Climate change adaptation measures in related standards for Risk Management in products (design, constructions, infrastructures).

The Deliverable provides the ongoing and future actions and activities on standardisation for these two groups. The related ICT standards consist mainly on issues related to data interoperability and big data. The water domain, which is very important for CI resilience to a series of natural hazards and extreme events (e.g. flooding) lags behind other sectors in standardisation. Consequently specific future activities are required, which have been detailed.

With regards to adaptation measures to climate change, the document provides a guidance on the steps to be taken for adapting/developing related standards for risk management.

In conclusion, there are several gaps and needs in standardisation, which need specific actions to enhance the resilience of Critical Infrastructure to natural hazards, related to Climate Change.

[27] The term “standards” is used in this document in a generic way for all such deliverables from both recognised standards organisations and from standardisation fora and consortia Whenever required in this document the terms are specified in a more detailed way drawing on the definitions given in the Regulation on European standardisation (1025/2012/EU).

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