EU-CIRCLE

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

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this issue

Adaptation to Climate Hazard Model

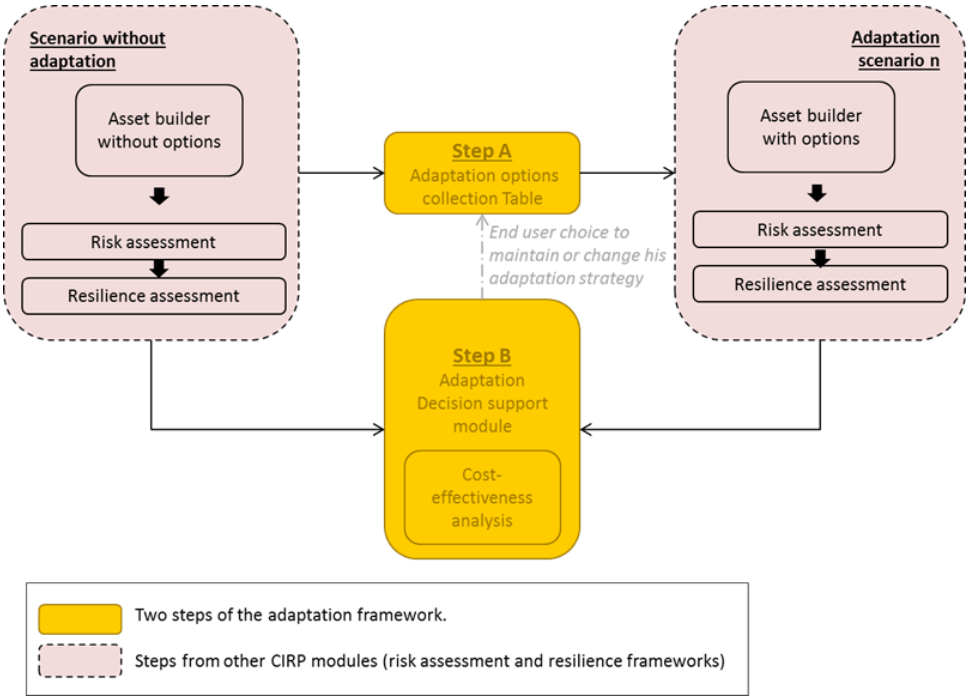
The EU-CIRCLE adaptation framework proposes a methodology allowing CI operators to identify, to assess and to select relevant adaptation options in order to improve their resilience to one or several climate change scenarios. This adaptation framework is consistent with the EU-CIRCLE risk and resilience assessment frameworks.

Description of the EU-CIRCLE adaptation framework

Build on a review of existing new approaches for decision-making under deep uncertainty (especially robust decision-making and adaptation pathways), this methodology is based on two main steps:

Step A: *selection of a range of adaptation options, according to the risk and resilience analysis (scenario without adaptation).*

Step B: *assessment of the selected options, according to their impact on the resilience and to their cost-effectiveness (comparing both scenarios without and with adaptation).*



Step	Stage	Description
A/ Identification of adaptation options	1. Establishment of the decision context	Definition of the acceptable resilience level (CI operator point of view) within climate change context; using the EU-CIRCLE Resilience Assessment Tool.
	2. Identification of options	Identification of adaptation options to reduce the damages (assessed using the risk assessment framework) and to improve resilience capacities (assessed using the Resilience Assessment Tool).
B/ Adaptation Decision Support Module	3. Identification of objectives and criteria	Regarding the decision context, determination of criteria to evaluate the adaptation options (including cost-effectiveness).
	4. Scoring of the expected performance in comparison to the defined criteria	Evaluation of the performance of each adaptation option against the selected criteria.
	5. Definition of weights for all criteria	Assignment of specific weight for each criterion with the decision makers.
	6. Computing the overall scoring/ value for each adaptation option	Final analysis.
	7. Sensitivity analysis	Results analysis to assess their stability to changes in the input parameters (climate change scenarios, criteria weights, etc.).

PROJECT DETAILS

Start date : 01/06/2015
End date : 30/09/2018
Duration : 40 months
Reference : GA no 653824
Call : H2020-DRS-2014

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Business Continuity model

The EU-CIRCLE Business Continuity model, focuses on Critical Infrastructure under climate pressures by:

1. presenting a business continuity plan based on existing operating principles and best practices
2. presenting how critical processes will continue operating to a minimal under recovery management
3. examining the feasibility of CI owners in specific regions to have a common and interrelated business continuity plan

The EU-CIRCLE BCM focus on the part of the curve that refers to resilience loss, aiming to evaluate different BC strategies that will reduce the recovery time, and secondly the part of adaptation, through various measures comparison. In order to achieve this and align with the requirements outlined in ISO 22301, a step process will be followed:

1. Identify possible business continuity strategies that will reduce the risk identified in the BIA and risk assessment to acceptable level. Three categories of business continuity strategy may be addressed:

- Risk Mitigation
- Incident Response
- Recovery of Activities and Resources

2. Assess the cost and benefits of identified alternatives and select the best contingency strategy for each core business process, asset or CI, in terms of resilience as described hereafter, but also in D4.3 and D4.5. From a CI's point of view, there are three important factors in the selection process:

- functionality: the degree to which the replacement functionality supports the production of a minimum acceptable level of output for a given core business process,
- deployment schedule: the time needed to acquire, test, and implement, and
- cost: life-cycle cost, including acquisition, testing, training, and maintenance.

3. Identify and document contingency plans and implementation modes

Based on the above steps, the following table is proposed as a general template that should be filled, in order to identify and describe BC activities.

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Phase	Time Frame	Activity
Phase I- Activation and Relocation	Approx. 0-12 Hours	• Alert and Notification. • Initial Actions • Activation Procedures Duty Hours. • Activation Procedures Non-Duty Hours. • Deployment and Departure Procedures • Transition to Alternate Operations. • Site-Support Responsibilities.
Phase II- Alternate Facility/ Work Site Operations	Approx. 12 Hours to Termination of Emergency	• Execution of Essential Functions. • Establishment of Communications. • Support and Contingency Team Responsibilities. • Augmentation of Staff. • Amplification of Guidance to Support and Contingency Teams. • Development of Plans and Schedules for Reconstitution & Termination.
Phase III- Reconstitution	Termination of Emergency	• Reconstitution Process. • Reconstitution Procedures. • After-Action Review and Remedial Action Plans.

To sum up, BCM is a business-owned, business-driven process that establishes a fit-for-purpose strategic and operational framework to review the way that a CI provides its products and services and increase its resilience to disruption, interruption or even loss. The EU-CIRCLE framework, incorporates CIs capabilities for supporting BCM and climate adaptation, providing guidelines and procedures properly defined and elaborated.

EU-CIRCLE BC model is tested and evaluated in context of proper test cases, through which a variety of CI's owners/stakeholders/managers shall identify and elaborate the more appropriate and cost-effective methods to manage the risk and impact associated with climate-triggered disruptive incidents.

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Case Study 3 - Torbay Coastal Flooding

The Torbay case study is focused on the effects of coastal flooding on critical infrastructure within Torbay. The objective of the case study was to analyse the effects of coastal, pluvial and fluvial flooding on CI as a result of climate change over the next 100 years within Torbay. Included within the analysis was adaptation proposals to reduce the risk of flooding to CI from coastal events within the town of Paignton.

Torbay is located in South Devon (UK) and covers an area of approximately 62 km2. The region includes three urban towns (Torquay, Paignton and Brixham) and hosts more than 3 million tourists every year that contribute over £450 million to local economy.

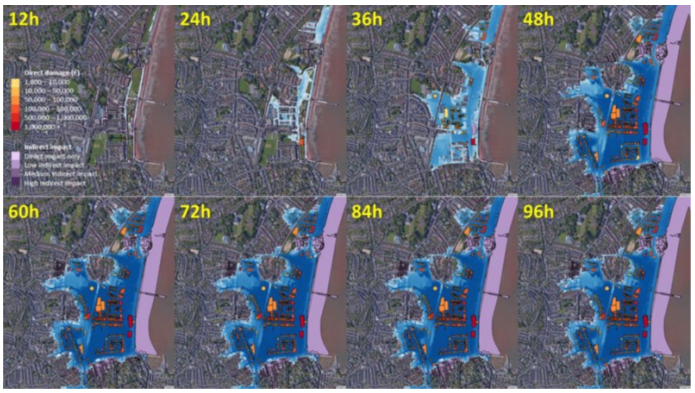
The area has suffered from flooding, during intense rainfall events, over many years from a number of different sources, including surface water run-off, highway flooding, sewer flooding, main river and ordinary watercourse. In addition the coastal areas of Torbay suffer coastal flooding due to overtopping of the sea defences during high tides that coincide with easterly winds. Figure 1 shows the effects of Storm Emma (March 2018) at Torquay sea front. (Further evidence of flooding to Torquay sea front can be seen using the following link: https://youtu.be/Oc2Imxkp9iY).

Historically, the consequences of these flooding events has resulted in many residential and commercial buildings in the town centres of Torquay, Paignton and Brixham being flooded together with roads being closed. As Torbay relies on tourism for it's economy, flooding of this nature has a very significant economic impact on the area.

Rising sea levels, as a result of climate change, will increase local flood risk both in coastal regions from increased risk of overtopping of the sea wall and inland from main rivers and watercourses due to the interaction with drains, sewers and watercourses. As sea level is predicted to rise by over 1m in Torbay over the next 100 years the frequency and impact of overtopping of the sea defences will increase resulting in more infrastructure and properties being affected by flooding.

Data provided by Torbay Council and the CI operators was utilised to analyse the risk of flooding to the CI. The analysis has identified both the direct and indirect effects on CI together with the costs associated with this damage. This work was carried out using the EU-CIRCLE CIRP tool, with the hydraulic modelling using CADDIES (a two-dimensional cellular automata based model) being incorporated into the CIRP tool. Flood visualisation has been developed for use within the case study using serious gaming techniques.

Figure 2 shows the predicted coastal flooding as a result of overtopping within Paignton for the 1 in 200 year storm event plus 50 years of climate change.



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An adaptation scenario was assessed within the case study where a secondary coastal defence was included behind the existing coastal defence in Paignton. The benefits provided by this secondary defence can be demonstrated within the CIRP tool and the visualisation for the 200 year event with 50 years of climate change as shown in figure 3.

Slide 1 – Identifies predicted combined coastal/pluvial flooding in Paignton for 2065
Slide 2 – Identifies predicted coastal flooding in Paignton for 2065
Slide 3 – Identifies predicted flooding in Paignton following adaptation scheme for 2065

Case Study 4 - International

This Case Study was conducted in Khulna city, in Khulna region, in the south-west of Bangladesh, the M35 of the project (24th April 2018). It was organized by the University of Huddersfield in collaboration with local researchers from the Khulna University of Engineering and Technology in the form of one day workshop (Figure 9). The case study is focused on cyclones and storm surges affecting the critical infrastructures of the area covering the sectors of communications, water and sewage, energy, transportation, commercial and residential buildings.

The participants of the workshop were:

- Khulna City Corporation (responsible for the municipal road network),
- the Khulna Power Company Ltd and
- the North West Zone Power Distribution Company Limited
- Leadership and Research professionals from Khulna University of Engineering and Technology

Additionally to the abovementioned workshop participants, the following entities offered data during the CS preparatory phase: Centre for Environment and Geographic Information Sciences (CEGIS), International Centre for Climate change and Development (ICCCAD), the Khulna Water and Sewerage Authority, the Khulna Development Authority.

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As described in Deliverable 6.8, Khulna city is a growing regional hub with a dense historic experience of tropical cyclones, a persistent urban drainage problem and a projected storm surge risk. Due to its location and topography, it is recognized as one of the most vulnerable cities to climate change. Due to the political and geo-economic history of the country, it is worth mentioned that Khulna's critical infrastructure has been assembled, disassembled and reassemble several times. Differently to the other CS, it has been decided not to make future projections for hazard analysis but to reproduce historic events, in order to encourage stakeholders engagement. The following storms, with estimated monetary damage from 1 to 15 billion dollars, were simulated: Cyclone Nargis (2008), Hurricane Mathew (2016) and Cyclone Mora (2017).

Risk assessment was performed during the workshop with implementation of CIRP. The latter was also used for wind hazard simulation while external software was used for flood modelling. Electricity distribution (electrical poles, substations) and road networks were modelled in the exposure layers. Further to CI assets, data of the built environment, with different structural typologies, was collected and included into the analysis. Results on building inundation, impact to electricity distribution caused by flooding at an electricity substation, wind impact on electric poles and buildings are provided. The RAT tool was demonstrated and distributed to participants but not completed since it has been considered that thorough knowledge of the CI is required. Adaptation options were not extensively discussed but it is recognized that RAT supports the decision process.

Upcoming Test Cases

Two more Case Studies will be conducted in the framework of EU-CIRCLE:

- CS5 – in Dresden, focusing on flooding of river Elbe, affecting networks such as that of roads and assets such of electrical substations and sewage pumps
- CS2b – in Cyprus, focusing on Mediterranean tropical-like cyclones, affecting CIs of the Energy sector (Power, Oil, Gas, Chemical, etc.)

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Dissemination Activities

Workshop on Critical Infrastructure Protection and Climate Change, Cyprus March 2017

On 7-8 March 2017 EU-CIRCLE organised a workshop on the topic of Critical Infrastructure Protection and Climate Change in Cyprus.

The workshop was organised by the European University Cyprus, and co-organised with the Cyprus Civil Defence (Cyprus's national contact point for EU CI), with the participation of the Joint Research Centre and local Critical Infrastructure Operators from the energy, ICT, water and public sectors.

In total, 50 stakeholders participated in the workshop, which included presentations on the potential impacts of hydro-meteorological hazards on CI, the changing climate in Cyprus and future climate change predictions as well as the EU-CIRCLE risk assessment and resilience frameworks.

The second day of the workshop included a table top exercise, where participants engaged in discussions on the predicted impacts of climate change exacerbated forest fires, on climate change risk assessment and on potential response options in interconnected national infrastructures.

DRMKC – Brussels

EU-CIRCLE (NCSRD and UNEXE) participated in the DRMKC event held on 16-17th March 2017 at Belraymont building in Brussels. Representatives of 14 FP7 and H2020 research projects that focus on geophysical hazards, cascade effects and extreme weather will present how their results can be used in practice, collect feedback from participants and propose common recommendations for the follow-up as well as for the implementation of European policies in the areas of disaster risk reduction, critical infrastructure protection and societal resilience. The workshop provided an inter-disciplinary forum for researchers, European and national policy-makers and risk management authorities, as well as owners/ managers of critical infrastructures to review the current state of knowledge and the needs of different stakeholders.

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Crisis Management Days 2018

EU-CIRCLE is presenting a poster on Business Continuity in a changing climate at the 11th Conference on Crisis Management Days, held in Brijuni, Croatia.

The Conference is organised by EU-CIRLCE partner the University of Applied Sciences Velika Gorica with the support of the National Protection and Rescue Directorate of Croatia.

Join us on 23rd and 24th of May.

Community of Users – May 2017

EU-CIRCLE participated in the workshop on Climate Clustering during the 7th CoU meeting that brought together project's coordinators, practitioners, policy makers and industry/SME representatives to boost possible synergies among projects and different actors. The twelve projects invited to the workshop are projects awarded under the Horizon 2020 DRS call 2014-2015 and initially identified as projects with potential synergies. Identified collaboration opportunities are focused around sharing and learning from each other's processes, developing a common tool to measure efficiency, developing a shared message towards policy makers and exploring joint actions, such as workshops and case studies.

Community of Users – June 2018

During the 11th CoU meeting, EU-CIRCLE participated at the Thematic Workshop – Theme 9: Extreme Weather and Climate Events - Afternoon session. Dave Stewart from TORBAY presented the project's 3rd Case Study focusing on how stakeholder may benefit from EU research projects. University of Exeter and Satways provided live demonstrations of CADDIES and the CIRP platform.

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Publications

Title of Publication	Type of Publication	Authors	Name of Journal/Conference
The role of climate data in assessing critical infrastructure resilience to climate change	Conference Paper	Athanasios Sfetsos, Diamando Vlachogiannis, Ivan Guettler, Melita Perčec Tadid, Ksenija Cindrid Kalin, Nadia Politi	Joint Congress of the 6th International Conference on Meteorology and Climatology of the Mediterranean (MetMed) & Challenges in Meteorology 5 (MI5), Zagreb Croatia, 20-22 February 2017
Enhancing the resilience of interconnected critical infrastructures to climate hazards	Conference, proceedings peer reviewed	Sfetsos A., Vamvakeridou-Lyroudia L.S., Chen A.S., Khoury, M., Savic D.A., Djordjevic S., Eftychidis G., Leventakis G., Gkotsis I., Karavokyros G., Koutiva I., Makropoulos C.,	15th International Conference on Environmental Science and Technology, Rhodes, Greece, 31 August to 2 September 2017
Energy critical infrastructures at risk from climate change: A state of the art review.	Journal	Mikellidou, C.V., Shakou, L.M., Boustras, G. and Dimopoulos, C.,	Safety Science, 2017
Demonstrable EU-CIRCLE scenarios in SimICI based on the interconnected European Critical Infrastructure of a virtual city,	Conference Proceedings - peer review	T. Katopodis, A.Sfetsos, V. Varela, G. Karavokyros, Ifigenia Koutiva, C. Makropoulos, D.Prior,	SafeAthens 2017, 28-30 June 2017 Athens Greece
Stakeholders' engagement in assessing the impacts of future wildfires on interconnected critical infrastructures in Cyprus,	Conference Proceedings - peer review	L.M. Shakou, C. Varianou Mikelidou, G. Boustras, A. Sfetsos, V. Varela, George Efctychidis	SafeAthens 2017, 28-30 June 2017 Athens Greece
How interconnected critical infrastructures can support societal resilience under future climate: The EU-CIRCLE approach	Publications Office of the European Union-ISBN: 978-92-79-74444-0	Athanasios Sfetsos, Theodoris Katopodis, Anastasia Eleftheriadou, George Eftychids, Ilias Gkotsis, George Leventakis, Ralf Hedel, Stefan Hamman, Louisa M. Shakou, Cleo Varianou Mikellidou, George Boustras, Catherine Freissinet, Jean Lecroart, Midori Million, Tariq Hisham, Chaminda Pathirage, Nenad Petrovic, Alen Stranjik	2nd International Workshop on Modelling of Physical, Economic and Social Systems for Resilience Assessment in 14-16 of December 2017

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