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On behalf of
Centunion, Española De Coordinación Técnica y Financiera, S.A.

THIRD-PARTY INDEPENDENT REVIEW OF CONTRIBUTION TO CLIMATE CHANGE ADAPTATION
PACKWACH BRIDGE - UGANDA

THIRD-PARTY INDEPENDENT REVIEW OF CONTRIBUTION TO CLIMATE CHANGE ADAPTATION PACKWACH BRIDGE - UGANDA

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EXECUTIVE SUMMARY

Ramboll has performed an assessment on the *climate resilience and contribution to adaptation* for the project of a new bridge in Pakwach, Uganda (replacing an existing smaller bridge). In particular, this is an independent third-party review required by Appendix II of 'The Renewable Energy, Climate Change Mitigation and Adaptation and Water Projects Sector Understanding (CCSU)' rule within the Organization for Economic Co-operation and Development (OECD)'s Arrangement on Officially Supported Export Credits for climate change adaptation projects (hereinafter the "CCSU rule") and it is requested by the Subdirección General de Instrumentos Financieros para la Internacionalización (Deputy Directorate General for Financial Instruments for Internationalization, or SGIFI).

The project consists of the replacement and upgrading of the existing 243-meter-long structure with a new 825-meter-long climate-resilient bridge over the Albert/White Nile River.

The "APPENDIX II: Eligibility Criteria for Climate Change Adaptation Projects" of the CCSU OECD document does not provide sufficient specificity on how to assess whether the project '*reduces the location-specific context of vulnerability to climate change*'. Ramboll has developed a methodology, previously agreed with the Lender (SGIFI) and shared with the EPC Contractor (Centunion S.A., herein and after Centunion), consisting in the application of the *sustainability proofing* guidelines´ requirements: "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" published by the European Commission and the Annex II of the EU Taxonomy's Delegated Regulation 2021/2139 (for climate change adaptation part).

The scope of the present assessment encompasses the evaluation of the sensitivity, exposure and vulnerability of the infrastructure to physical climate-related hazards. This is aimed at identifying and assessing potential physical climate change-related risks, both current and future. Subsequently, the pertinent hazards related to vulnerability are analyzed to assess the relative risk level before and after the bridge's construction. This is conducted to verify the bridge's resilience to these risks and to evaluate the infrastructure's contribution to the local community's and territory's adaptation to climate change.

Ramboll's assessment is based on the screening and review of public information and tools, as well as information and reports provided by Centunion regarding physical climate-related hazards for the area of interest.

Overview of project phases:

Phase 1: Ramboll consulted publicly available tools and documentation received from Centunion to classify physical climate-related hazards in Uganda considering three levels of sensitivity and exposure. The guidelines issued by the European Commission, specifically the criteria indicated in the *sustainability proofing* guidelines and the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" were utilized to score the different hazards, resulting in a vulnerability matrix for the project.

Phase 2: Ramboll carried out a high-level risk assessment to evaluate the likelihood of occurrence and the potential impact of each relevant hazard (medium or high vulnerability) identified in phase 1. The potential impact was assessed for two conditions, before and after the construction of the bridge. This was done to distinguish the level of risk following the completion of the project and to confirm the project's contribution to reducing the risk level. This step took into account the technical information provided by Centunion for the project.

Outcomes:

Phase 1: based on Ramboll's expert opinion and the information available from the provided documents, the vulnerability of the project, evaluated as the combination of sensitivity and exposure, is as follows:

- high vulnerability to inland flooding, extreme temperatures and soil erosion;
- medium vulnerability to extreme precipitation events and extreme wind conditions;
- low vulnerability to wildfires, drought, and subsidence.

Phase 2: based on the region-specific information and on the technical project information provided by Centunion, the following risk levels have been identified for the existent Packwach bridge and for the new one. This evaluation considers the likelihood of occurrence and potential impact (rated on five levels each, as outlined by the *sustainability proofing* guidelines):

Risk matrix under current condition

RISK MATRIX						
		OVERALL IMPACT				
		1 INSIGNIFICANT	2 MINOR	3 MODERATE	4 MAJOR	5 CATASTROPHIC
LIKELIHOOD	1 RARE					
	2 UNLIKELY			Extreme wind conditions Soil erosion		
	3 MODERATE		Extreme precipitation events			
	4 LIKELY				Inland flooding	
	5 ALMOST CERTAIN		Extreme temperature			

Risk matrix after new bridge construction

RISK MATRIX						
		OVERALL IMPACT				
		1 INSIGNIFICANT	**2 MINOR**	**3 MODERATE**	**4 MAJOR**	**5 CATASTROPHIC**
LIKELIHOOD	**1 RARE**					
	2 UNLIKELY		Extreme wind conditions	Soil erosion		
	3 MODERATE	Extreme precipitation events				
	4 LIKELY	Inland flooding				
	5 ALMOST CERTAIN		Extreme temperature			

The construction of the new bridge, which will replace the existing one, contributes positively to reducing inland flooding risks, particularly river flooding. The risk assessment for the existing bridge indicates a very high risk, while the new bridge is rated at a medium risk level.

The new bridge is designed to mitigate the potential impact of floods on the infrastructure itself by increasing both its height and the length. This design would prevent clogging due to limited vertical clearance, submergence of the bridge, and overcoming possible flooded areas in the vicinity.

Moreover, this project enhances the region's resilience and supports the population in adapting to climate change effects, particularly extreme flood events. Unlike the existing bridge, the new bridge does not obstruct the normal water flow of the river. The current bridge often causes clogging from vegetation or debris, which is especially problematic during flood events, as it increases the river flow and triggers flooding in surrounding areas.

By improving the resilience of the infrastructure itself and minimizing the bridge's impact on the territory during flood events, the new bridge enhances the local communities' adaptative capacity and reduces their vulnerability to flood hazards, as highlighted in Appendix II of the OECD CCSU.

Ramboll's analysis aimed to evaluate the necessary adaptation measures to be incorporated into the project design (currently not available) to address and mitigate the identified potential climate-related risks. This will support alignment with adaptation requirements and enhance the infrastructure's resilience to such events. Specifically:

- for extreme temperatures and heatwaves: select construction materials and structural design features that can withstand high maximum temperatures and frequent heatwaves. This ensures that the bridge remains safe and durable under thermal stress conditions, accounting for increased temperature projections in the region;

- for extreme precipitation events: include the use of draining asphalt to avoid localized flooded areas and ensure its resilience to this kind of risk;
- for extreme wind conditions: incorporate wind-resistant design measures to ensure long-term resilience, particularly for exposed components such as lighting poles and signage;
- for soil erosion: it is suggested to consider some measures in the design of the bridge's pillars, both in the river channel and on land, for the increase of stability against the effect of soil erosion related to water action and debris transport in the river.

It is expected that the conclusions of this report are considered for the detailed Project design and thus that the Bridge will be constructed following "state-of-the-art" practices and applicable best practices. This approach will incorporate necessary adjustments to prevent or reduce the impact of the above-indicated physical climate-related hazards.

1. INTRODUCTION, SCOPE OF WORK AND APPROACH

1.1 Introduction

Ramboll was retained by Centunion Española De Coordinación Tecnica Y Financiera SA (hereinafter "Centunion" or the "EPC Contractor") for conducting an independent third-party review of the "**Packwach** (Albert Nile) Bridge" project (hereinafter the "Project" or the "Bridge"), which involves the replacement and upgrading of the existing 243-meter-long structure with a new 825-meter-long climate-resilient bridge over the Albert Nile. The bridge is located along the Pakwach–Nebbi–Arua Road in Pakwach District, northwestern Uganda, at approximately 188 km northwest of Gulu.

The independent third-party review is required by Appendix II of 'The Renewable Energy, Climate Change Mitigation and Adaptation and Water Projects Sector Understanding (CCSU)' rule within the Organization for Economic Co-operation and Development (OECD)'s Arrangement on Officially Supported Export Credits for climate change adaptation projects (hereinafter the "CCSU rule") and is requested by the Subdirección General de Instrumentos Financiero para la Internacionalización (Deputy Directorate General for Financial Instruments for Internationalization, or SGIFI).

According to Centunion ToR, the existing bridge, constructed in 1965, originally served the Uganda railway system and now also accommodates road traffic, is located in a flood-prone area. The current bridge and its low-lying approach roads are regularly flooded during heavy rains, with floating vegetation often clogging the piers and embankments. Preliminary assessments highlight structural vulnerabilities including erosion of foundations and inadequate drainage during flood events, which could eventually lead to collapse and isolation of the region. Moreover, its single-lane design and insufficient width prevent simultaneous passage of two large trucks, causing congestion and inefficiencies. The bridge lies on a key national transport artery linking the West Nile region to central Uganda, including the strategic Gulu-Karuma corridor (information from "*PACKWACH - Climate Resilient Bridges Studies - TOR request information*" document).

The present Third-Party Review of Contribution to Climate Change Adaptation has been carried out by Ramboll on a desk-based analysis of the Project documents made available by the Client and of the climate-related information publicly available.

The objective of the review is to verify that the Project reduces the location-specific context of vulnerability to climate change, in compliance with the CCSU rule for "green" projects related to climate change adaptation.

1.2 Scope of Work and Methodology

Ramboll reviewed the documentation provided, in particular:

- documentation and information of the Project provided by the Client, including answers by Centunion to specific questions;
- documentation and information regarding the Project location or region, publicly available;
- additional flood hazard assessment by Fathom[1].

Considering that the "APPENDIX II: Eligibility Criteria for Climate Change Adaptation Projects" of the CCSU OECD document does not provide sufficient specificity on how to assess whether the project '*reduces the location-specific context of vulnerability to climate change'* by the "independent third-party reviewers", Ramboll has agreed with Centunion and with SGIFI the following

[1] Fathom is a global leader service that provides information of flood area and maximum water level under climate change projections and for multiple time periods, making scientifically rigorous water and climate information available for the benefit of businesses and communities worldwide.

methodology, consisting in the application of reasonable available best practices and recognized guidelines.

In particular the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" by the European Commission, and the Annex II of the Delegated Regulation 2021/2139 of the EU Taxonomy were considered as reference, due to their recognized value for assessing projects to be financed as well as their applicability to infrastructure project such as the bridge proposed by Centunion.

In order to assess the "location-specific context of vulnerability to climate change" mentioned in the CCSU, a vulnerability review to climate change physical risk was carried out, identifying climate-related hazards and the project sensitivity and combining them to obtain a vulnerability level; both acute and chronic hazards were considered.

Subsequently, a review of the available project-specific information was conducted to assess the relevant climate-related vulnerabilities. This review aimed to establish the "direct link between the climate vulnerability context and the specific project adaptation activities that address the climate vulnerability". In other words, the review evaluated whether and to what extent the Project mitigates the vulnerability of the site and region to physical climate change. It also assessed how the Project enhances resilience to physical climate change, thereby contributing to climate change adaptation.

It should be noted that physical climate-related factors are only considered under these methodologies to assess climate change adaptation contribution, whereas other environmental matters (e.g. biodiversity, pollution, water resources, etc.) and the comply of the bridge with the do no significant harm technical screening criteria are not included in Ramboll review. Further information on the perimeter of the assessment and on the methodology can be found in Appendix 2.

The application of the proposed methodology has been implemented by Ramboll as described in the following chapters and sections of the present document.

1.3 Reliance and General Limitations

The evaluation presented in this report represent Ramboll's best professional judgment based upon the information available and conditions existing as of the date of the review. In performing its assignment, Ramboll must rely upon information provided by the EPC Contractor, publicly available information, and information provided by third parties.

Accordingly, the outcomes of the study performed for this report are valid only to the extent that the information provided to Ramboll was accurate and complete. This review is not intended as legal advice, nor is it an exhaustive review of Project conditions or Project compliance. Ramboll makes no representations or warranties, express or implied, about the conditions of the Project.

Ramboll's scope of work for this assignment is limited to a desktop review and a virtual interview with Centunion, and did not include performing site visits, field topographic, hydraulic, weather or climate site-specific observations; as such, this review cannot rule out the existence of latent conditions, and is intended, consistent with normal standards of practice and care, to assist the Client in identifying the risks of such conditions.

1.4 Duty of Care and Terms & Conditions

Ramboll's duty of care is to SGIFI.

Applicable Terms & Conditions are as per the signed contract (Proposal Nº 219835, issue Nº 3, dated 23/04/2025).

2. PROJECT INFORMATION

The Packwach Bridge Project, located on the Karuma–Pakwach–Nebbi–Arua Road, serves as a vital connection between Uganda's northwestern districts and the rest of the country. Originally built in 1965 to link the Uganda railway network to the West Nile region, the bridge now plays a dual role by supporting road traffic as part of the major highway corridor to Arua. It also serves the critical Gulu–West Nile national route, reinforcing regional integration and accessibility to border areas near the Democratic Republic of Congo and South Sudan.

A preliminary assessment of the existing structure was indicated in the document "*PACKWACH – Climate resilient bridge – TOR request information*" provided by Centunion (see Appendix 1, document #3) and has identified significant concerns, including erosion of bridge foundations, reduced vertical clearance due to rising river levels, and persistent clogging by floating vegetation, particularly during the rainy season. The insufficient vertical clearance of the bridge is critical during extreme precipitation events, after the increase of river level, due to insufficient space for the water flow, potentially resulting in the overtake of the river and the overflow into the surrounding area. The existing bridge is therefore not resilient to the rising river level during extreme rainfall events and increases the exposure of the surrounding area. These vulnerabilities could severely disrupt connectivity and economic activities, such as fishing and tourism in the channel area, and potentially render the crossing impassable during flood events.

The existing bridge low-lying approach roads and culvert systems are reportedly frequently overtopped during floods, disrupting traffic and creating hazardous conditions.

To address these issues, the construction of a climate-resilient replacement bridge was reportedly deemed essential. According to the information received from Centunion, the proposed preliminary design represents a major functional and adaptive upgrade with the following key specifications:

- **Waterway vertical clearance**: raised from 3 meters (m) to 7 m;
- **Waterway horizontal opening**: widened from 243 m to 825 m;
- **Bridge length**: increased from 243 m to 825 m;
- **Carriageway width**: expanded from 6 m to 7 m;
- **Sidewalks**: upgraded from a single 1.5 m walkway to two 1.7 m sidewalks.

In addition to improving structural resilience, the new design will reportedly restore the natural width of the Albert Nile by removing the existing causeway, which has reportedly contributed to sediment buildup and ecological degradation. These interventions are expected to enhance navigability, protect biodiversity, and ensure long-term transport continuity across the Albert Nile.

The Packwach Bridge is located at approximately 2°27'34.32"N, 31°30'26.57"E, spanning the Albert Nile in Pakwach District (Northern Uganda). The location is represented in **Figure 1** below.

Figure 1 - Location of the proposed Packwach bridge.

Source: Google Earth, June 2025

3. EVALUATION OF CONTRIBUTION TO CLIMATE CHANGE ADAPTATION

3.1 Phase 1 – Vulnerability review

The scope of the assessment encompasses the evaluation of sensitivity, exposure and vulnerability to physical climate-related hazards within the Project area. This evaluation aims to identify and assess vulnerability to potential climate related hazards, both current and future (here long term to 2080).

Ramboll has conducted a preliminary evaluation of the sensitivity and exposure of the site of the bridge using a three-level assessment framework. This framework is grounded in expert opinion, inhouse-sector specific knowledge and hazard exposure databases for screening purposes. The evaluation adheres to the guidelines released by the European Commission, specifically the criteria set forth in the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" and the Delegated Act (EU) 2021/2139, which supplements the European Regulation on Taxonomy 2020/852 concerning activities that contribute substantially to climate change mitigation and adaptation.

The present assessment focuses on climate change physical adaptation and considers the physical climate-related hazards that are deemed applicable for the Site location (see Appendix 2 for further information).

It is important to note that the exposure analysis identifies relevant hazards to the planned Project location, irrespective of the project type and specifications, in both current and future climate conditions. Instead, sensitivity assesses the degree to which a system is affected by climate variability or change, independent of the location, as shown in the figure below.

Figure 2 - Criteria for the score of sensitivity

A score of 'high', 'medium' or 'low' should be given for each theme and climate hazards:

— **High sensitivity**: the climate hazard may have a significant impact on assets and processes, inputs, outputs and transport links;

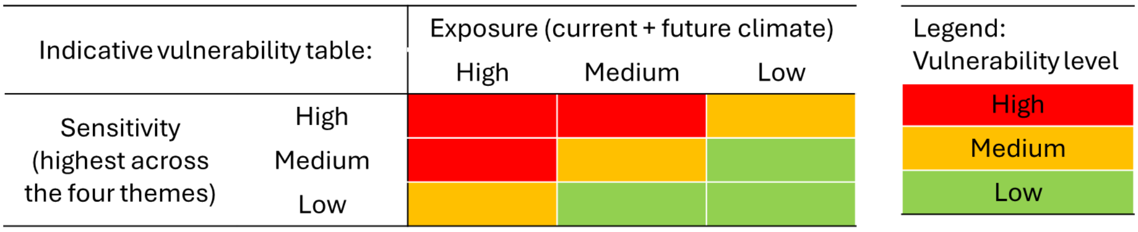
— **Medium sensitivity**: the climate hazard may have a slight impact on assets and processes, inputs, outputs and transport links;

— **Low sensitivity**: the climate hazard has no (or an insignificant) impact.

Source: Commission Notice "Technical guidance on sustainability proofing for the InvestEU Fund" (2021/C 280/01).

Subsequently, the vulnerability analysis integrates the outcomes from both sensitivity and exposure analyses to pinpoint the most pertinent hazards for the proposed Project. These are identified as vulnerabilities with a 'Medium' or 'High' ranking, in accordance with the criteria specified in the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" and shown in the figure below:

Figure 3 - Vulnerability matrix as combination of exposure and sensitivity scores, as defined in the Commission Notice "Technical guidance on the climate proofing of infrastructure in the period 2021-2027"



Source: Prepared by Ramboll based on Commission Notice "Technical guidance on the climate proofing of infrastructure in the period 2021-2027" (C(2021) 5430).

Two climate change scenarios from IPCC (SSP2-4.5 and SSP5-8.5) have been considered for the long-term future time horizon (2080), considering the expected life span of the new bridge.

The results are provided in the present Chapter.

3.1.1 Fathom flood risk assessment

Fathom overview

Ramboll used flood maps developed by Fathom as reference for evaluating flood hazard. Fathom has developed a global hydraulic model to simulate flood areas and corresponding water levels across various return periods, climate scenarios and time horizons.

The latest version of the Fathom flood hazard dataset ("Global Flood Map") includes a new terrain model, the FABDEM+, offering ~30m resolution globally and ~10m resolution for regions with enhanced data[2].

The data encompass inundation depths for inland and coastal flooding at ~30m resolution globally. The inland flooding hazard is categorized into fluvial flooding, stemming from rivers or stream overflows (i.e. main water courses), and pluvial flooding, resulting from direct heavy rainfall and/or flooding of the minor hydrographic network and/or reclamation water network, and/or sewage network.

Rainfall boundary conditions used within the Fathom model are reproduced using the so-called "Intensity-Duration-Frequency" (IDF) relationships. For rainfall event durations of 1, 3, 6 hours gauge-based rainfall intensities are derived from the Global Sub-Daily Rainfall (GSDR) data set of Lewis et al. (2019)[3], which includes precipitation records from 23,687 measurement stations with an average record length of 13 years.

Regarding water propagation across the Earth's surface, Fathom employs a hydrodynamic modeling suite that simulates hydrodynamic phenomena, including flash-flooding, riverine flooding and coastal inundation.

<u>Fathom limitations:</u>

- Fathom does not directly include the sewage network in its flood model;
- Fathom model results were not calibrated using site-specific historical flooding data because such data do not exist[4];

[2] US, UK and Japan
[3] Lewis, E., Fowler, H., Alexander, L., Dunn, R., McClean, F., Barbero, R., ... & Blenkinsop, S. (2019). GSDR: a global sub-daily rainfall dataset. Journal of Climate, 32(15), 4715-4729.
[4] Fathom is a global model, validated using observed flooding data where available and designed to model flood areas when no historical data exist.

- Fathom's global flood map considers current land use (indirectly parameterized considering urbanized settlement only[5]) and elevation without giving the option to change these factors as would be necessary to accurately assess the effects induced by new project scenarios.

Here the inland fluvial/pluvial flood is only considered, due to the distance of the site from the coast. The flood depth data are available for 5, 10, 20, 50, 100, 200, 500 and 1000 years return periods with a horizontal resolution of 1 arcsecond (about 30 meters).

In this case, the climate scenario SSP5-8.5 is considered to evaluate the flood risk for the Packwach bridge, and the years 2020 and 2080 are considered as reference for the baseline and the future conditions, according to the expected life of the infrastructure. Considered return periods are 20, 50, 100, 200 and 500 years, corresponding to high, medium and low risk areas, as reported below.

The return period is linked to a certain value of precipitation intensity and consequent water discharge, river level and flooded area. Risk levels correspond to different return periods basing on the frequency of occurrence of the corresponding precipitation/flood events: low return periods (e.g. 20 and 50 years) correspond to frequent flood events, so the area is subject to a high risk of flooding; on the contrary high return periods (e.g. 500 years) correspond to rare flood events, so the area is under a low risk.

Climate change can potentially influence the frequency of precipitation events with a certain intensity with consequences on the frequency of flood events of a certain magnitude. Reason why a defined event can change the return period of reference, or for a certain return period events of different intensity can occur. A baseline (year 2020 as reference) and a future (year 2080 as reference) condition are evaluated here to identify differences and climate change effects on the extreme precipitation events and flood events occurrences.

In this paragraph results of Fathom are reported, while in the next chapter an analysis of the exposure for present and future condition is reported.

Flood Risk results – Inland flood

Results are aggregated by analyzing the percentage of the area of interest affected by fluvial and pluvial flooding across various return periods. Specifically, percentages of the area under low, medium, and high hazard levels are evaluated, taking into account both average and maximum water depths for each hazard condition.

- The area under high risk is characterized by events with a return period of 20 and 50 years.
- The area under medium risk is characterized by events with a return period of 100 and 200 years.
- The area under low risk is characterized by events with a return period of 500 years.

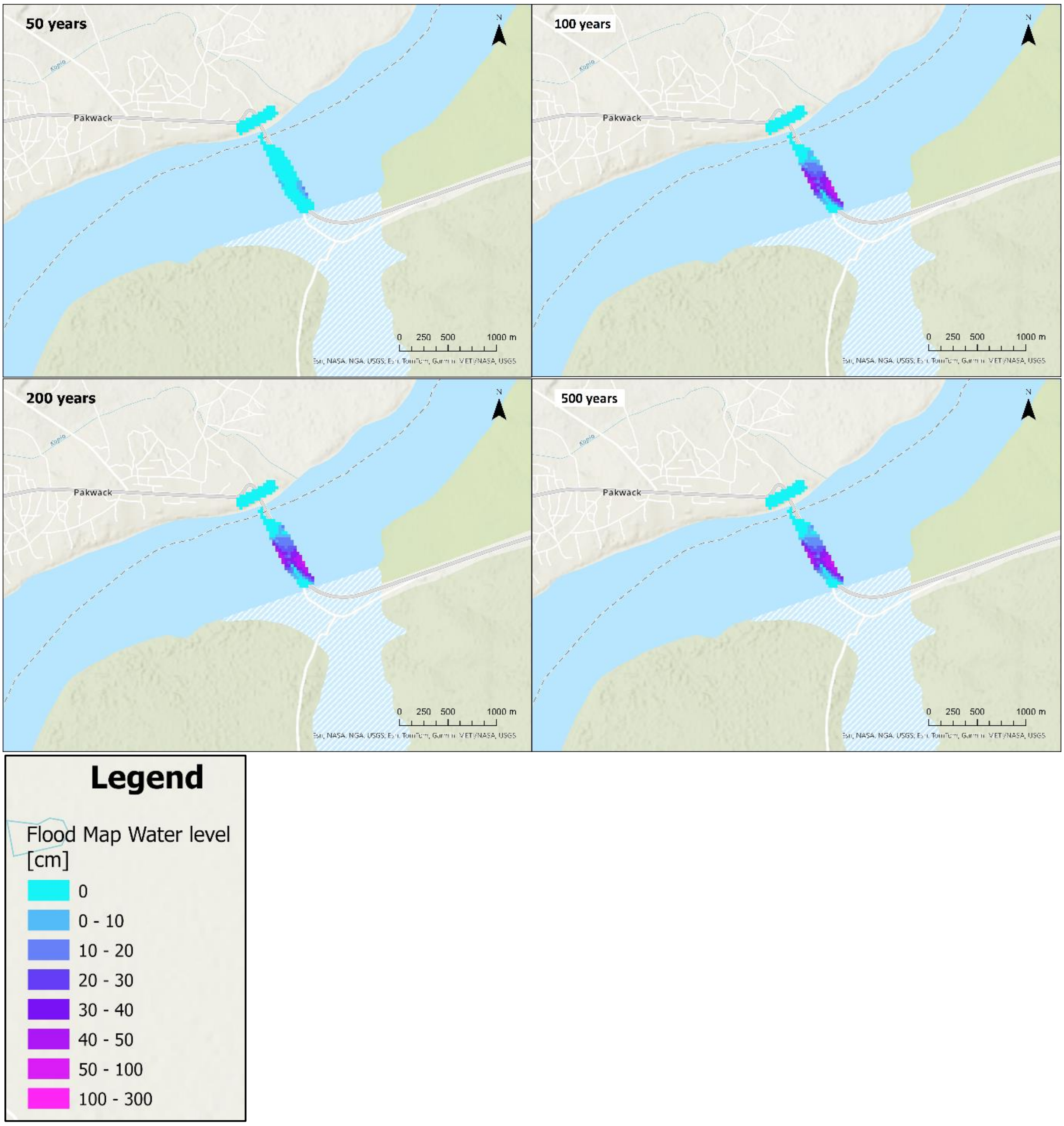
Table 1 presents the results of Fathom simulations for the pluvial flood risk in the current condition (year 2020). The table details the percentage of the area subject to flooding, categorized by water depths below and above 20 cm. **Figure 4** includes the maps of areas under pluvial flood hazards for each return period in the present condition (year 2020). **Table 2** and **Figure 5** present the results of Fathom simulations for the pluvial flood risk under future conditions (year 2080).

[5] Global Human Settlement Layer available at https://human-settlement.emergency.copernicus.eu/.

Table 1 – Pluvial flood risk results according to Fathom simulation for 2020

Risk score	Return period [years]	Percentage subject to flooding 0-20 cm	Percentage subject to flooding >20 cm	Average water depth within the area [cm]	Max water depth within the area [cm]
High	20	0%	0%	0	0
	50	7%	0%	0.6	14
Medium	100	21%	30%	13.0	51
	200	20%	31%	13.2	52
Low	500	20%	31%	13.2	52

Figure 4 - Pluvial flood risk in the area of Packwach bridge for the year 2020 for return periods equal to 50, 100, 200, 500 years

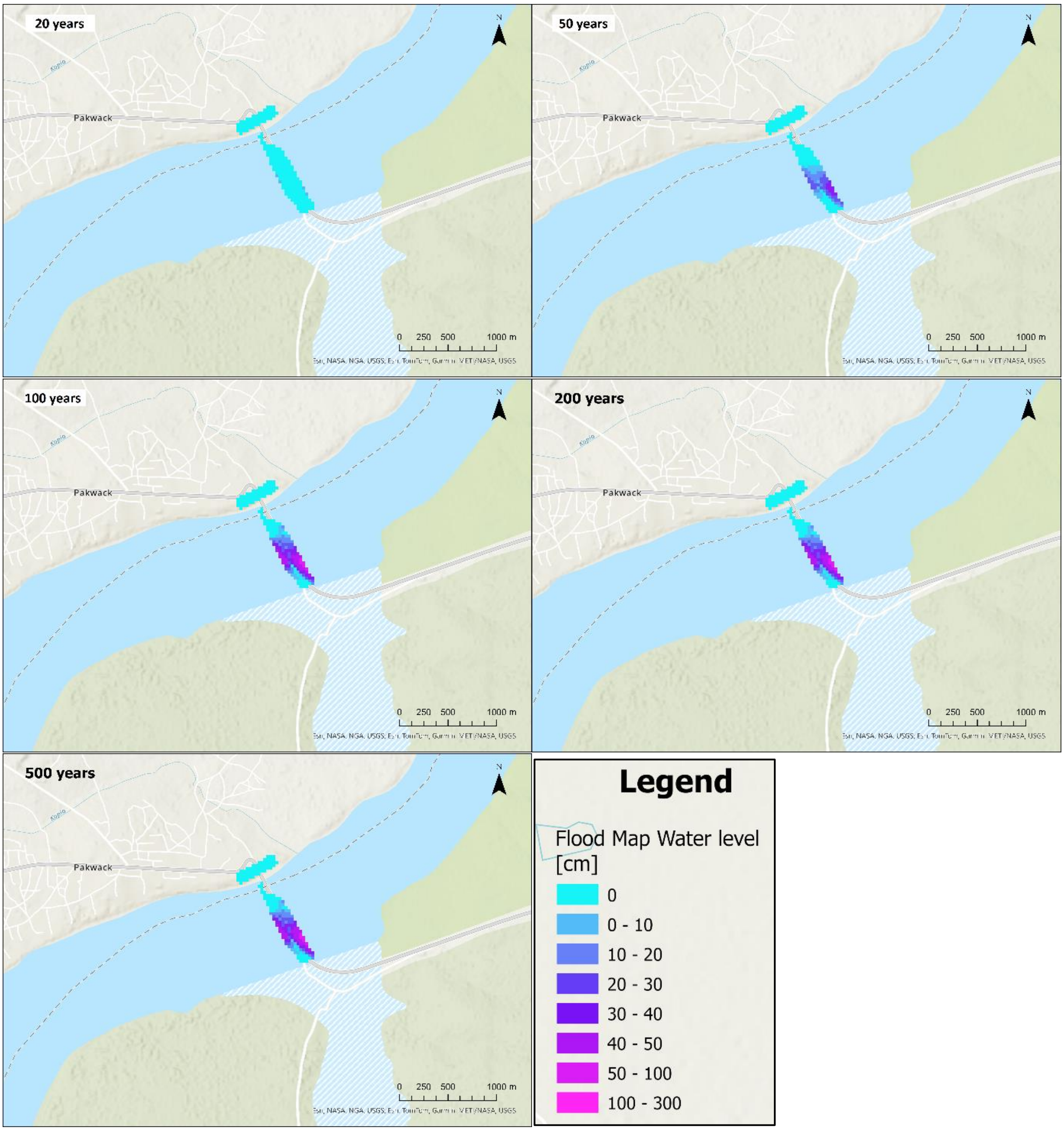


Source: Fathom Global Flood Map

Table 2 – Pluvial flood risk results according to Fathom simulation for 2080

Risk score	Return period [years]	Percentage subject to flooding 0-20 cm	Percentage subject to flooding >20 cm	Average water depth within the area [cm]	Max water depth within the area [cm]
High	20	2%	0%	0.1	10
	50	21%	17%	7.4	39
Medium	100	17%	34%	14.6	55
	200	18%	34%	14.7	55
Low	500	18%	34%	14.8	55

Figure 5 - Pluvial flood risk in the area of Packwach bridge for the year 2080 for return periods equal to 20, 50, 100, 200, 500 years



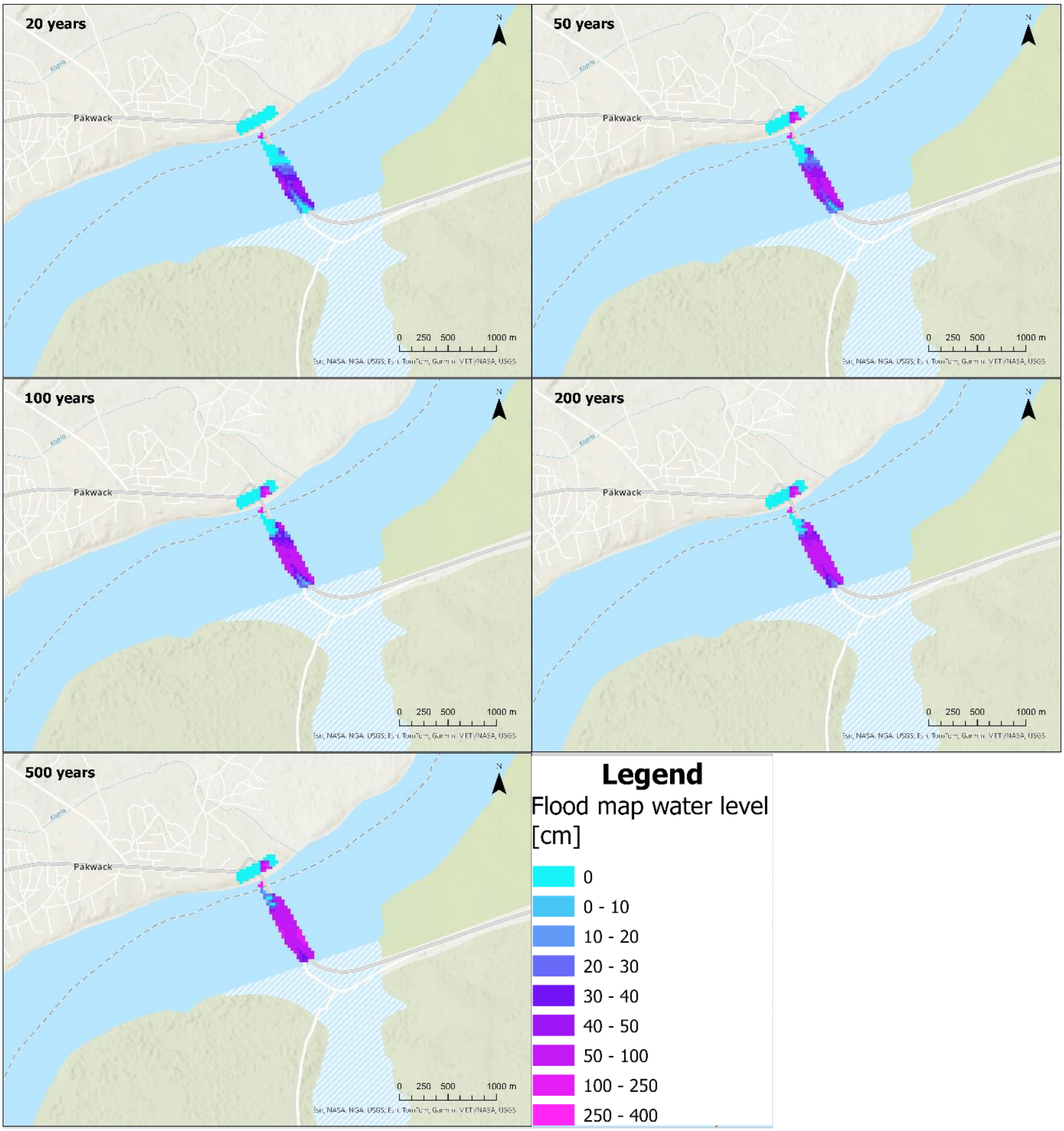
Source: Fathom Global Flood Map

Table 3 presents the results of Fathom simulations for the fluvial flood risk in the current condition (year 2020). In **Figure 6** the maps of areas under fluvial flood hazards are reported for return period of 500 years in present condition (year 2020). **Table 4** and **Figure 7** present the results of Fathom simulations for the fluvial flood risk under future conditions (year 2080).

Table 3 – Fluvial flood risk results according to Fathom simulation for 2020

Risk score	Return period [years]	Percentage subject to flooding 0-20 cm	Percentage subject to flooding >20 cm	Average water depth within the area [cm]	Max water depth within the area [cm]
High	20	14%	38%	17.1	145
	50	7%	59%	34.3	338
Medium	100	4%	66%	41.3	348
	200	4%	66%	41.4	348
Low	500	5%	72%	61.4	369

Figure 6 - Fluvial flood risk in the area of Packwach bridge for the year 2020 for return period equal to 20, 50, 100, 200 and 500 years

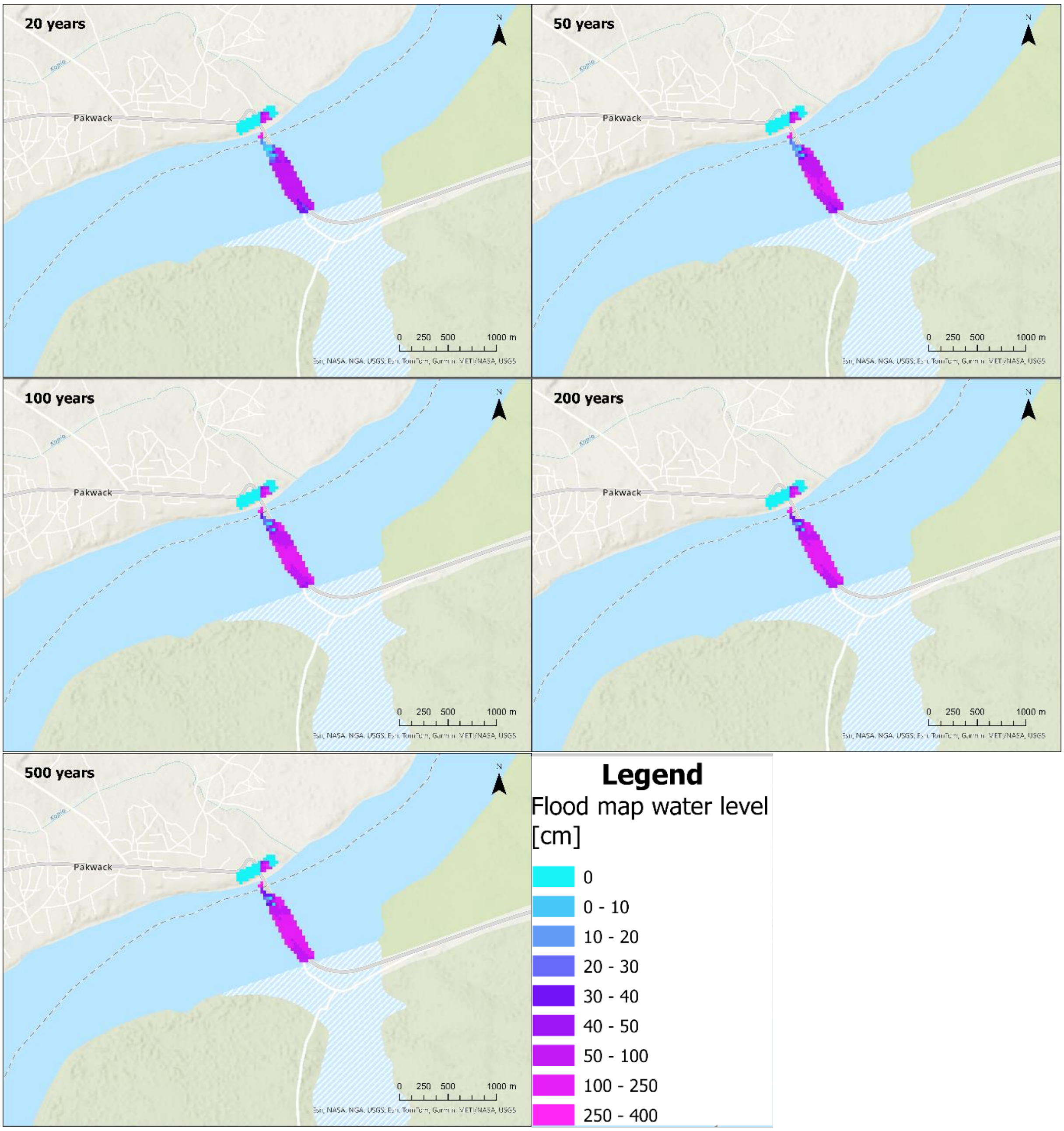


Source: Fathom Global Flood Map

Table 4 – Fluvial flood risk results according to Fathom simulation for 2080

Risk score	Return period [years]	Percentage subject to flooding 0-20 cm	Percentage subject to flooding >20 cm	Average water depth within the area [cm]	Max water depth within the area [cm]
High	20	7%	70%	54.1	360
	50	3%	74%	67.7	373
Medium	100	0%	77%	76.3	380
	200	0%	77%	81.4	385
Low	500	0%	77%	81.4	385

Figure 7 - Fluvial flood risk in the area of Packwach bridge for the year 2080 for return periods equal to 20, 50, 100, 200, 500 years



Source: Fathom Global Flood Map

3.1.2 Vulnerability analysis and results

Hazard	Exposure	Sensitivity	Vulnerability
a. Fluvial & pluvial Flooding	According to Fathom simulations, under present conditions (year 2020 is considered as baseline), 7% of the analyzed area is classified as being under *high* hazard for pluvial flooding, while 51% is under *medium* and *low* hazard. Looking ahead to the SSP5-8.5 scenario in 2080, the area under high hazard for pluvial flooding is projected to increase to 38%, with the area under medium and low hazard expected to rise to 52%. No significant differences emerge between the medium and low hazard areas concerning pluvial flooding; thus, under a return period of 500 years, no changes are anticipated compared to lower return periods of 100 and 200 years. Additionally, no relevant changes are expected between the present and future scenarios. Maximum water depth of 55 cm is expected in the area in the future for long return periods for pluvial flood. For fluvial hazard, according to Fathom simulations, under present conditions, 66% of the area is subject to high flood hazard, 70% is under medium hazard, and 77% is under low hazard. The maximum water depth varies between 145 cm for a return period of 20 years and 369 cm for a return period of 500 years. In the future, fluvial flood hazard is expected to increase, with 77% of the area subject to risk for every return period. The variations will be evident only in the average and maximum water depths. Specifically, the average water depth will range between 54 cm and 81 cm, and the maximum water depth will range between 360 cm and 385 cm, respectively, for return periods of 20 years and 500 years.	Structural damage to the bridge might occur due to direct impact with water in case of strong water currents during river flooding events. In addition, the bridge functions would be subject to interruption and damage in case of flooding and water overflowing, also if limited to a small part. For these reasons the sensitivity is also deemed **high**.	**HIGH**

Hazard	Exposure	Sensitivity	Vulnerability
	Due to these factors, the exposure is evaluated as **high**[6]**.**		
b. Extreme precipitation events	From the National Adaptation Plan for the Agricultural Sector of Uganda, emerges that extreme precipitation, followed by potential flooding events, occurs relatively frequently and is linked with El Niño/La Niña. According to the World Bank country profile, trends in extreme rainfall conditions occurred in the last years are difficult to be define due to the lack of data and high seasonal variability in precipitation. However, more erratic onsets and ends to rainfall seasons, and heavier and more violent rainfall events have been seen in recent years, and the occurrence of heavy precipitation events in Northern Uganda is expected to rise, increasing the risk of disasters such as floods. Under a high-emission scenario, monthly annual precipitation is expected to increase in the second half of the century. Differently, the greatest change in the intensity and frequency of extreme rainfall events is likely to take place between the current and the mid-century period. There is a likely increase for the number of consecutive wet days (daily accumulation of rainfall larger than 1mm per day) throughout the year expected for the future. Also, the number of days with precipitation greater than 20mm will increase during the rainy season (March to October in Northern Uganda). The increase in extreme precipitation events is also connected to the increase in frequency of floods.	Possible adverse effect related to precipitation excess is deemed to limitedly affect the Project causing interruption and damage in case of excess precipitation water runoff and ponding, also limited to a small part. For these reasons sensitivity is deemed **low**.	**MEDIUM**

6 It has to be noted that the reported possible level increase of Lake Albert (located downstream of the Bridge) does not have a climate-related origin and therefore has not been considered in the present assessment.

Hazard	Exposure	Sensitivity	Vulnerability
	Based on these considerations, exposure is evaluated **high**.The above assessment is based on the average of existing climate projections on precipitations.		
c. Extreme wind conditions	According to the World Bank country profile, Uganda does not experience tropical cyclones. However, the Packwach Bridge Project site can still be affected by strong winds, particularly during severe convective storms and thunderstorms that are common during the wet season (March to October with the more intense period from April to August)[7]. Local meteorological reports (Uganda National Meteorological Authority) indicate that average daily wind speeds in the Pakwach District typically range between 10 and 15 km/h, but according to local studies[8] for a 100-year return period (i.e., a 1% annual chance), during intense thunderstorms wind gusts can reach or exceed 25 m/s (90 km/h) in the region. These events can be particularly challenging for bridge operations and maintenance, requiring appropriate design considerations to ensure structural resilience. Historically, severe wind events have caused localized damage in northern Uganda, including uprooted trees, roof damage, and power line failures. Strong wind speeds can pose risks to the bridge's structure and ancillary components, especially when coinciding with heavy rainfall that can compromise soil stability around bridge piers and abutments. For the future, while average wind speeds are not expected to change significantly throughout the century under different climate scenarios, climate models suggest that the frequency and intensity of severe thunderstorms may increase under	The Packwach Bridge Project site is moderately sensitive to strong wind hazards. According to the description on the TOR document and the bridge design as reported in Paragraph 2, the bridge's large and exposed structure means it can experience wind-induced stresses on its superstructure and supporting elements. Surrounding vegetation and power lines can add to the risk of secondary damage from falling debris during severe storms. While modern design can incorporate features to manage wind loads, some infrastructure components—such as lighting poles and signage—remain vulnerable. Overall, sensitivity is rated as **medium**, given the potential for damage under intense wind events.	**MEDIUM**

7 https://unfccc.int/sites/default/files/resource/Final%20TNC%20Uganda.pdf
8 https://wwfafrica.awsassets.panda.org/downloads/nbs-brief-and-rights-booklet.pdf

Hazard	Exposure	Sensitivity	Vulnerability
	high-emission scenarios. This could raise the likelihood of damaging wind events in northern Uganda by 2050 and 2090. For these reasons exposure is thus evaluated **medium**.		
d. Wildfires	The ThinkHazard tool developed by the GFDRR (Global Facility for Disaster Reduction and Recovery) indicates that for the Packwach district the current wildfire hazard is classified as high, meaning there is a greater than 50% chance of encountering weather conditions that could support a significant wildfire that might result in damage to property or threaten human safety in any given year. However, according to regional and local studies[9], the fire hazard in Pakwach District is considered low to medium, based on land cover, agricultural practices, and the limited presence of forested areas that sustain large-scale wildfires. These studies highlight that fires in the region are typically seasonal grassland fires or accidental structural fires rather than large wildfires. Modelled projections of future climate suggest that the frequency of fire weather occurrence in this region is likely to increase during the dry season. This increase is driven by rising temperatures, higher evapotranspiration rates, and greater variability in rainfall, which could lead to periods of drought that elevate the risk of vegetation fires. Considering that the Packwach Bridge Project location is primarily within an agricultural and semi-urban context with relatively limited forested areas, exposure to wildfire hazard is evaluated as **low**.	Small fires can occur near the bridge and embankments, potentially affecting access and visibility. The bridge itself, constructed from concrete and steel, is not highly flammable, but maintenance activities and nearby vegetation could be impacted during fire events. This could affect bridge approaches, embankments, or local utilities, posing operational and safety risks. Sensitivity is deemed **medium**.	**LOW**

9 https://nema.go.ug/sites/all/themes/nema/docs/Lead%20Agency%20edit%20Fina%2003%2001%202023.pdf

Hazard	Exposure	Sensitivity	Vulnerability
e. Extreme temperatures – maximum temperature and heatwaves	According to the World Bank country profile and its Climate Change Knowledge Portal, Uganda's temperatures have already increased and are projected to increase by more than +1°C by mid-century (relative to the historical baseline) and potentially exceed +3°C by the end of the century under the high-emission scenario SSP5-8.5. The largest increases are expected during the traditionally cooler months of June to September[10]. By mid-century, Uganda is likely to experience both higher minimum and maximum temperatures, with more frequent occurrences of days where apparent temperatures (heat index) exceed 35°C. The number of days with high heat index conditions is projected to increase significantly compared to historical averages, with corresponding rises in the number of tropical nights (minimum temperatures above 25°C). This trend is expected to worsen under higher emission scenarios (SSP3-7.0 and SSP5-8.5), increasing the hazard of heat-related stress for both the population and critical infrastructure[11]. Heatwaves, defined as consecutive days with maximum temperatures exceeding historical thresholds, are also projected to increase in both frequency and duration. The Warm Spell Duration Index, which measures the length of heatwaves, has already shown an upward trend in Uganda and is expected to further increase by mid-century. Under SSP5-8.5, maximum daily temperatures in Pakwach District could exceed 42°C during the hottest months (January to March) by the end of century.	The Packwach Bridge Project site is sensitive to extreme temperatures and heatwaves. High temperatures can affect construction materials, causing thermal expansion that leads to stress and potential cracking in concrete and steel components. Workers are also exposed to heat stress during construction and maintenance activities, which can impact productivity and health. According to local environmental studies, prolonged heat exposure can also increase risks of material fatigue, thermal expansion, and health hazards for workers. For these reasons sensitivity is deemed **medium**.	**HIGH**

[10] https://climateknowledgeportal.worldbank.org/country/uganda/climate-data-projections

[11] https://ccd.go.ug/wp-content/uploads/2019/10/Uganda-Strategic-Programme-for-Climate-Resilience_May_2017.pdf

Hazard	Exposure	Sensitivity	Vulnerability
	Although the Packwach Bridge site is not located in a major urban heat island, heatwaves can still pose risks to bridge components and construction workers, especially during peak construction activities. Considering that extreme temperatures are already occurring and are projected to increase substantially in frequency, intensity, and duration, exposure to current and future heat hazards at the Packwach Bridge site is evaluated as **high**.		
f. Extreme temperatures - cold waves	Being near the equator and at altitude (~600-700 m), Pakwach site maintains fairly consistent temperatures year-round. Average lows range from 17–23 °C, even in the coolest months; temperatures rarely drop below 15–16 °C. Cold wave phenomena—marked abrupt drops in temperature to near-freezing or below—do not occur in this region. Available data show no record of temperatures under 10 °C, and no evidence of frost or freezing events. No exposure hazard from cold waves applies to the Packwach Bridge site, as this hazard is effectively not applicable	-	**N/A**
g. Drought	According to the Standardized Precipitation-Evapotranspiration Index (SPEI) provided by the Climate Change Knowledge Portal, the Packwach Bridge Project is located in an area with no significant annual drought hazard, meaning that on a yearly scale, rainfall and evapotranspiration typically balance out, and persistent drought is not a consistent threat. However, the region experiences a pronounced dry season from December to February, during which rainfall is minimal, and temperatures are high. Under mid-century and end-of-century climate projections, the number of consecutive dry	The Packwach Bridge Project site has medium sensitivity to drought hazard during the construction phase: construction activities such as concrete mixing, dust suppression, and compaction require a reliable water supply, which can be limited during extended dry spells. Drought conditions can also make soils more prone to cracking and erosion, complicating earthworks and embankment stabilization. These factors can delay construction timelines and increase costs.	**LOW**

Hazard	Exposure	Sensitivity	Vulnerability
	days during this period is expected to increase due to higher temperatures and more variable rainfall patterns, potentially leading to seasonal drought stress in the dry season. While the site is not a coastal area and does not face the same challenges as regions with high coastal drought hazard, some studies indicate that episodic dry spells can still affect agriculture and water availability, with indirect impacts on project operations and local communities. Considering the projected increase in dry season intensity, exposure to seasonal drought hazard is therefore evaluated as **medium**.	However, as during the operational phase sensitivity is deemed to be negligible, overall sensitivity to drought is rated as **low**.	
h. Landslides	Considering the morphology of the Project area, it is considered to be not likely subject to landslides in the present or in the future. Exposure is thus evaluated as not applicable.	-	**N/A**
i. Soil erosion	According to the global GloSEM 1.3 database, which provides indicators on estimated rates (Mg/ha year) of soil displacement by water by 2070, the baseline for the area of the Project (2019) is between 25 Mg/ha and 50 Mg/ha to the North of the riverbank and around 5 Mg/ha to the South of the riverbank per year of displaced soil; in the future (2070) the values of displaced soil are expected to experience a little increase for scenarios RCP 2.6 and RCP 8.5, reaching values around 60 Mg/ha per year to the North and between 5 Mg/ha and 10 Mg/ha per year to the South. These values are considered between high (from 10 to 50 Mg/ha) and extreme (above 50 Mg/ha). The increase in future soil erosion is also related to the increase in frequency expected for extreme precipitation	The hazard has potential to negatively impact the Project considering structural damages to the bridge and other new structures along the riverbanks. The sensitivity is classified as **medium**.	**HIGH**

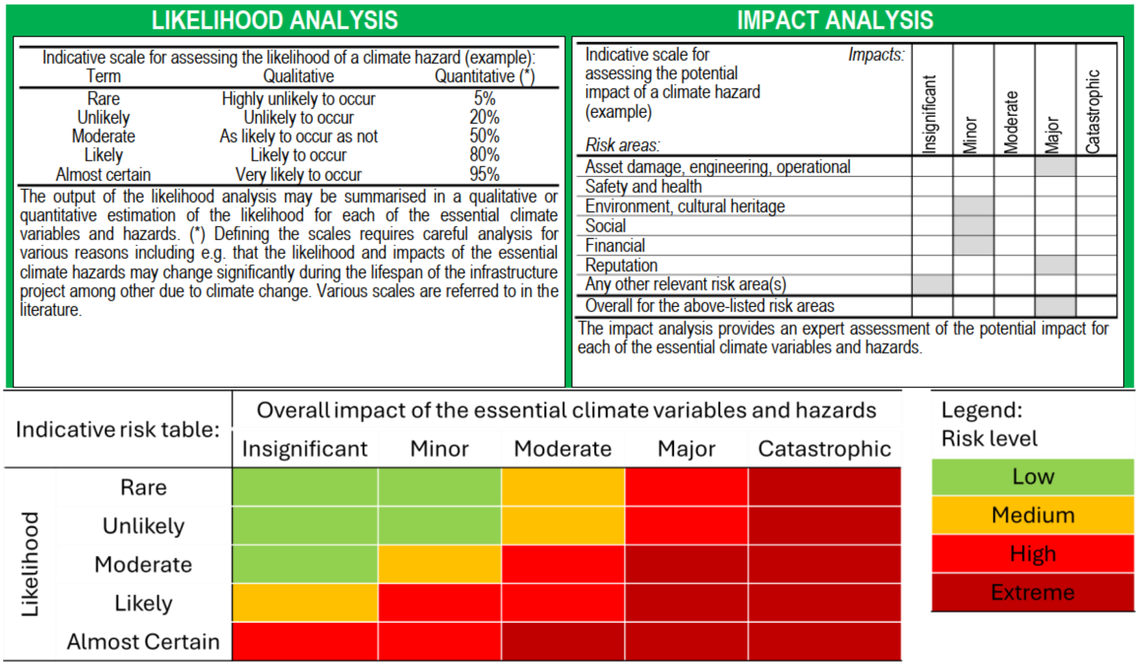
Hazard	Exposure	Sensitivity	Vulnerability
	events and consequent flood events under climate change, that can accelerate the process of erosion. Intense precipitation can increase soil erosion on land for the effect of rainfall on the transport of superficial soil, while inland flooding can cause a diffuse flood on the surrounding area increasing the action of water. Exposure is thus evaluated **high**.		
j. Subsidence	Due to the complexity of the phenomenon, it is difficult to determine future changes in the subsidence rate under different climate scenarios. The present analysis therefore considers the current subsidence rates according to the global analysis carried out by Davydzenka (2024)[12]. The average subsidence rate in the area of the Project is of the order of 10^{-4} mm/year. This value is considered low. Also due to possible future worsening under climate change (in the absence of precise projections), exposure is evaluated as **low**.	The hazard has reduced potential to negatively impact the Project considering structural damages to the Bridge. The sensitivity is classified as **medium**.	**LOW**

[12] Davydzenka, T., Tahmasebi, P., & Shokri, N. (2024). Unveiling the global extent of land subsidence: The sinking crisis. Geophysical Research Letters, 51, e2023GL104497, https://doi.org/10.1029/2023GL104497

3.2 Phase 2 – Risk Analysis and Contribution to Adaptation

Building on the results of the phase 1, Ramboll carried out a high-level risk assessment to evaluate the likelihood of occurrence and the potential impact of each relevant hazard (classified as medium or high), in accordance with the guidelines released by the European Commission. Specifically, this evaluation follows the criteria outlined by the sustainability proofing guidelines and the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027 (section 3.3.2.1 page 35):

Figure 8 - Criteria for the scores of likelihood and impact. Below the risk matrix as combination of likelihood and impact, as defined in the Commission Notice "Technical guidance on the climate proofing of infrastructure in the period 2021-2027"



LIKELIHOOD ANALYSIS

Indicative scale for assessing the likelihood of a climate hazard (example):

Term	Qualitative	Quantitative (*)
Rare	Highly unlikely to occur	5%
Unlikely	Unlikely to occur	20%
Moderate	As likely to occur as not	50%
Likely	Likely to occur	80%
Almost certain	Very likely to occur	95%

The output of the likelihood analysis may be summarised in a qualitative or quantitative estimation of the likelihood for each of the essential climate variables and hazards. (*) Defining the scales requires careful analysis for various reasons including e.g. that the likelihood and impacts of the essential climate hazards may change significantly during the lifespan of the infrastructure project among other due to climate change. Various scales are referred to in the literature.

IMPACT ANALYSIS

Indicative scale for assessing the potential impact of a climate hazard (example) — Impacts: / Risk areas:	Insignificant	Minor	Moderate	Major	Catastrophic
Asset damage, engineering, operational					
Safety and health					
Environment, cultural heritage					
Social					
Financial					
Reputation					
Any other relevant risk area(s)					
Overall for the above-listed risk areas					

The impact analysis provides an expert assessment of the potential impact for each of the essential climate variables and hazards.

Indicative risk table:	Overall impact of the essential climate variables and hazards				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Moderate	Low	Medium	High	Extreme	Extreme
Likely	Medium	High	High	Extreme	Extreme
Almost Certain	High	High	Extreme	Extreme	Extreme

Legend: Risk level — Low, Medium, High, Extreme

Source: Commission Notice "Technical guidance on the climate proofing of infrastructure in the period 2021-2027" (C(2021) 5430).

The indicative scale for likelihood presented in the guidance has been considered, along with different risk areas listed to assess the potential impact level.

Based on project-specific information provided by Centunion and expert judgment, risk levels have been identified by evaluating the likelihood of occurrence and potential impact (using a 5-level scale as indicated by the *sustainability proofing* guidelines). The results are presented in the table below.

In the second phase of the assessment, only climate hazards deemed relevant to the Project are analyzed, specifically those hazards to which the Project exhibits medium to high vulnerability.

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL after new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
a. Fluvial & pluvial Flooding	**Likely** (4/5) Upon analysing the site's vulnerability to inland flooding, according to the hydraulic simulation for the present condition and the future scenario, it has been determined that the area frequently experiences pluvial flooding under both current conditions and future projections (year 2080 is considered for long-term time horizon). Additionally, the site is occasionally subject to significant pluvial and fluvial flood events. Consequently, the likelihood of occurrence of flood is likely for the study area.	**Major** (4/5) Pakwach Bridge has reportedly experienced multiple flooding events in recent years: December 2019, October 2020, August 12th, 2024, and November 27th, 2024, with the latest date claiming the life of an engineer from the Uganda Roads Authority, with many more feared dead. There is reportedly public media information available on these events. The current bridge vertical clearance is 3 meters, and it is expected to decrease due to debris accumulation, closing the existing waterway opening. Moreover, vegetation often clogs the channel and prevents boat navigation between the White Nile and Lake Albert.	**Insignificant** (1/5) A potential flood occurring in the future is not expected to impact the new bridge. The vertical clearance of the new bridge is meant to be of 7 m, more than double the clearance of the present bridge. Under these conditions, the raise of water level in the channel during flood events will not affect the bridge; the increased clearance also prevents debris and vegetation from clogging the channel. This ensures sufficient vertical height for navigation and water flow during extreme events, thereby reducing the likelihood of flooding in the surrounding areas and on the riverbanks. Additionally, the increased length of the new bridge, extending from 240 meters	**MEDIUM**	The current risk of inland flooding is **very high**. However, the construction of the new bridge reduces this risk level to **medium**. The new bridge is meant to provide a sufficient vertical clearance for the water flow under normal condition and in case of extreme precipitation events and consequent risk of flood (the height of the bridge is meant to avoid the clogging of debris and vegetation), and especially the width of the river will be increased as the new bridge will be much longer than the existing one. This is a necessary condition to avoid clogging during flood events. The facilitation of water flows is necessary to avoid the flood of surrounding territory and of riverbanks.

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL after new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
		For this reason, a potential flood in the near future, according to projections expected by climate scenarios reported above, can have a likely relevant impact on the existing bridge. Additionally, high water level in the river can flood in the area around the river. If the bridge and the surrounding area will be subject to flood there are not alternative crossings for the White Nile, implying the circumnavigation of the Lake Albert for hundreds of kilometers. Otherwise, the ferry service in Wanseko can be used as an alternative, although it operates only six days a week; furthermore, ferry or barge crossing are typically not available during or after floods events.	to over 800 meters, will have a significant effect, as the usable width of the river for water flow will more than double, eliminating the current artificial narrowing of the river. This enhancement will further facilitate the flow of water and reduce the risk of flooding in the surrounding areas. The continuity in the service of the bridge to cross the channel is important for transportation between the two banks of the river. Representatives of local communities have repeatedly expressed their eagerness to improve or replace the existing bridge over the channel crossing. The new bridge can assure the security and the economy of the area, providing continuity of		Moreover, the height should be sufficient to avoid the flood of the bridge itself, continuing to permit transit and transportation also during flood events. This infrastructure is important for local communities because it is the unique cross of the river, and the continuity of service improves their condition reducing the necessity to circumnavigate the lake to cross the river. The development of this bridge will play an important role in enabling local communities to access essential services, including during emergencies, reducing their isolation and improving economy.

Hazard	**LIKELIHOOD** **[L]**	**IMPACT under current condition** **[I]**	**IMPACT after new bridge construction** **[I2]**	**RISK LEVEL** <u>**after**</u> **new bridge construction** **[L x I2]**	**PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project**
			transportation and movement of goods and people. During flood events, the use of the bridge crossing will not pose danger to people.		<u>For these reasons the new Packwach Bridge is considered to significantly contribute to the adaptation of the area and local communities to the effects of climate change on flooding events.</u>
b. Extreme precipitation events	**Moderate** (2/5) Extreme precipitation events are frequent in the area, also considering the significant amount of total precipitation during the year. Moreover, in the future they are expected to become more frequent. Extreme precipitations are strictly connected with the increase in flood hazard. However, climate projections in terms of extreme precipitation are still uncertain.	**Minor** (2/5) With the existent bridge, under present and future climate conditions, extreme precipitation is deemed to bring only a limited impact on the Project area, with possible effects on transit and transportation continuity, local communities and safety of people during extreme rainfall events, considering the age and condition of the existing bridge. No structural damage is expected.	**Insignificant** (1/5) Extreme precipitation events are directly correlated with the occurrence of inland floods, whose impacts on the new bridge infrastructure are insignificant as the new bridge is deemed to be much more reliable than the existing one under extreme rainfall events. However, intense precipitation can make asphalt slippery or create localized water ponding. For this reason, it is necessary to include the use of draining asphalt or	**LOW**	The current risk of extreme precipitation is **medium**, whereas the expected risk after the construction of the new bridge is **low**. <u>The new bridge is expected to be more resilient to the occurrence of extreme precipitation events, and it does not worsen their impacts on the population and the territory.</u> <u>However, it is important that the material used for the construction is resilient to rainfall.</u>

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL after new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
			comparable material to ensure the bridge is resilient to this kind of impact.		
c. Extreme wind conditions	**Unlikely** (2/5) The probability of severe windstorms occurring in the Packwach area is considered medium-low, with a return period estimated at 100 years for the strongest gusts (≥25 m/s). While strong convective storms with high wind speeds occasionally occur in the area, they are not as frequent or intense as coastal tropical cyclones in other regions.	**Moderate** (3/5) The impact of strong winds on the existing bridge is considered medium (moderate), as they have the potential to cause minor structural damages to the bridge and its usage, directly or indirectly due to fallen trees and power lines, which could lead to temporary usage interruptions or damage to users and transportation, also considering the age and the wear of the existing bridge.	**Minor** (2/5) Strong winds from convective storms have the potential to cause minor structural damage also to the new bridge infrastructure, which could lead to temporary service interruptions, as well as on bridge users and transportation. However, in the event that the new bridge design specifications and materials take into account strong wind conditions, the impact would be considered minor. It is important to consider the maximum expected wind speeds associated with severe convective storms when designing the	**LOW**	The risk of damage from strong winds at the Packwach Bridge site is currently **medium** for the existent bridge and deemed **low** in the future after the construction of the new bridge, in light of the entire replacement of the existing structure with a new and bigger one. As preventive action against extreme events, wind-resistant design measures should be incorporated to ensure long-term resilience, particularly for exposed components such as lighting poles and signage.

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL after new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
			bridge to ensure its resilience to potential impacts from extreme wind events.		
d. Extreme temperature – maximum temperature and heatwaves	**Almost certain** (5/5) Climate projections for Uganda indicate a significant increase in the frequency, intensity, and duration of heatwaves, along with increases in both maximum and average temperatures. Extreme temperatures already occur regularly in northern Uganda, and their likelihood of occurrence is projected to rise further in the future.	**Minor** (2/5) The current mode of transit and transportation on the existing bridge is limitedly vulnerable to extreme heat impacts with regards to heat stress, users' fatigue, social stress and costs from heat conditions. Also, the existent bridge can be subject to structural problems due to its historical exposure to extreme and prolonged heat.	**Minor** (2/5) Extreme temperatures and heatwaves can cause minor structural impacts to the bridge infrastructure: it is important to consider the potential for thermal stress in the design and selection of construction materials to ensure the bridge's resilience to prolonged high temperatures. Other types of impact (safety, social, economic) are also deemed minor.	**HIGH**	The current risk from extreme temperatures at the Packwach Bridge site is similar to the expected risk after construction of the new bridge, being assessed as **high** (despite minor impact, due to very high likelihood). It is crucial to consider extreme temperature conditions in the design of the bridge — particularly in choosing construction materials and expansion joints — to ensure the bridge's long-term resilience against high temperatures and heatwaves.
e. Soil erosion	**Unlikely** (2/5)	**Moderate** (3/5)	**Moderate** (3/5)	**MEDIUM**	The current risk from soil erosion at the Packwach Bridge site is similar to the

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL after new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
	The soil erosion has a chronic effect, and its occurrence is continuous but with low efficacy. According to the data and projections reported above, it is unlikely that a bursting event of crash or collapse can occur but considering the long lifetime of the bridge a limited probability of occurrence has to be considered. The likelihood is also related to the increase in frequency expected for extreme precipitation events and consequent flood events, that can accelerate the process of erosion.	Soil erosion can have critical impacts on the existing bridge, in particular for the excavation of water near the river banks in proximity of the pillars. The bridge is located in an area close to a tributary river and characterised by wetlands and water-rich areas, due to the wide meanders of the tributary. Thus, the bridge's access from a tongue of land makes it vulnerable to impacts from soil erosion, due principally to the water action. Moreover, the stop of vegetation and debris can increase the effect of erosion on the pillars of the bridge. Such impacts would affect the bridge structural stability and consequently its usage.	Soil erosion can have critical impacts on the new bridge, in particular for the excavation of water in proximity of the pillars located in the river channel, on the riverbanks and on the land. The amount of water in the area of access to the bridge increase the risk of soil erosion creating a necessary condition to improve the stability and the resilience of the new bridge to this risk. The accumulation of vegetation and debris in proximity of the pillars will be reduced, thanks to the widening of the bridge and height increase, but will remain possible and it can increase the effect of erosion. On the other hand, the increase of the number of pillars to be installed inside the river (due to increased length of the bridge)		expected risk after construction of the new bridge, being assessed as **medium.** It is important to consider improvement measures in the design of the bridge's pillars, both in the river channel and on land, to increase the stability of the structure against the effect of soil erosion related to water action and debris transport in the river.

Hazard	LIKELIHOOD [L]	IMPACT under current condition [I]	IMPACT after new bridge construction [I2]	RISK LEVEL <u>after</u> new bridge construction [L x I2]	PROJECT CONTRIBUTION to reduce and ADAPT to the identified risk & recommended measures for RESILIENCE of the Project
			increases the possible impact of erosion on the bridge structure. Such impacts would affect the bridge structural stability and consequently its usage. It is important to consider measures to increase the stability of pillars in the river channel and on land to avoid problems related to soil erosion.		

3.2.1 Summary of required measures for the resilience of the Project

The risk analysis included an evaluation of how the new Packwach Bridge Project can contribute to mitigating local climate-related physical risks and strengthening the resilience of nearby communities and territories against climate change impacts, with a focus on flooding. Furthermore, the analysis identified specific measures that need to be integrated into the project design (currently not available) and construction of the Bridge to ensure the project's resilience to the identified relevant climate hazards.

Specifically, these measures are:

- for extreme temperatures and heatwaves (high residual risk): it is important to select construction materials and structural design features that can withstand high maximum temperatures and frequent heatwaves. This ensures that the bridge remains safe and durable under thermal stress conditions, accounting for increased temperature projections in the region;

- for extreme precipitation events (low residual risk): it is suggested for the new bridge to include the use of draining asphalt and other draining systems to avoid localized flooded areas and ensure its resilience to this kind of risk;
- for extreme wind conditions (low residual risk): as a preventive measure against extreme events, wind-resistant design measures should be incorporated to ensure long-term resilience, particularly for exposed components such as lighting poles and signage;
- for soil erosion (medium residual risk): it is suggested to consider some measures in the design of the bridge's pillars, both in the river channel and on land, for the increase of stability against the effect of soil erosion related to water action and debris transport in the river.

It is expected that the conclusions of this report are considered for the detailed Project/Bridge design and thus it will be constructed following "state-of-the-art" practices and applicable best practices. This approach will incorporate necessary adjustments to prevent or reduce the impact of these hazards.

4. CONCLUSIONS

Physical Climate-related risks associated with the Project for the construction of a new bridge (replacing an existing smaller bridge) in Pakwach - Uganda have been evaluated.

Following the vulnerability analysis carried out in a first phase, the likelihood of occurrence and potential impact have been assessed in Phase 2 for hazards to which the Project exhibits medium or high vulnerability. This risk analysis was performed under two conditions: prior and following the construction of the new infrastructure. This approach enabled the evaluation of the bridge's contribution climate adaptation, and recommendations were developed to integrate measures into the project to ensure the infrastructure's resilience to climate risks.

The identified risk levels for the current condition are:

- very high risk to inland flooding;
- high risk to extreme temperature;
- medium risk to extreme precipitation events, extreme wind conditions and soil erosion.

While the identified risk levels after the new Bridge construction are:

- high risk to extreme temperature;
- medium risk to inland flooding and soil erosion;
- low risk to extreme precipitation events and extreme wind conditions.

The construction of the new Packwach bridge contributes positively to the reduction of risk levels for inland flooding (mainly river flooding). This project enhances the resilience of the territory and provides a service that assists the population in to adapting to the effects of climate change, particularly concerning extreme flood events. Additionally, the new Bridge is expected to be more resilient to extreme precipitation events and extreme wind conditions.

Ramboll's analysis also aimed to provide a high-level evaluation of the adaptation measures to be integrated into the project design in order to mitigate the identified potential climate-related risks, ensuring the infrastructure's resilience to such events. These requirements are summarized in section 3.2.1.

From the National Adaptation Plan for the agricultural sector (Uganda currently lacks a National Adaptation Plan and instead has sector-specific plans, such as the one for agriculture), it is evident that transport infrastructure is highly vulnerable to extreme weather events, flooding, and other climate change impacts. Specifically, roads, bridges and railways are often damaged or destroyed by floods and storms, which significantly hinders the marketing of agricultural products. Additionally, aging and poorly maintained infrastructure further impedes access to markets. Therefore, strategic planning and investment in rural transport infrastructure, such as the new Packwach bridge, is a government priority under the adaptation strategy. These efforts aim to enhance connectivity between rural and urban areas and improve market accessibility. In particular, the climate-proofing of these infrastructures to withstand increasing climate variability is crucial.

Final statement

The construction of the bridge ensures connectivity between the territory and surrounding areas. Currently, the population is dependent on an old bridge with a vertical clearance that does not guarantee the water flow during extreme events of precipitation with consequent water level rise and flood risk, and a sufficient height for navigation on the river. This is due in particular to the clogging of debris and vegetation, also due to the artificial narrowing of the river occurred for the construction of the first bridge.

The construction of the bridge will strengthen the existing network for connection with other cities and communities, facilitating the movement of people and the transportation of goods, both during normal condition and during possible flood events. This improvement will enhance the economy and access to services for the population, including health services.

However, specific measures should be incorporated in the project's design to ensure the bridge's resilience and eligibility for adaptation to climate change also to additional hazards, including extreme precipitation events, extreme temperatures and extreme wind. These events could affect the bridge and/or its functions, making it essential to employ a meticulous approach in design and material selection to endure potential future extremes in temperature, rainfall, and wind.

In conclusion, **the new Packwach bridge infrastructure is considered to contribute to the adaptation of local communities to the effects of climate change on flood events**. The new bridge is reportedly aimed at ensuring service continuity and reducing damage during river flood events, which is particularly relevant considering the projected increase in frequency and intensity of floods due to climate change in the future. Furthermore, by incorporating the resilience measures mentioned above into the design, the project is also deemed resilient to the additional residual climate-related risks.

APPENDIX 1 - LIST OF DOCUMENTS FOR THE ASSESSMENT

1. World Bank Group. (2021). Uganda Climate Risk Country Profile. Washington, DC: World Bank.
2. National Technical Task Team on Government Response to Flooding in Uganda. (2020, October). Report on Joint Field Trip to Evaluate Flood Impacts in Uganda. Kampala: Government of Uganda.
3. Climate Resilient Bridges Studies – TOR Request Information (Packwach).
4. Gebrechorkos, S. H., Hülsmann, S., & Bernhofer, C. (2023). Future changes in climate and hydroclimate extremes in East Africa. Earth's Future
5. Uganda National Meteorological Authority. (2021). Status of Water Levels Monitoring Report – 210521. Kampala: UNMA.
6. Global Facility for Disaster Reduction and Recovery (GFDRR). (2024).
7. ThinkHazard -Uganda.
8. Uganda National Meteorological Authority. (various years). Annual climate reports and hazard assessments. Kampala: UNMA.
9. Uganda National Environment Management Authority. (2021). Annual Environment Management Report 2020/21. Kampala: NEMA.
10. Tumusiime, D., et al. (2022). Regional projections of extreme heat, wind speeds, and fire risks in northern Uganda. Journal of Climate Risk and Resilience, 5(1), 123-137.
11. The Republic of Uganda – Ministry of Agriculture, Animal industry and Fisheries. (2018, November). National Adaptation Plan for the Agricultural Sector.
12. Additional information provided by Centunion following a list of preliminary questions sent by Ramboll.

APPENDIX 2 - OVERVIEW OF MAIN REFERENCE GUIDELINES

The present Appendix provides further details on the reference guidelines adopted by Ramboll for the independent third-party review. Considering that the "APPENDIX II: Eligibility Criteria for Climate Change Adaptation Projects" of the CCSU OECD document does not provide sufficient specificity on how to assess whether the project 'reduces the location-specific context of vulnerability to climate change' by the "independent third-party reviewers", Ramboll has agreed with the EPC Contractor and the Lender a methodology consisting in the application of reasonable available best practices and recognized guidelines.

In particular the "Technical guidance on climate-proofing of infrastructure projects for the period 2021-2027" by the European Commission (adopted for the Climate resilience proofing within the Invest EU Sustainability proofing), and the Annex II of the EU Taxonomy's Delegated Regulation 2021/2139 were considered as reference, due to their recognized value for assessing projects to be financed as well as their applicability to infrastructure project such as the bridge proposed by Centunion.

1. EC Technical Guidance on Climate Proofing of Infrastructure

1.1. Overview

On July 29, 2021, the European Commission released a technical guidance on climate-proofing infrastructure projects for the 2021-2027 period[13]. This guidance aims to ensure infrastructure projects are compatible with the Paris Agreement and EU climate objectives. It focuses on integrating climate change mitigation and adaptation into project development, enabling informed decisions by investors.

The guidance meets the following requirements laid down in the legislation for several EU funds, notably InvestEU, Connecting Europe Facility (CEF), European Regional Development Fund (ERDF), Cohesion Fund (CF), and the Just Transition Fund (JTF):

- It is consistent with the Paris Agreement and EU climate objectives, which means it is consistent with a credible greenhouse gas (GHG) emission reduction pathway in line with the EU's new climate targets for 2030 and climate neutrality by 2050, as well as with climate-resilient development.
- It follows the principle 'energy efficiency first', which is defined in Article 2(18) of Regulation (EU) 2018/1999.
- It follows the principle 'do no significant harm', which is derived from the EU's approach to sustainable finance and enshrined in Regulation (EU) 2020/852 (Taxonomy Regulation).

Key aspects of the guidance include:

- Two pillars:
  - Mitigation (reducing greenhouse gas emissions) and Adaptation (building resilience to climate impacts).
- Two phases:
  - Screening and detailed analysis. Screening determines if a detailed analysis is needed, while detailed analysis assesses climate-related risks.
- Integration with other processes:

[13] https://ec.europa.eu/newsroom/cipr/items/722278/en

    - The guidance integrates climate-proofing with project cycle management (PCM), environmental impact assessments (EIA), and strategic environmental assessments (SEA).
- Scope:
    - The guidance covers a wide range of infrastructure, including buildings, network infrastructure, and built systems and assets.
- Target audience:
    - The guidance is primarily for project promoters and experts but can also be a useful reference for public authorities, implementing partners, investors, and stakeholders.

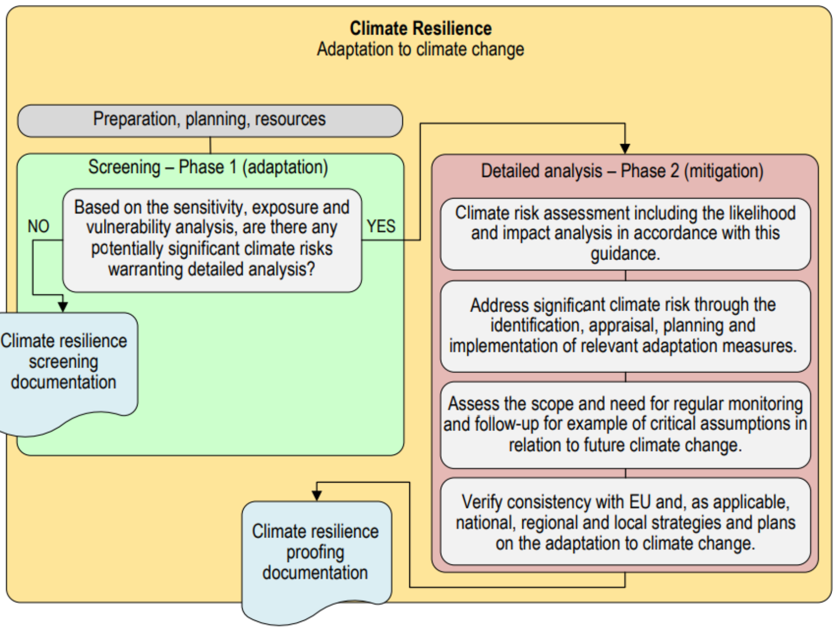
1.2. Adaptation to climate change (climate resilience)

As the APPENDIX II of the CCSU OECD document is targeted on Climate adaptation, other climate or environmental topics (such as GHG emissions, pollution, water resources or biodiversity) are not considered.

Infrastructure is usually long-lasting and may be exposed for many years to a changing climate with increasingly adverse and frequent extreme weather and climate impacts.

The climate vulnerability and risk assessment help identifying the significant climate risks. It is the basis for identifying, appraising and implementing targeted adaptation measures. This will help reduce the residual risk to an acceptable level.

Figure 9 – Overview of the climate adaptation-related process for climate proofing



Source: EC Technical Guidance on Climate Proofing of Infrastructure

Climate change adaptation measures for infrastructure projects focus on ensuring a suitable level of **resilience to the impacts of climate change**, which include **acute events** such as more intense **floods, droughts, heatwaves, wildfires, storms and landslides** and **hurricanes**, as well as **chronic events** such as projected **sea-level rise** and changes in average **precipitation** and **temperature**. In addition to enhancing the project's own climate resilience, **it is essential to ensure that it does not increase the vulnerability of surrounding economic and social systems**.

The climate change adaptation assessment is distributed in the following phases:

- Phase 1 (screening):
  - Sensitivity analysis
  - Exposure analysis
  - Vulnerability analysis
- Phase 2 (subject to the outcome of phase 1):
  - Likelihood analysis
  - Impact analysis
  - Risk assessment
  - Identification and appraisement of adaptation options and planning

The figure on the following page, taken from the official guidance document, provides an overview of the methodology used in the two phases, outlines the levels of assessment adopted for vulnerability and risk evaluation, and includes illustrative examples.

Figure 10 - Indicative overview of the climate vulnerability and risk assessment, and the identification, appraisal and planning/integration of relevant adaptation measures

Phase 1 (screening)

SENSITIVITY ANALYSIS

Indicative sensitivity table: *(example)*	Climate variables and hazards: Flood	Heat	...	Drought
Themes: On-site assets, ...	High	Low	...	Low
Inputs (water, ...)	Medium	Medium	...	Low
Outputs (products, ...)	High	Low	...	Low
Transport links	Medium	Low	...	Low
Highest score 4 themes	High	Medium	...	Low

The output of the sensitivity analysis may be summarised in a table with the sensitivity ranking of the relevant climate variables and hazards for a given project type, irrespective of the location, including critical parameters, and divided in e.g. the four themes.

EXPOSURE ANALYSIS

Indicative exposure table: *(example)*	Climate variables and hazards: Flood	Heat	...	Drought
Current climate	Medium	Low	...	Low
Future climate	High	Medium	...	Low
Highest score, current+future	High	Medium	...	Low

The output of the exposure analysis may be summarised in a table with the exposure ranking of the relevant climate variables and hazards for the selected location, irrespective of the project type, and divided in current and future climate. For both the sensitivity and exposure analysis, the scoring system should be carefully defined and explained, and the given scores should be justified.

VULNERABILITY ANALYSIS

Indicative vulnerability table: *(example)*		Exposure (current + future climate): High	Medium	Low
Sensitivity (highest across the four themes)	High	Flood		
	Medium		Heat	
	Low			Drought

Legend: Vulnerability level: High, Medium, Low

The vulnerability analysis may be summarised in a table for the given specific project type at the selected location. It combines the sensitivity and the exposure analysis. The most relevant climate variables and hazards are those with a high or medium vulnerability level, which are then taken forward to the steps below. The vulnerability levels should be carefully defined and explained, and the given scores justified.

Phase 2 (subject to the outcome of phase 1)

LIKELIHOOD ANALYSIS

Indicative scale for assessing the likelihood of a climate hazard (example):

Term	Qualitative	Quantitative (*)
Rare	Highly unlikely to occur	5%
Unlikely	Unlikely to occur	20%
Moderate	As likely to occur as not	50%
Likely	Likely to occur	80%
Almost certain	Very likely to occur	95%

The output of the likelihood analysis may be summarised in a qualitative or quantitative estimation of the likelihood for each of the essential climate variables and hazards. (*) Defining the scales requires careful analysis for various reasons including e.g. that the likelihood and impacts of the essential climate hazards may change significantly during the lifespan of the infrastructure project among other due to climate change. Various scales are referred to in the literature.

IMPACT ANALYSIS

Indicative scale for assessing the potential impact of a climate hazard (example) — *Risk areas:* / *Impacts:*	Insignificant	Minor	Moderate	Major	Catastrophic
Asset damage, engineering, operational					
Safety and health					
Environment, cultural heritage					
Social					
Financial					
Reputation					
Any other relevant risk area(s)					
Overall for the above-listed risk areas					

The impact analysis provides an expert assessment of the potential impact for each of the essential climate variables and hazards.

RISK ASSESSMENT

Indicative risk table: *(example)*	Overall impact of the essential climate variables and hazards (example): Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood: Rare					
Unlikely		Drought			
Moderate		Heat	Flood		
Likely					
Almost certain					

Legend: Risk level: Low, Medium, High, Extreme

The output of the risk analysis may be summarised in a table combining likelihood and impact of the essential climate variables and hazards. Detailed explanations are required to qualify and substantiate the assessment conclusions. The risk levels should be explained and justified.

IDENTIFYING ADAPTATION OPTIONS

Option identification process:
- Identify options responding to the risks (use e.g. expert workshops, meetings, evaluations, ...)

Adaptation may involve a mix of responses, e.g.:
- training, capacity building, monitoring, ...
- use of best practices, standards, ...
- nature-based solutions, ...
- engineering solutions, technical design, ...
- risk management, insurance, ...

APPRAISING ADAPTATION OPTIONS

The appraisal of adaptation options should give due regard to the specific circumstances and availability of data. In some cases a quick expert judgement may suffice whereas other cases may warrant a detailed cost-benefit analysis. It may be relevant to consider the robustness of various adaptation options vis-à-vis climate change uncertainties.

ADAPTATION PLANNING

Integrate relevant climate resilience measures into the technical project design and management options. Develop implementation plan, finance plan, plan for monitoring and response, plan for regular review of the assumptions and the climate vulnerability and risk assessment, and so on. The vulnerability and risk assessment and adaptation planning is aiming to reduce the remaining climate risks to an acceptable level.

Source: EC Technical Guidance on Climate Proofing of Infrastructure

2. Annex II of the EU Taxonomy's Delegated Regulation 2021/2139

2.1. Overview

The EU Taxonomy Regulation (Regulation (EU) 2020/852) establishes a framework for defining environmentally sustainable economic activities within the EU. It sets the stage for green investments by classifying activities that contribute to six environmental objectives. The regulation outlines four key conditions for an activity to be considered environmentally sustainable: make a substantial contribution to at least one objective, do no significant harm to the others, comply with minimum social safeguards, and meet the technical screening criteria.

Key elements of the EU Taxonomy Regulation:

- Purpose:
  - The regulation aims to promote sustainable investments and align them with the EU's climate and energy targets, as outlined in the European Green Deal.
- Environmental Objectives:
  - The taxonomy defines six environmental objectives: climate change mitigation, **climate change adaptation**, sustainable use of water and marine resources, transition to a circular economy, pollution prevention and control, and the protection and restoration of biodiversity and ecosystems.
- Technical Screening Criteria:
  - The European Commission develops specific technical criteria for each objective, determining which activities substantially contribute and which do not significantly harm.
- Minimum Safeguards:
  - Activities must comply with minimum social safeguards.
- Reporting Obligations:
  - Companies are required to assess how their activities perform against the taxonomy criteria and disclose these results. The specific reporting requirements vary depending on whether the company is a financial or non-financial undertaking.
- Scope:
  - The regulation applies to measures adopted by the EU or Member States regarding financial products and corporate bonds labelled as environmentally sustainable, as well as to financial market participants and certain undertakings subject to non-financial reporting obligations.

2.2. Technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change adaptation

On December 9, 2021, the European Commission published the Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives[14].

Annex II of the Delegated Regulation sets out the technical screening criteria for determining when an economic activity qualifies as contributing substantially to climate change adaptation, and for assessing whether it causes no significant harm to the other environmental objectives.

Specifically, the **construction and modernisation of bridges is included within category '*6.15 Infrastructure enabling road transport and public transport*'** and **applicable technical screening criteria for the substantial contribution to climate change adaptation** is as follows:

1. *The economic activity has implemented physical and non-physical solutions ('adaptation solutions') that substantially reduce the most important physical climate risks that are material to that activity.*
2. *The physical climate risks that are material to the activity have been identified from those listed in Appendix A to this Annex by performing a robust climate risk and vulnerability assessment with the following steps:*

   (a) screening of the activity to identify which physical climate risks from the list in Appendix A to this Annex may affect the performance of the economic activity during its expected lifetime;

   (b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to this Annex, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;

   (c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

   The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

   (a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;

   (b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios consistent with the expected lifetime of the activity, including, at least, 10-to-30-year climate projections scenarios for major investments.
3. *The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports, scientific peer-reviewed publications and open source or paying models.*
4. *The adaptation solutions implemented:*

   (a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

   (b) favour nature-based solutions or rely on blue or green infrastructure to the extent possible;

   (c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

[14] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R2139

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

As the APPENDIX II of the CCSU OECD document is targeted only on the contribution to Climate adaptation, other environmental objectives of the EU Taxonomy (such as GHG emissions, pollution, water resources or biodiversity) are not considered.

The following figure contains a table of all the physical climate-related hazards listed by the EU Taxonomy Delegated Regulation; please note that a preliminary screening has been carried out for the Project/Bridge of interest, selecting only the hazards with a minimum degree of applicability based on their geographic location.

Figure 11 – Classification of climate-related hazards

Appendix A

CLASSIFICATION OF CLIMATE-RELATED HAZARDS [1]

	Temperature-related	Wind-related	Water-related	Solid mass-related
Chronic	Changing temperature (air, freshwater, marine water)	Changing wind patterns	Changing precipitation patterns and types (rain, hail, snow/ice)	Coastal erosion
	Heat stress		Precipitation or hydrological variability	Soil degradation
	Temperature variability		Ocean acidification	Soil erosion
	Permafrost thawing		Saline intrusion	Solifluction
			Sea level rise	
			Water stress	
Acute	Heat wave	Cyclone, hurricane, typhoon	Drought	Avalanche
	Cold wave/frost	Storm (including blizzards, dust and sandstorms)	Heavy precipitation (rain, hail, snow/ice)	Landslide
	Wildfire	Tornado	Flood (coastal, fluvial, pluvial, ground water)	Subsidence
			Glacial lake outburst	

Source: Commission Delegated Regulation (EU) 2021/2139